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Florentin Smarandache . Mohamed Abdel-Basset
Maikel Leyva Vazquez - Said Broumi

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"Neutrosophic Sets and Systems" has been created for publications on advanced studies in neutrosophy, neutrosophic set, neutrosophic logic, neutrosophic probability, neutrosophic statistics that started in 1995 and their applications in any field, such as the neutrosophic structures developed in algebra, geometry, topology, etc.

The submitted papers should be professional, in good English, containing a brief review of a problem and obtained results. Neutrosophy is a new branch of philosophy that studies the origin, nature, and scope of neutralities, as well as their inter actions with different ideational spectra.

This theory considers every notion or idea <A> together with its opposite or negation <antiA> and with their spectrum of neutralities <neutA> in between them (i.e. notions or ideas supporting neither <A> nor <antiA>). The <neutA> and <antiA> ideas together are referred to as <nonA>.

Neutrosophy is a generalization of Hegel's dialectics (the last one is based on <A> and <antiA> only).
According to this theory every idea <A> tends to be neutralized and balanced by <antiA> and <nonA> ideas - as a state of equilibrium.

In a classical way <A>, <neutA>, <antiA> are disjoint two by two. But, since in many cases the borders between notions are vague, imprecise, Sorites, it is possible that <A>, <neutA>, <antiA> (and <nonA> of course) have common parts two by two, or even all three of them as well.

Neutrosophic Set and Neutrosophic Logic are generalizations of the fuzzy set and respectively fuzzy logic (especially of intuitionistic fuzzy set and respectively intuitionistic fuzzy logic). In neutrosophic logic a proposition has a degree of truth (T), a degree of indeterminacy (I), and a degree of falsity (F), where T, I, F are standard or non-standard subsets of]-0, 1+[.

Neutrosophic Probability is a generalization of the classical probability and imprecise probability.
Neutrosophic Statistics is a generalization of the classical statistics.
What distinguishes the neutrosophics from other fields is the <neutA>, which means neither <A> nor <antiA>.

<neutA>, which of course depends on <A>, can be indeterminacy, neutrality, tie game, unknown, contradiction, igno- rance, imprecision, etc.

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University of New Mexico

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Dr. Mohamed Abdel-Basset, Faculty of Computers and Informatics, Zagazig University, Egypt, Email: mohamed.abdelbasset@fci.zu.edu.eg.
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Selcuk Topal, Mathematics Department, Bitlis Eren University, Turkey, Email: s.topal@beu.edu.tr. Ibrahim El- henawy, Faculty of Computers and Informatics, Zagazig University, Egypt, Email: henawy2000@yahoo.com.
A. A. Agboola, Federal University of Agriculture, Abeokuta, Nigeria, Email: aaaola2003@yahoo.com.
Luu Quoc Dat, Univ. of Economics and Business, Vietnam National Univ., Hanoi, Vietnam, Email: datlq@vnu.edu.vn.
Maikel Leyva-Vazquez, Universidad Politécnica Salesiana, extensión Guayaquil, Ecuador, Email: mleyvaz@gmail.com.
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Ridvan Sahin, Department of Mathematics, Faculty of cience, Ataturk University, Erzurum 25240, Turkey, Email: mat.ridone@gmail.com.
Victor Christianto, Malang Institute of Agriculture (IPM), Malang, Indonesia, Email: victorchristianto@gmail.com.
Wadei Al-Omeri, Department of Mathematics, Al- Balqa Applied University, Salt 19117, Jordan, Email: wadeialomeri@bau.edu.jo.
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Ilanthenral Kandasamy, School of Computer Science and Engineering (SCOPE), Vellore Institute of Technology (VIT), Vellore 632014, Tamil Nadu, India, Email: ilanthenral.k@vit.ac.in
Kul Hur, Wonkwang University, Iksan Jeollabukdo, South Korea, Email: kulhur@wonkwang.ac.kr.
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Riad K. Al-Hamido, Math Departent, College of Science, Al-Baath University, Homs, Syria, Email: riad-hamido1983@hotmail.com.
Abduallah Gamal, Faculty of Computers and Informatics, Zagazig University, Egypt, Email: abduallahgamal@zu.edu.eg.
Ibrahim M. Hezam, Department of computer, Faculty of Education, Ibb University, Ibb City, Yemen, Email: ibrahizam.math@gmail.com.
Pingping Chi, China-Asean International College, Dhurakij Pundit University, Bangkok 10210, Thailand, Email: chipingping@126.com.
Ameirys Betancourt-Vázquez, 1 Instituto Superior Politécnico de Tecnologias e Ciências (ISPTEC), Luanda, Angola, E-mail: ameirysbv@gmail.com. Karina Pérez-Teruel, Universidad Abierta para Adultos (UAPA), Santiago de los Caballeros, República Dominicana, E-mail: karinapt@gmail.com.
Jesús Estupiñán Ricardo, Centro de Estudios para la Calidad Educativa y la Investigación Científica, Toluca, México, Email: jestupinan2728@gmail.com.
B. Davvaz, Department of Mathematics, Yazd University, Iran, Email: davvaz@yazd.ac.ir.
Faruk Karaaslan, Çankırı Karatekin University, Çankırı, Turkey, E-mail: fkaraaslan@karatekin.edu.tr.
Suriana Alias, Universiti Teknologi MARA (UiTM) Kelantan, Campus Machang, 18500 Machang, Kelantan, Malaysia, Email: suria588@kelantan.uitm.edu.my.
Angelo de Oliveira, Ciencia da Computacao, Universidade Federal de Rondonia, Porto Velho - Rondonia, Brazil, Email: angelo@unir.br.
Valeri Kroumov, Okayama University of Science, Japan, Email: val@ee.ous.ac.jp.
E. K. Zavadskas, Vilnius Gediminas Technical University, Vilnius, Lithuania, Email: edmundas.zavadskas@vgtu.lt.
Darjan Karabasevic, University Business Academy, Novi Sad, Serbia, Email: darjan.karabasevic@mef.edu.rs.
Dragisa Stanujkic, Technical Faculty in Bor, University of Belgrade, Bor, Serbia, Email: dstanujkic@tfbor.bg.ac.rs.
Luige Vladareanu, Romanian Academy, Bucharest, Romania, Email: uigiv@arexim.ro.

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Stefan Vladutescu, University of Craiova, Romania, Email: vladutescu.stefan@ucv.ro.
Fernando A. F. Ferreira, ISCTE Business School, BRU- IUL, University Institute of Lisbon, Avenida das Forças Armadas, 1649-026 Lisbon, Portugal, Email: fernando.alberto.ferreira@iscte-iul.pt
Julio J. Valdés, National Research Council Canada, M- 50, 1200 Montreal Road, Ottawa, Ontario K1A 0R6, Canada, Email: julio.valdes@nrc-cnrc.gc.ca
Tieta Putri, College of Engineering Department of Computer Science and Software Engineering, University of Canterbury, Christchurch, New Zeeland. M. Al Tahan, Department of Mathematics, Lebanese International University, Bekaa, Lebanon, Email: madeline.tahan@liu.edu.lb
Sudan Jha, Pokhara University, Kathmandu, Nepal, Email: jhasudan@hotmail.com
Lonay 11, 1110 Morges, Switzerland, Email: flippe2@gmail.com.
Saeid Jafari, College of Vestsjaelland South, Slagelse, Denmark, Email: jafaripersia@gmail.com.
Willem K. M. Brauers, Faculty of Applied Economics, University of Antwerp, Antwerp, Belgium, Email: willem.brauers@ua.ac.be.
M. Ganster, Graz University of Technology, Graz, Austria, Email: ganster@weyl.math.tu-graz.ac.at. Umberto Rivieccio, Department of Philosophy, University of Genoa, Italy, Email: umberto.rivieccio@unige.it.
F. Gallego Lupiañez, Universidad Complutense, Madrid, Spain, Email: fg_lupianez@mat.ucm.es. Francisco Chiclana, School of Computer Science and Informatics, De Montfort University, The Gateway, Leicester, LE1 9BH, United Kingdom, Email: chiclana@dmu.ac.uk.
Yanhui Guo, University of Illinois at Springfield, One University Plaza, Springfield, IL 62703, United States, Email: yguo56@uis.edu

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University of New Mexico

Preface of The Special Issue on Impact of Neutrosophic Scientific Publication in Latin American Context

Neutrosophy has given way to its research method for a transdisciplinary study that crosses the boundaries between the sciences. The neutrosophic research method is a generalization of Hegel's dialectics (dynamics of opposites: <A> and <antiA>). It suggests that scientific and humanistic research will progress by studying the opposite ideas and the neutral ideas related to them to have a broader view of the whole problem to be solved. These ideas are based on neutrosophy (study of opposites and their neutrals: <A> and <antiA> and <neutA>), a new philosophy created by the Romanian-born researcher Florentin Smarandache.

This special issue reflects the impact of neutrosophic theory in Latin America, especially after creating the Latin American Association of Neutrosophic Sciences. Among the areas of publication most addressed in the region are found in the interrelation of social sciences and neutrosophy, presenting outstanding results in these research areas.

The main objective of this special issue is to divulge the impact publication related to the Neutrosophic theory and explore new areas of research and application in the region. The SI reflects the influence of the neutrosophic publications in Latin America by opening new research areas mainly related to Neutrosophic Statistics, Plithogeny, and NeutroAlgebra.

Furthermore, it is worth mentioning the incorporation of authors from new countries in the region, such as Paraguay, Uruguay, and Panama, to have authors in total from 15 countries, 12 of them from the Latin American region.

We are thankful to Prof Florentin Smarandache for his continuous support. The editors firmly believe that this Special Issue will be helpful for researchers working on all aspects related to neutrosophic research, especially in social sciences.

Prof. Maikel Leyva Vázquez PhD.

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Neutrosophic Statistics applied in Social Science

Adrián Alejandro Alvaracín Jarrín[1], David Santiago Proaño Tamayo[2], Salomón Alejandro Montecé Giler[3] ,Juan Carlos Arandia Zambrano[4] and Dante Manuel Macazana Fernández[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.adrianalvaracin@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.davidpro@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.salomonmontece@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador. Email: uq.juanarandia@uniandes.edu.ec
[5] Universidad Nacional Mayor de San Marcos. Perú. dmacazanaf_af@unmsm.edu.pe

Abstract. Social Science deals with the study of phenomena related to the social status of human beings. The importance of such sciences lies in the fact that they make it possible to know, predict, modify and improve the functioning of human societies today. Due to the great complexity of modern societies, it is virtually impossible to have accurate data or knowledge about any contemporary society. That is why neutrosophic theory is suitable for representing and modeling the data from studies on any social sciences. They may contain data that is contradictory, incomplete, inaccurate, vague, and so on. In particular, neutrosophic statistics generalizes classical statistics to interval-valued data. Since classical statistics are of great importance for the study of Social Sciences, in this paper, we compile, define and illustrate some statistical methods typical of classical statistics generalized to neutrosophic statistics. We will emphasize the Legal Sciences in our approach.

Keywords: Social Sciences, Neutrosophy, Neutrosociology, Neutrosophic Statistics.

1 Introduction

Social Sciences are a generic name for the disciplines or fields of knowledge that claim for themselves the condition of sciences, which analyze and treat different aspects of social groups and human beings in society, dealing with their material and immaterial manifestations [1]. According to the intention of the one who uses them, other convergent or differentiated names are those of human sciences or humanities (terms that are differentiated by diverse epistemological and methodological considerations). Different combinations of these terms are also used, such as Human and Social Science. Social Science studies the origin of individual and collective behavior, seeking to discover the social rules that determine them and are expressed in the set of human institutions and societies.

In the classification of sciences, they are distinguished from the Natural Sciences and the Formal Sciences. They deal with the behavior and activities of humans, generally not studied in the Natural Sciences. The Social Sciences present methodological problems that do not appear in the Natural Sciences. Within the Natural Sciences, there is little discussion about what constitutes a Natural Science and what does not. However, in Social Sciences, there has historically been greater discussion about what genuinely constitutes a Social Science and what does not. Although they involve rational reasoning and discussion, some disciplines or social studies are not considered Social Sciences.

In general, there is no reasonable agreement on which disciplines should be considered part of the Social Sciences and for the Natural Sciences, although the traditional division between them is doubtful in some cases. Thus, for example, if the study of the language had been considered almost universally a Social Science, the modern approach that started with the generative grammar of Noam Chomsky suggests that the language is not so much of the social interaction but should be seen as a part of psychology, or evolutionary biology, as in the operation of the languages and their temporal evolution of the consciousness of the speakers or their representations psychological not seem to play any role. For this reason, some authors consider that languages are a natural object that is generated spontaneously and not by the deliberate intention of human beings [2-5].

In general, and without being overly rigorous, the following disciplines have been considered examples of Social Sciences by a large number of authors:

Sciences related to social interaction: Anthropology, History, Human Geography, Economics, Social Psychology, Sociology, and Political Science.

Sciences related to the human cognitive system: Linguistics, Psychology.

Sciences related to the evolution of societies: Archaeology, Demography, and Human Ecology.

On the other hand, Neutrosophy studies the neutralities that are contained in the lack of knowledge, contradictions, paradoxes, and imprecision, among others. Neutrosophic sets generalize fuzzy sets, and fuzzy intuitionist sets, among others, [6]. This theory has been applied in many real-life problems.

An approach of Neutrosophy to sociology is Neutrosophic Sociology (or Neutrosociology), which is the study of sociology using neutrosophic scientific methods [7]. The massive amount of social data we face in sociology is usually vague, incomplete, contradictory, hybrid, biased, ignorant, redundant, superfluous, meaningless, ambiguous, unclear, etc.

That is why some neutrosophic research tools and methods should be involved, such as Neutrosophy (a new branch of philosophy), neutrosophic set, neutrosophic logic, neutrosophic probability, and neutrosophic statistics, neutrosophic analysis, neutrosophic measure, and so on.

Specifically, Neutrosophic Statistics refers to a set of data and the methods used to analyze them when the data or at least a part of them are indeterminate to some degree [8]. In Classical Statistics, all data are determined; this is the main distinction between neutrosophic statistics and classical statistics. Some researches on Neutrosophic Statistics can be read in [9-17].

When indeterminacy is zero, neutrosophic statistics coincide with classical statistics. Therefore, we can use the neutrosophic measure for assessing indeterminate data. The neutrosophic statistical methods will enable us to interpret and organize data that may have some indeterminacies to reveal underlying patterns.

The purpose of this paper is to compile, define and illustrate the use of neutrosophic statistics methods in Social Sciences because these disciplines often present imprecise, inconsistent, insufficient, and unknown data. Specifically, we will emphasize the field of Legal Sciences within the Social Sciences, where this type of data is very common, despite precise decisions that can affect people's lives need to be made, hence its importance. Some papers on Neutrosophy applied to the Social and Legal Sciences can be found in [9, 18-24].

This article is divided into the following sections; section 2 exposes the main concepts of neutrosophic statistics. Section 3 contains the classical and neutrosophic statistical methods that we recommend applying and defining for Social Sciences, particularly in Legal Sciences. Finally, the paper ends with the conclusions.

2 Neutrosophic Statistics

This section contains some basic concepts of neutrosophic sets and neutrosophic statistics [25-46].

Definition 1: ([6]) Let X be a universe of discourse. Three membership functions characterize a Neutrosophic Set (NS), $u_A(x), r_A(x), v_A(x) : X \to]-0, 1^+[$, which satisfy the condition $-0 \leq inf\ u_A(x) + inf\ r_A(x) + inf\ v_A(x) \leq sup\ u_A(x) + sup\ r_A(x) + sup\ v_A(x) \leq 3^+$ for all xX. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]-0, 1^+[$.

Definition 2: ([6]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for allxX. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate, and falseness of x in A, respectively. For convenience, a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where a, b, c [0,1] and satisfy $0 \leq a + b + c \leq 3$.

Neutrosophic Statistics extends classical statistics such that we can deal with set values rather than crisp values [8].

Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data.

Neutrosophic Inferential Statistics consists of methods that allow the generalization from a neutrosophic sampling to a population from which the sample was selected.

Neutrosophic Data is the data that contains some indeterminacy. Similarly to classical statistics, it could be classified as:

- *Discrete neutrosophic data,* if the values are isolated points.
- *Continuous neutrosophic data*, if the values form one or more intervals.

Another classification is the following:

- *Quantitative (numerical) neutrosophic data*; for example, a number in the interval (we do not know exactly), 46, 53, 68, or 70, not knowing exactly;
- *Qualitative (categorical) neutrosophic data*; for example: blue or red (we don't know exactly), white, black or green, or yellow (not knowing exactly).

The *univariate neutrosophic data* is neutrosophic data that consists of observations on a neutrosophic single attribute.

Multivariable neutrosophic data is neutrosophic data that consists of observations on two or more attributes.

A *Neutrosophic Statistical Number* N has the form $N = d + I$, [47], where d is called *determinate part* and I is called *indeterminate part*.

A *Neutrosophic Frequency Distribution* is a table showing the categories, frequencies, and relative frequencies with some indeterminacy. Most often, indeterminacies occur due to incomplete, imprecise, or unknown data related to frequency. As a consequence, relative frequency becomes imprecise, incomplete, or unknown too.

Neutrosophic Survey Results are results from a survey that contains indeterminacy.

A *Neutrosophic Population* is a population not well determined at the membership level where we are not sure if some individuals belong or do not belong to the population).

A *simple random neutrosophic sample* of size n from a classical or neutrosophic population is a sample of n individuals such that at least one of them has some indeterminacy.

A *stratified random neutrosophic sampling* is the pollster groups of the (classical or neutrosophic) population by a stratum according to a classification; afterward, the pollster takes a random sample of appropriate size according to a criterion from each group. If there is indeterminacy, we deal with neutrosophic sampling.

Additionally, we describe concepts of interval calculus, which shall be useful in this paper.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as follows, [47]:

$N_1 + N_2 = a_1 + a_2 + (b_1 + b_2)I$ (Addition),

$N_1 - N_2 = a_1 - a_2 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

Additionally, given $I_1 = [a_1, b_1]$ and $I_2 = [a_2, b_2]$ we have the following operations between them (see [48]):

1. $I_1 \leq I_2$ if and only if $a_1 \leq a_2$ and $b_1 \leq b_2$.
2. $I_1 + I_2 = [a_1 + a_2, b_1 + b_2]$ (Addition);
3. $I_1 - I_2 = [a_1 - b_2, b_1 - a_2]$ (Subtraction),
4. $I_1 \cdot I_2 = [min\{a_1 b_1, a_1 b_2, a_2 b_1, a_2 b_2\}, max\{a_1 b_1, a_1 b_2, a_2 b_1, a_2 b_2\}]$ (Product),
5. $I_1 / I_2 = I_1(1/I_2) = \{a/b: aI_1, bI_2\}$, always that 0□$I_2$ (Division).
6. $\sqrt{I} = [\sqrt{a}, \sqrt{b}]$, always that $a \geq 0$ (Square root).
7. $I^n = I \cdot I \cdot \cdots \cdot I \cdot \underbrace{I}_{n\ times}$

3 Neutrosophic statistics applied in Social Sciences

This section covers the neutrosophic statistics methods that can be used in Social Sciences. Especially, correlation methods like Contingency Tables, Pearson's correlation coefficient, and Spearman's correlation coefficient are introduced.

3.1 Contingency Tables

In classical statistics, contingency tables are used to record and analyze the relationship between two or more variables, usually of a qualitative nature (nominal or ordinal) [49]. This table is based on the frequency of cases that satisfy the characteristics that each cell in the table represents. However, in many cases, this frequency of cases cannot be defined with a single number due to differences of opinion among several experts in the Social Sciences. Some sciences are based on various theories, some of them can partially contradict each other, and therefore the cases that are studied may have different meanings depending on the theory that is applied. On the other hand, there may be unknown or unclassifiable cases, because there is insufficient data, one investigator classifies the case in one way, and another considers it in another, and so on. Therefore, instead of numerical frequencies, it is recommendable to perform the calculations with frequency intervals.

A contingency table is important in the social sciences because it allows the representation of qualitative values, which are data widely used in this type of science.

Definition 3: We define a *neutrosophic contingency table* as a contingency table such that at least one cell element is an interval rather than a crisp value.

Let us note that when the range of the intervals contains the same limit values, it is a crisp value and the neutrosophic contingency table becomes a classical contingency table. Additionally, according to the authors' knowledge, the neutrosophic contingency table is defined for the first time here.

The coefficient (also called quadratic contingency coefficient), on which the contingency coefficient is based, is a measure of the "intensity" of the relationship between the observed characteristics. In *neutrosophic contingency tables*, the same formula as in classical statistics is maintained, using the interval-valued operators of the quadratic contingency. This formula is the following:

$$\frac{N\chi^2}{n} = \frac{1}{n}\sum_{i=1}^{k} \sum_{j=1}^{m} \frac{\left(I_{ij} - \frac{I_{i.}I_{.j}}{n}\right)^2}{\frac{I_{i.}I_{.j}}{n}} \qquad (2)$$

Where, $\frac{N\chi^2}{n}$ is the neutrosophic mean quadratic contingency, I_{ij} is the interval value of the cell in the i-th row and the j-th column. $I_{i.}$ is the sum for columns of the i-th row, $I_{.j}$ is the sum for rows of the jth column. n is the interval sampling size, while k is the number of rows and m is the number of columns of the table.

The greater this measure, the more intense is the relationship between the two analyzed characteristics. If both characteristics (variables) are independent, then each of the summands is 0, as a result of which the numerator of the fraction is 0 and with it the measure itself as well. In the case of a 2x2 contingency table, the measurement is normalized and assumes values in the interval [0, 1].

$N\chi^2$ can assume very large values in principle and is not limited to a subinterval of [0, 1]. To exclude the dependence of the contingency coefficient on the sample size, the contingency coefficient NC extends the contingency coefficient C. The case of interval values is calculated based on $N\chi^2$, based on the following formula:

$$NC = \sqrt{\frac{N\chi^2}{N\chi^2 + n}} \qquad (3)$$

Where n is the interval size of the sample. In this case, the division is defined as follows:

$$\frac{I_1}{I_2} = \left[\frac{a_1}{b_1}, \frac{a_2}{b_2}\right] \qquad (4)$$

An example is used below to illustrate the method:

Example 1:

Suppose that in Ecuadorian City X an average of 35 women's rapes is reported during a year. This crime is highly sensitive because it involves psychological, social, moral, and family damage to the woman that is a victim of the crime. That is why some women do not report it and the crime goes unpunished, which gives the rapist confidence to continue committing it, and then it becomes a judicial problem for the city. Experts estimate that in reality, this crime rate must be 10% higher. They know by reference some women who have been raped and have not reported the incident to the police. In other cases, friends or relatives have reported the incident, but the woman has refused to give details of the incident out of shame and therefore, the prosecutor has not been able to do anything about it.

Another important aspect has to do with the delivery of justice. Table 1 represents the neutrosophic contingency table that relates the number of rapes that occurred in the year 2020 in city X with the number of these crimes in which the guilty party has been punished. Unreported violations are included in this statistic, which of course is considered among the crimes that have gone unpunished.

Rapes reported in one year\Outcome of	Punished	Not punished	Total
Reported	[22, 24]	[11, 13]	[33, 37]
Not reported	[0, 0]	[1, 9]	[1, 9]
Total	[22, 24]	[12, 22]	[34, 46]

Table 1. Neutrosophic contingency table representing denounced and non-denounced rapes against punished and not punished rapes in city X during 2020.

See that the table considers the reported crimes in the form of intervals, this has to do with the fact that some reported crimes are still in the judicial phase. Therefore, there is also imprecision in the reported crimes; however, it has been decided to maintain this imprecision for greater accuracy.

The obtained result is the following:

$N\chi^2 = [1.8487, 137.2568]$ and $NC = [0.22709, 0.89006]$ which indicates that the correlation of punished cases and reported cases can be from very correlated with C H 0.89 to little correlated with C H 0.23.

3.2 Pearson's correlation coefficient

In classical statistics, Pearson's correlation coefficient is a measure of the linear relationship between two quantitative random variables. Unlike covariance, Pearson's correlation is independent of the measurement scale of the variables.

Less formally, we can define the Pearson correlation coefficient as an index that can be used to measure the degree of relationship of two variables as long as both are quantitative.

In the case that two random variables x and y are being studied on a population; the Pearson correlation coefficient is represented with the letter ρ_{XY}, and the expression that allows us to calculate it is [49]:

$$\rho_{XY} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y} = \frac{E[(X-\mu_X)(Y-\mu_Y)]}{\sigma_X \sigma_Y} \tag{5}$$

Where:

- σ_{XY} is the covariance of (X, Y),
- σ_X is the standard deviation of variable X,
- σ_Y is the standard deviation of variable Y.

Similarly, we can calculate this coefficient on a sample statistic, denoted as r_{xy}:

$$r_{xy} = \frac{\sum \quad x_i y_{i-n\underline{\underline{xy}}}}{n s_X s_Y} \tag{6}$$

In both formulas, Equation 4 of the division is used. Formulas 5 and 6 are converted into neutrosophic equations when the data (X, Y) or $\{(x_i, y_i)\}$ are intervals more than crisp values, respectively. Let us denote the generalizations of formulas 5 and 6 to the neutrosophic framework by $N\rho_{XY}$ (which we will call *neutrosophic Pearson' correlation coefficient*) and Nr_{xy}, respectively. The explanation for using interval data instead of crisp data is the same as in the previous subsection.

The value of Nr_{xy} is a subinterval of [-1, 1]:

- If $1 \in Nr_{xy}$, there are cases with a perfect positive correlation. The index designates a total dependence between the two variables called a direct relationship: when one of them increases, the other also increases in constant proportion.
- If $(0, 1) \subseteq Nr_{xy}$, there is a positive correlation.
- If $0 \in Nr_{xy}$, there are cases where there is no linear relationship. But this does not necessarily imply that the variables are independent: there may still be nonlinear relationships between the two variables.
- If $(-1, 0) \subseteq Nr_{xy}$, there is a negative correlation.
- If $-1 \in Nr_{xy}$, there are cases with a perfect negative correlation. The index designates a total dependence between the two variables called an inverse relationship: when one of them increases, the other decreases in constant proportion.

Below we illustrate the use of this coefficient by an example:

Example 2:

Tax evasion is an illegal activity and is usually regarded as an administrative offense in most legal systems. It is an illegal act of concealing property or income to pay fewer taxes. "Black money" is anyone who has evaded the payment of taxes. They are profits obtained in illegal or legal activities, but that are not declared to the Treasury to evade taxes. The intention is to keep it in cash, and not to deposit it with financial institutions so that it is not recorded in bank movements and the State is not aware of its existence.

Suppose that we want to study the relationship between the numbers in millions of dollars deposited in tax havens by citizens living in 21 cities of the territory of a country X, concerning the cost of living, measured in Consumer Price Index (CPI). In this way, both the economic and social impacts of tax evasion in each studied city are related. Hence, this phenomenon has economic, political, social, and legal significance.

However, it is difficult to have an exact figure of the millions of dollars that are in tax havens and that should be used in public expenditures of the city, because this illegal practice is hidden, therefore the most accurate way to represent it is in the form of an interval.

So, the data are summarized in Table 2:

Number of the City	Millions of dollars in tax havens	Consumer Price Index (CPI) (%)
1	[2.60, 3.40]	2.9
2	[5.30, 5.88]	7.9
3	[8.60, 9.52]	1.7
4	[7.40, 7.73]	7.7
5	[1.40, 1.81]	6.5
6	[5.40, 6.29]	3.8
7	[0.40, 0.88]	1.8
8	[1.90, 2.46]	6.9
9	[3.40, 3.59]	8.8
10	[7.30, 8.22]	4.1

11	[7.40, 7.81]	7.9
12	[8.00, 8.20]	1.4
13	[7.70, 8.55]	4.3
14	[5.80, 6.01]	8.5
15	[7.80, 8.21]	1.1
16	[2.50, 3.25]	7.1
17	[4.20, 4.39]	5.7
18	[0.80, 0.88]	8.9
19	[5.00, 5.69]	7.4
20	[9.90, 10.53]	4.7
21	[7.40, 7.53]	8.2

Table 2: Data from 21 cities that relate estimated amounts of millions in tax havens vs. CPI.

The result of applying Formula 6 to the data in Table 2 is $Nr_{xy} = [-0.27838, -0.23236]$, which indicates that in this case, the correlation is negative and quite small. Let us note that the data in the second column could be given as intervals and still formulas 5 and 6 remain applicable. This indicates that in this case the estimated amount of dollars in tax havens of citizens of the city does not significantly influence the standard of living of citizens.

3.3 Spearman's correlation coefficient

In classical statistics, Spearman's correlation coefficient, ρ is a measure of the correlation (association or interdependence) between two continuous random variables, [49]. To calculate ρ, the data are sorted and replaced by their respective order.

The statistic ρ is given by the following expression:

$$\rho = 1 - \frac{6\sum \quad D^2}{N(N^2-1)} \qquad (7)$$

Where:

- D is the difference between the corresponding X-Y order statistics.
- N is the number of pairs.

The existence of identical data has to be considered when ordering them, although if these are few, this circumstance can be ignored.

For samples larger than 20 observations, we can use the following approximation by the t-Student distribution:

$$t = \frac{\rho}{\sqrt{\frac{(1-\rho^2)}{(n-2)}}} \qquad (8)$$

The interpretation of Spearman's coefficient is the same as that of Pearson's. It oscillates between -1 and +1, indicating negative or positive associations respectively, 0 means no correlation but no independence.

As for contingency table and Pearson's correlation coefficient, it is possible and useful to extend ρ to the neutrosophic framework, denoting by $N\rho$ when $\{(x_i, y_i)\}$ are intervals rather than crisp values. Similarly, Equation 8 becomes Nt when ρ is replaced by $N\rho$. Neutrosophic Spearman's correlation coefficient is a crisp value because orders are crisp values when interval values are compared, using the interval-value order definition.

The use of this coefficient will be illustrated with the following example:

Example 3:

Let us revisit Example 2 and apply Spearman's correlation coefficient in it. In this case, we wish to confirm whether there is a correlation among the standard of living of citizens of the 21 cities, concerning the order (not the number of millions) in tax havens of citizens investigated by the courts.

Thus, Table 2 becomes the following Table 3 of ordered data:

Number of the City	Order of millions of dollars	Order of Consumer Price	D
1	6	5	1
2	10	16	-6
3	20	3	17
4	14.5	15	-0.5
5	3	11	-8
6	11.5	6	5.5
7	1	4	-3
8	4	12	-8
9	7	20	-13
10	14.5	7	7.5
11	14.5	17	-2.5
12	17.5	2	15.5
13	17.5	8	9.5

14	11.5	19	-7.5
15	19	1	18
16	5	13	-8
17	8	10	-2
18	2	21	-19
19	9	14	-5
20	21	9	12
21	14.5	18	-3.5

Table 3: Order of data from the 21 cities that relate the estimated dollar amounts in tax havens vs. CPI, and D.

Table 3 shows that the 11th, 13th, and 17th cases are considered repeated because they cannot be compared by the order between intervals. For example, it is not $[5.40, 6.29] \nless [5.80, 6.01]$ nor $[5.80, 6.01] \nless [5.40, 6.29]$ in Table 2, therefore they are considered to have the same order, the 11th one, which is converted into $\frac{11+12}{2} = 11.5$. The result is $N\rho = -0.32857$, which is consistent with Neutrosophic Pearson's correlation coefficient.

Let us note that in this case the amount of millions in tax havens does not matter, only the order.

Conclusion

This paper covered the definition, illustration, and proposition of neutrosophic statistics methods in Social Sciences. On many occasions, the data available in Social Sciences contain inconsistencies due to inaccuracies, contradictions in the sources of information and knowledge, lack of objectivity in some opinions, among other factors. That is why in these cases, data represented in the form of intervals may be necessary. Specifically, in this paper, we define and illustrate the use of contingency tables, Pearson's correlation coefficient, and Spearman's correlation coefficient generalized to the neutrosophic framework. Three examples of the use of each of them served to show how and why to use neutrosophic statistics in these cases, where the examples used are mainly based on hypothetical problems of Legal Sciences. In future research, we will propose to generalize other methods of classical statistics to the framework of Neutrosophy, so that they will be helpful to solve problems of Social Sciences.

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Neutrosophic Matrix Games to Solve Project Management Conflicts

Roberto Carlos Jiménez Martínez[1], César Elías Paucar Paucar[2], José Ignacio Cruz Arboleda[3] Miguel Ángel Guambo Llerena[4] and Erick González Caballero[5]

[1]Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.robertojimenez@uniandes.edu.ec
[2]Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.cesarpaucar@uniandes.edu.ec
[3]Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.josecruz@uniandes.edu.ec
[4]Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.miguelguambo@uniandes.edu.ec
[5]Member, Asociación Latinoamericana de Ciencias Neutrosóficas, La Habana, Cuba. Email: erickgc@yandex.com

Abstract. A project is an effort made by a group of actors during a certain period to obtain a product, service, or result. Project management is the application of knowledge, skills, tools, and techniques to plan and execute activities to achieve the project requirements. Project management implies the need for negotiation between the parties because there may be a contradiction between the parties involved, that is, e.g. between the one who provides the knowledge or goods and the client who receives the final product or knowledge. That is why we propose a neutrosophic solution to manage the contradictions in the negotiation and execution of any project. The advantages offered by this solution are that the data can be entered in the form of linguistic terms, in addition to explicitly including the indeterminacy that exists in the modeling of this type of activity. This methodology is useful in negotiating qualitative content between parties.

Keywords: Single-valued triangular neutrosophic number, matrix games, neutrosophic games, project management, negotiation.

1 Introduction

In general, problems related to conflicts of interest or decision-making are characterized by the existence of a group of individuals who have to face a situation that may have more than one outcome concerning the specific personal preferences of each of the individuals. In addition, each individual controls some of the variables that determine the final result, although he does not control the totality. These situations are called games. Thus, a game can include situations as diverse as a game of cards, obtaining a contract by certain companies, or negotiating international agreements among some countries, [1].

The beginning of the mathematical theory that studies conflicts of interest, called Game Theory, was established in 1944, following the publication of the book “Game Theory and Economic Behavior” by John von Neumann and Oskar Morgensen, although there were already records of previous works at the beginning of the twentieth century, [2]. Since then, Game Theory has evolved widely and has seen how its models have been applied, especially to economics and politics as well as other social sciences such as philosophy or psychology, since its models fit the study of human behavior.

It is not that Game Theory can cover any problems related to decision-making or conflicts of interest; in general, it must be assumed that there is a specific number of players, that all possible outcomes of the game are known and determined, that each player has a preference among the different outcomes that can be expressed in terms of a utility function, and that each player's goal is to maximize the utility gained after the outcome of the game.

The problem for each player is to determine the strategy to follow so that their partial influence on the game is as beneficial as possible. Given this situation, the first classification between cooperative and non-cooperative games is presented, [1].

Non-cooperative game theory deals with the behavior of game agents in situations where each player's choice of optimal strategy depends on his forecast of opponents' choices and seeks to maximize his profit by ignoring the choice made by others.

If there can be communication between the players to negotiate or establish agreements that allow coalitions to be formed, then the situation is framed within the so-called cooperative games. In these situations, it is considered as basic information the profits that each coalition can obtain by coordinating the strategies of its members, independently of the actions of the rest of the agents in the game. Thus, the agreements among the members of each coalition are aimed at coordinating their actions or redistributing the payments or obtained profits.

Conflict situations modeled by game theory present uncertainty, which is why mathematical models have emerged that incorporate this component to the solution [3, 4]. For example, there are fuzzy cooperative games that appear in [5]. These solutions are obtained from applying the Zadeh extension principle to deterministic solutions of cooperative games, not only to Shapley's value but also to the Core. There are solutions to cooperative and non-cooperative games that use fuzzy theories, such as fuzzy sets or intuitionistic fuzzy sets, e.g., [6]. However, these solutions do not explicitly consider the indetermination as a result of lack of knowledge, hidden information, contradictions of interests between agents, and inconsistencies, among other reasons. That is why in this paper we introduce a problem-solving method with the help of neutrosophic theory. Neutrosophy is the branch of philosophy that studies all related to neutralities, where lack of information, contradictions, paradoxes, ambiguity, and so on are modeled [7, 8].

Neutrosophy applications to game theory can be found in [9-12] for non-cooperative games in matrix form. The paper in [13] proposes neutrosophic off-uninorms as an alternative aggregator to arithmetic addition in the definition of Shapley value in cooperative games. In [14], neutrosophic matrix games are used in the resolution of political conflicts.

A project is a plan that consists of a set of activities that are interrelated and coordinated. It is a temporary effort that is made to create a unique product, service, or result. From these concepts, it is evident that the reason for a project is to achieve specific results or goals within limits imposed by a budget, previously established qualities, and a previously defined period. There are multiple types of projects, one of which considers them productive and public.

A productive project seeks to generate economic profitability and obtain profits in money. On the other hand, public projects are those that seek to achieve an impact on the quality of life of the population, which are not necessarily expressed in money. Specifically, a scientific project is a set of plans, ideas, and actions that must be developed in a coordinated way to achieve a goal. This is called a project, such that scientific is an adjective that mentions its link to science (the grouping of methods, procedures, and techniques to generate objective knowledge).

A project is not free of contradictions among the agents' points of view and interests that make it up, including customers and/or users. That is why this paper aims to propose a neutrosophic matrix solution to the resolution of conflicts among the parts of a project. The advantage of applying this theory is that it allows us the use of natural language as input data for modeling problems and includes indeterminacy as part of the model. Some neutrosophic approaches to decision-making applied in project management can be read in [15-17].

This methodology is useful when it is necessary to establish a negotiation based on qualitative elements, for example in a scientific project it is not possible to establish a monetary value to the negotiations based on the knowledge that must be contributed for the success of this task. Another variant may be the decision that must be made on financial payoffs, but that decision-makers want to make based on qualitative payoffs. According to the authors ' knowledge, it is the first time that neutrosophic matrix games are used for the resolution of conflicts among parts of a project.

This paper is divided as follows; section 2 contains the main concepts of non-cooperative game theory in matrix form and neutrosophic sets. Section 3 contains the proposed model and one illustrative example. Finally, the paper finishes with the conclusions.

2 Preliminary concepts

In this section, we describe the main concepts necessary to comprehend the method proposed in this paper. The first subsection contains the basic concepts of matrix games. The second subsection describes the concepts of Neutrosophy [18].

2.1 Matrix games

Definition 1 ([1]): A game consists of a nonempty set of players, denoted by $\mathrm{N} = \{1, 2, \cdots, \mathrm{n}\}$, a set of moves (or pure strategies) available to those players, denoted by $\mathrm{A} = \{\mathrm{A}_1, \mathrm{A}_2, \cdots, \mathrm{A}_\mathrm{p}\}$, and a specification of rewards for each combination of strategies. In this case, where two players are considered, the rewards of the players are represented using a payoff matrix, one player selects the row and the other one the column. The element of the i-th row and the j-th column contains the utility obtained by player I (by rows) when applying the i-th strategy ($i \in \{1, 2, \cdots, p\}, p \geq 1$) when player II (by columns) applies the jth strategy ($j \in \{1, 2, \cdots, q\}, q \geq 1$) and also the utility obtained by player II. Let us call u_I: $\mathrm{A} \times \mathrm{B} \to \mathbb{R}$ the payoff function for player I, A is the set of strategies of player I and B is the set of strategies of player II, whereas u_{II}: $\mathrm{A} \times \mathrm{B} \to \mathbb{R}$ is the payoff function for player II.

Let us denote by S the Cartesian set of strategies sets $\mathrm{A} \times \mathrm{B}$.

The mixed strategies are defined as pure strategies, each of them is associated with one probability.

Definition 2 ([1]): The *mixed strategies* in the game of two players I and II, with strategies $A = \{A_1, A_2, \cdots, A_p\}$ for player I and $B = \{B_1, B_2, \cdots, B_q\}$ for player II, are defined as the vectors $x = (x_1, x_2, \cdots, x_p) \in [0,1]^p$ and $y = (y_1, y_2, \cdots, y_q) \in [0,1]^q$, such that $\sum_{i=1}^{p} x_i = \sum_{j=1}^{q} y_i = 1$.

In this case, to calculate the payoff, the average is used according to the following formulas:

$E_I(x,y) = \sum_{i=1}^{p}\sum_{j=1}^{q} x_i u_I(A_i, B_j) y_j$ and $E_{II}(x,y) = \sum_{i=1}^{p}\sum_{j=1}^{q} x_i u_{II}(A_i, B_j) y_j$.

Nash equilibrium in game theory is a solution concept for games with two or more players, which assumes that ([19]):

- Each player knows and has adopted their best strategy, and
- Everyone knows each other's strategies.

Consequently, each player wins nothing by modifying their strategy while the others keep theirs. Thus, each player executes the best "move" he can, given the other players' moves.

Often it is overlooked the fact that in a game, Nash equilibrium will be adopted only under certain conditions:

1. All players seek to maximize their expected payoffs according to the profits that describe the game.
2. Players execute their strategies without mistakes.
3. Players have enough intelligence to deduce their balances and those of others.
4. Players assume that changing their strategy will not lead to deviations in the strategies of others.
5. There is common knowledge of both, rules and assumptions of rationality.

Definition 3 ([19]): Given a rectangular game $(N, A \times B, u_I \times u_{II})$, $\tau \in S$ is said to be a Nash equilibrium in pure strategies if for each player in N the following conditions are satisfied:

$u_I(\tau) \geq u_I(\tau/A_j)$ and $u_{II}(\tau) \geq u_{II}(\tau/B_j)$ $\forall A_j \in A$ and $\forall B_j \in B$.

This means that if each player changes their strategy for any other, while the other players keep the strategy given by profile τ, then the payoff of the player who changes his or her strategy does not improve.

Definition 4 ([19]): A mixed strategy profile X is said to be a Nash equilibrium of mixed strategy if for each player $k \in \{I, II\}$ the following property is fulfilled:

$$E_k(X) \geq E_k(X/X_k)\ \forall X_k.$$

Where $E_k(X)$ is the expected payoff (or average payoff) that player I will get by always playing the mixed strategy profile X. Intuitively, a mixed strategy profile is a Nash equilibrium if on average no player can improve their payoff by changing their mixed strategies when the rest of the players stick to the current strategy.

2.2 Basic concepts on Neutrosophy

Definition 5 ([7]): The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^{-}0, 1^{+}[$, and $^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}$.

See that according to Definition 5, $T_A(x), I_A(x), F_A(x)$ are real standard or non-standard subsets of $]^{-}0, 1^{+}[$ and hence, $T_A(x), I_A(x), F_A(x)$ can be subintervals of $[0,1]$.

Definition 6 ([7]): The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \rightarrow [0,1]$, $I_A: U \rightarrow [0,1]$, and $F_A: U \rightarrow [0,1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic Number* (SVNN) is represented by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 7 ([20-24]): The *single-valued triangular neutrosophic number* $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \leq a_3 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x)=\begin{cases}\dfrac{\left(a_2-x+\beta_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1\le x\le a_2\\ \beta_{\tilde{a}}, & x=a_2\\ \dfrac{\left(x-a_2+\beta_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_2<x\le a_3\\ 1, & \text{otherwise}\end{cases} \tag{2}$$

$$F_{\tilde{a}}(x)=\begin{cases}\dfrac{\left(a_2-x+\gamma_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1\le x\le a_2\\ \gamma_{\tilde{a}}, & x=a_2\\ \dfrac{\left(x-a_2+\gamma_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_2<x\le a_3\\ 1, & \text{otherwise}\end{cases} \tag{3}$$

Where $\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\in[0,1]$, $a_1, a_2, a_3 \in \mathbb{R}$ and $a_1\le a_2\le a_3$.

Definition 8 ([20-22, 25]): Given $\tilde{a}=\langle(a_1,a_2,a_3);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle$ and $\tilde{b}=\langle(b_1,b_2,b_3);\alpha_{\tilde{b}},\beta_{\tilde{b}},\gamma_{\tilde{b}}\rangle$, two single-valued triangular neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a}+\tilde{b}=\langle(a_1+b_1,a_2+b_2,a_3+b_3);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle$

Subtraction: $\tilde{a}-\tilde{b}=\langle(a_1-b_3,a_2-b_2,a_3-b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle$

Inversion: $\tilde{a}^{-1}=\langle(a_3^{-1},a_2^{-1},a_1^{-1});\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle$, where $a_1,a_2,a_3\neq 0$.

Multiplication by a scalar number:

$$\lambda\tilde{a}=\begin{cases}\langle(\lambda a_1,\lambda a_2,\lambda a_3);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle, & \lambda>0\\ \langle(\lambda a_3,\lambda a_2,\lambda a_1);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle, & \lambda<0\end{cases}$$

Division of two triangular neutrosophic numbers:

$$\frac{\tilde{a}}{\tilde{b}}=\begin{cases}\left\langle\left(\frac{a_1}{b_3},\frac{a_2}{b_2},\frac{a_3}{b_1}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\right\rangle, a_3>0 \text{ and } b_3>0\\ \left\langle\left(\frac{a_3}{b_3},\frac{a_2}{b_2},\frac{a_1}{b_1}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\right\rangle, a_3<0 \text{ and } b_3>0\\ \left\langle\left(\frac{a_3}{b_1},\frac{a_2}{b_2},\frac{a_1}{b_3}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\right\rangle, a_3<0 \text{ and } b_3<0\end{cases}$$

Multiplication of two triangular neutrosophic numbers:

$$\tilde{a}\tilde{b}=\begin{cases}\langle(a_1b_1,a_2b_2,a_3b_3);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_3>0 \text{ and } b_3>0\\ \langle(a_1b_3,a_2b_2,a_3b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_3<0 \text{ and } b_3>0\\ \langle(a_3b_3,a_2b_2,a_1b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_3<0 \text{ and } b_3<0\end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm, [26].

Let $\tilde{a}=\langle(a_1,a_2,a_3);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle$ be a single-valued triangular neutrosophic number, then,

$$S(\tilde{a})=\frac{1}{8}[a_1+a_2+a_3](2+\alpha_{\tilde{a}}-\beta_{\tilde{a}}-\gamma_{\tilde{a}}) \tag{4}$$

$$\mathbf{A}(\tilde{a})=\frac{1}{8}[a_1+a_2+a_3](2+\alpha_{\tilde{a}}-\beta_{\tilde{a}}+\gamma_{\tilde{a}}) \tag{5}$$

They are called the score and accuracy degrees of $\tilde{a}$, respectively.

Definition 9 ([14, 20-22, 27]): Let $\tilde{a}$ and $\tilde{b}$ be two SVTNNs. Let us define the order relation denoted by $\preccurlyeq$, such that $\tilde{a}\preccurlyeq\tilde{b}$ if and only if $\mathbf{A}(\tilde{a})\le\mathbf{A}(\tilde{b})$.

Let $\{\widetilde{A}_1,\widetilde{A}_2,\cdots,\widetilde{A}_n\}$ be a set of n SVTNNs, where $\widetilde{A}_j=\langle(a_j,b_j,c_j);\alpha_{\tilde{a}_j},\beta_{\tilde{a}_j},\gamma_{\tilde{a}_j}\rangle$ (j = 1, 2, …, n), then the *weighted mean of the SVTNNs* is calculated with the following Equation:

$$\widetilde{A}=\sum_{j=1}^{n}\lambda_j\widetilde{A}_j \tag{6}$$

Where λ_j is the weight of A_j, $\lambda_j\in[0, 1]$ and $\sum_{j=1}^{n}\lambda_j=1$.

3 Methodology

In this methodology, some particularities are taken into account. The first one is that there are supposed to be pair-wise negotiations among the agents involved in the implementation of the project. Each of these negotiations is modeled using a matrix or bimatrix. According to the results of each of the two parts of the project, they decide the extent that these two parts contribute to the project and how the profits obtained will be divided as fairly as possible. For example, in the construction of a public social work, one construction company is hired, which in turn subcontracts two others. However, these two companies must decide whether it is in their best interest to work together or one of them prefers to work with a third one. This situation is best explained in [28], where it is resolved with the help of the prisoner's dilemma model game.

The second particularity of the methodology is that the model uses classical game theory in the case of quantitative input values are measured in price, cost, monetary gains, etc. in these cases the particular gains can be divided into the amount of money or other quantitative and divisible goods that each party will receive in the negotiation. The methodology we propose allows us to divide profits into qualitative terms, which serves to complement the quantitative negotiations mentioned above. An example is scientific projects, which on the one hand need investors who want to be part of the profits of the product obtained, which is done through financial negotiations. In these negotiations, we recommend that a classic solution be used. On the other hand, the scientific project also needs to agree on institutions and scientific personnel, whose profits cannot be measured in the amount of money, for this, it would be necessary to measure the profits qualitatively, preferably through the use of a linguistic scale. In this last sense, our proposal is useful, which will also take into account the imprecision that is typical of all negotiations.

As the third and final point of the methodology, it is assumed that each party will try to make as much profit as possible and will not cooperate with the others. The methodology will therefore be based on the theory of non-cooperative games.

The table listing the linguistic terms and the single-valued triangular neutrosophic numbers associated with them is summarized below:

Linguistic term	**SVTNN**
Very low (VL)	$\langle(0,0,1);0.00,1.00,1.00\rangle$
Medium-low (ML)	$\langle(0,1,3);0.17,0.85,0.83\rangle$
Low (L)	$\langle(1,3,5);0.33,0.75,0.67\rangle$
Medium(M)	$\langle(3,5,7);0.50,0.50,0.50\rangle$
High (H)	$\langle(5,7,9);0.67,0.25,0.33\rangle$
Medium-high (MH)	$\langle(7,9,10);0.83,0.15,0.17\rangle$
Very high (VH)	$\langle(9,10,10);1.00,0.00,0.00\rangle$

Table 1: Scale of linguistic terms and neutrosophic triangular scale associated with them. Sources: [17, 29].

Therefore the methodology that is used is the following:

1. Define which two players are going to negotiate.
2. Define the type of solution:
   2.1. If the payoff of the negotiation has to be expressed in the form of money or other goods that can be expressed in monetary form, the traditional game theory is used, with quantitative input data.
   2.2. If on the other hand the payoff has or needs to be expressed qualitatively based on linguistic terms, go to the next step.
3. The possible strategies of players I and II are defined, which are the sets $\mathrm{A}=\{\mathrm{A}_1,\mathrm{A}_2,\cdots,\mathrm{A}_\mathrm{p}\}$ and $\mathrm{B}=\{\mathrm{B}_1,\mathrm{B}_2,\cdots,\mathrm{B}_\mathrm{q}\}$, respectively.
4. Players define what kind of game to utilize, whether it is a prisoner's dilemma, a chicken game, or other, see [28]. For example, the chicken game is based on strategies in which each party delays making concessions until the end of the negotiation period is imminent. Psychological pressure can force a negotiator to give in for avoiding a negative outcome. This can be a very dangerous tactic as if neither side gives in there will be a collision. The payoff bimatrix of both players is defined through the payoff functions, $\mathrm{u}_\mathrm{I}\colon \mathrm{A}\times\mathrm{B}\to\widetilde{\mathrm{A}}$ and $\mathrm{u}_{\mathrm{II}}\colon \mathrm{A}\times\mathrm{B}\to\widetilde{\mathrm{A}}$, such that $\widetilde{\mathrm{A}}=\{\widetilde{\mathrm{A}}_1,\widetilde{\mathrm{A}}_2,\cdots,\widetilde{\mathrm{A}}_7\}$ where each of the $\widetilde{\mathrm{A}}_\mathrm{l}$ is an SVTNN of Table 1, which is selected by its equivalent linguistic term. This bimatrix has the following form:

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_p \end{array} \begin{array}{c} \begin{array}{cccc} B_1 & B_2 & \cdots & B_q \end{array} \\ \begin{pmatrix} (\tilde{t}_{11},\tilde{s}_{11}) & (\tilde{t}_{12},\tilde{s}_{12}) & \cdots & (\tilde{t}_{1q},\tilde{s}_{1q}) \\ (\tilde{t}_{21},\tilde{s}_{21}) & (\tilde{t}_{22},\tilde{s}_{22}) & \cdots & (\tilde{t}_{2q},\tilde{s}_{2q}) \\ \vdots & \vdots & \vdots & \vdots \\ (\tilde{t}_{p1},\tilde{s}_{p1}) & (\tilde{t}_{p2},\tilde{s}_{p2}) & \cdots & (\tilde{t}_{pq},\tilde{s}_{pq}) \end{pmatrix} \end{array} \quad (7)$$

Where $\tilde{t}_{ij} = u_I(A_i, B_j)$ and $\tilde{s}_{ij} = u_{II}(A_i, B_j)$.

5. The bimatrix in Equation 7 is converted into a crisp bimatrix as in Equation 8.

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_p \end{array} \begin{array}{c} \begin{array}{cccc} B_1 & B_2 & \cdots & B_q \end{array} \\ \begin{pmatrix} (t_{11},s_{11}) & (t_{12},s_{12}) & \cdots & (t_{1q},s_{1q}) \\ (t_{21},s_{21}) & (t_{22},s_{22}) & \cdots & (t_{2q},s_{2q}) \\ \vdots & \vdots & \vdots & \vdots \\ (t_{p1},s_{p1}) & (t_{p2},s_{p2}) & \cdots & (t_{pq},s_{pq}) \end{pmatrix} \end{array} \quad (8)$$

Where, $t_{ij} = \mathbf{A}(\tilde{t}_{ij})$ and $s_{ij} = \mathbf{A}(\tilde{s}_{ij})$, using $\mathbf{A}(\cdot)$ which is the accuracy degree of Equation 5.

6. The Nash equilibrium point is calculated using Definition 3. This gives at least a pair of strategies, one for each player, which is selected as the most suitable for both cases.

To illustrate the usefulness of this methodology we will use an example.

Example 1: This example is based on the case presented in [28]. Suppose a project is at 70% of its execution and is in its critical phase of completion. The missing part needs certain results from a contracted Research and Development (R&D) firm to provide the scientific-technical know-how necessary to culminate with the remaining 30%. However, as usual, the expected scientific results are not necessarily obtained at a specific time. This situation creates a dispute between the contracting company and the contracted R&D Company.

1. The hiring company will be denoted as player I, while the R&D Company will be denoted as player II.
2. By the nature of the problem, it is determined that it is qualitative, which is why the proposed methodology is needed to seek a solution.
3. The strategies that will be taken into account are the following:
   For player I:
   A_1 = "Gives extension time".
   A_2 = "Gives no extension time".
   For player II:
   B_1 = "Non-overtime work (fixed speed)".
   B_2 = "Overtime work (increase mobility)".
   That is, for the contractor, there are two options, either it allows finishing the project in a long time, or it forces the R&D Company to comply with its commitment to finish in the established time. While the two strategies of the R&D Company are to maintain its same working speed or on the contrary increase the speed to achieve in the given time.
4. To predict what to do, player I decides that the best role model is chicken game.
   The bimatrix that was determined from the linguistic terms of Table 1 is as follows:

Player II (R&D enterprise)		Strategies that can be used by contractors and R&D enterprises, in chicken game theory.	
Non-overtime work (fixed speed)	Overtime work (increase mobility)		
(ML, H)	(M, M)	Gives extension time	Player I (Contractor)
(VL, VL)	(H, ML)	Gives no extension time	

Table 2: Bimatrix obtained to solve the problem posed in the example.

Note that the results are expressed in the form of linguistic terms, which is very convenient for analysts.

5. The bimatrix of Table 2 becomes a crisp bimatrix by applying the accuracy degree of Equation 5 on the SVTNN associated with the linguistic terms that appear in the bimatrix of Table 2. The following bimatrix is obtained as it is shown in Table 3.

Player II (R&D enterprise)		Strategies that can be used by contractors and R&D enterprises, in chicken game theory.	
Non-overtime work (fixed speed)	Overtime work (increase mobility)		
(1.0750, 7.2188)	(4.6875, 4.6875)	Gives extension time	Player I (Contractor)
(0.2500, 0.2500)	(7.2188, 1.0750)	Gives no extension time	

Table 3: Crisp bimatrix obtained to solve the problem posed in the example.

In the case of the chicken game the Nash equilibrium points are (A_1, B_2) and (A_2, B_1).
Note that if the calculations are made with mixed strategies, then we must use the crisp bimatrix in Table 3.

Conclusion

In this paper, we expose a methodology for resolving conflicts among the parties within the same project. Specifically, the use of linguistic terms is proposed to express the evaluation of payoffs in the bimatrix, which is useful when it comes to qualitative assessments. The calculations are made with the help of single-valued triangular neutrosophic numbers, which implicitly include the indeterminacy of any negotiation. The advantages of this methodology are that experts can easily express their evaluations, since the model supports linguistic terms, unlike using numerical values. Finally, different solutions or problem-solving models can be used [30]. We specifically propose the Nash equilibrium, the prisoner's dilemma, and the chicken games models. The use of the methodology was illustrated in the case of a hypothetical example. Future research works will include the extension of the methodology to cases involving more than two players, as well as the possible modeling of cooperative games.

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University of New Mexico

Study of the Situation of Venezuelan Emigrants in Ecuador based on NeutroAlgebra

Luis Antonio Rivera Velazco[1], Janneth Ximena Iglesias Quintana[2], Carlos Ramiro Hurtado Lomas[3], Marco Rodrigo Mena Peralta[4] and José Sergio Puig Espinosa[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.luisrivera@uniandes.edu.ec

[2] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.jannetiglesias@uniandes.edu.ec

[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.carloshurtado@uniandes.edu.ec

[4] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.marcomena@uniandes.edu.ec

[5]University for Scientific Research, 5201 Blue Lagoon Drive, Suite 921. 33126. Miami, Florida. USA. Email: puigespinosa@gmail.com

Abstract. Venezuelan migration to neighboring countries in the area is a phenomenon that has been growing in recent years. Ecuador is one of the main countries where migrants who leave Venezuela have gone to reside.They initially arrived in the country as a transit to reach other countries, however, over time many of them decided to settle in Ecuador permanently. Venezuelan migration in our country presents certain characteristics, such as the youth of those who arrive, the high educational level, and the motivation for economic improvement that prompted them to emigrate at first and in a second wave for family reunification. This research aims to apply a survey to know more precisely the economic, social, labor, and humanitarian situation of this sector of migration in the country. We selected a model that uses NeutroAlgebra and is generated by the PROSPECTOR function. PROSPECTOR function is the well-known function used in the classic medical expert system MYCIN, while NeutroAlgebra is an algebra that has at least one NeutroOperation or one NeutroAxiom, where some cases are indeterminate. This model has previously been used in the evaluation of medical care of migrants in Chile. However, unlike the model we are inspired on, here input data are linguistic terms associated with Single-Valued Neutrosophic Numbers, which allows respondents to express more reliably what they want to say.

Keywords: migration, single-valued triangular neutrosophic number, PROSPECTOR function, NeutroFunction, NeutroAlgebra

1 Introduction

Until September 2019, approximately 4.3 million people left Venezuela. Eighty percent emigrated to Latin America, and the main recipient countries have been Colombia, Peru, and Ecuador [1]. At the beginning of the Venezuelan exodus, Ecuador was characterized as a transit country to Peru or other countries of the Southern Cone such as Chile and Argentina. However, between 2015 and September 2019, almost 400,000 Venezuelans decided to settle in Ecuador.

To deal with thesecircumstances, the Government of Ecuador asked the World Bank to analyze the situation to make informed policy decisions that allow compliance with the constitutional duty to guarantee human mobility, health, and education services. Accordingly, the World Bank worked together with six United Nations agencies, the Survey of People in Human Mobility and Host Communities in Ecuador (in Spanish EPEC). In addition, qualitative information was collected through focus groups. Based on the survey, the focus groups, and the analysis of administrative data from different sectors, a report was prepared on the situation of the Venezuelan population in Ecuador.

Venezuelans in mobility are, on average, 26 years old, 3 less than the average age of Ecuadorians in host communities. These migrants are also younger than those of other nationalities: just over a third of migrants of other nationalities are between 19 and 35. In addition, the majority of the Venezuelan population in the country has a secondary education, and the Ecuadorian host population has a predominantly level of primary education. Similarly, the proportion of the population with third-level education is higher for migrants, particularly for women.

Until July 2019, more than 80% of those who entered the country registered their entry through an official way, but 54% of those who reside are in an irregular situation. Among Venezuelans who arrived in 2016, 9 out of 10 had a valid ID document. However, the situation of those who arrived later was much more precarious. Among migrants who arrived in 2017, 2018, and 2019, 44 percent, 63 percent, and 45 percent did not have regular status, respectively. More than half of whom did not register their entry did not have a valid ID card, passport, or Andean letter. A large proportion of migrants did not register their entry because: they did not meet the immigration requirements, they did so because of irregular points, they were sick, or because of the lack of authorization from the parents of minor children. More than 80 percent of Venezuelans on the move report having a passport that expires between 2019 and 2020. This shows the possibility that a large part of this population will pass through an irregular migratory status in the coming years if they do not have the information or sufficient resources to carry out the regularization procedures in Ecuador. Given this reality, in July 2019, decree 826 was issued that recognizes the validity of the passport up to five years after its expiration date.

The flow of migrants is expected to increase in the region because a contraction in the Venezuelan economy occurred in 2019 and because of family reunification. For example, in Peru, one-third of the total flow of migrants are children, suggesting that family reunification is an important motivation. In the case of Ecuador, more than half of Venezuelans chose their destination city motivated by their family, and about 40 percent plan to bring their relatives within the next two years.

Venezuela is going through a deep crisis, whose impacts resemble a country's conditions at war and cause a massive exodus. Thus, Venezuelan economic contraction in the last five years is comparable to that of Sierra Leone in 1991 and Rwanda in 1994. In addition, the Venezuelan migration is similar to the refugee crises experienced in other countries such as Syria, Afghanistan, Somalia, and South Sudan. In the first wave of migration, Venezuela's economic situation and insecurity were the main reasons for leaving the country. Between 2016 and 2017, most were expelled because of the economic situation, and about a third left because of insecurity. It is also observed that 32% of men arrived first to look for work. In the second wave of migration, family reunification was the main reason for emigration. For those who migrated between 2018 and 2019, family reunification began to be an important reason to leave Venezuela. Mainly women, children, and adolescents (41%) were part of this second migratory movement.

The authors of this research decided to survey Venezuelan emigrants in the country to know their social, economic, humanitarian, and labor conditions. We consider that, beyond the information that the application of a classical statistical test could provide, we need a mathematical tool where respondents could express qualitatively, preferably using a linguistic scale, their opinion on the different aspects of their lives that we were interested in studying. Additionally, the used model should allow us to decide why it is important to take into account the aggregation operator used to perform this study.

We determined to use the model that appeared in [2], which is a method based on NeutroAlgebra theory. However, in this paper, we make some modifications, where instead of respondents proposing an assessment based on a scale of -10 to 10, we use a linguistic scale that allows them to express more reliably what they want to say. For this purpose, the original method is adapted to these new features. In other words, the objective of this article is to determine the situation of Venezuelan migrants through the use of the evaluative model appeared in [2], utilizing input data based on a scale of linguistic terms. A NeutroAlgebra is an algebra that has at least one NeutroOperation or one NeutroAxiom (axiom that is true for some elements, indeterminate for other elements, and false for the other elements), [2-12]. The linguistic scale is associated with Single-Valued Neutrosophic Numbers.

This article has the following structure:Section 2 contains the main concepts used in this research. Section 3 contains the adaptation of the model used in [2] adapted to the input data of the survey that was conducted and also the results of the study. The last section shows the conclusions.

2 Preliminaries

This section summarizes the main theories and concepts used to do this study. Subsection 2.1 contains the concept of single-valued triangular neutrosophic numbers, whereas subsection 2.2 contains NeutroAlgebra and PROSPECTOR function [13].

2.1 Single-valued triangular neutrosophic number

Definition 1 [14]: The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A,and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^{-}0, 1^{+}[$, and $^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}$.

See that according to Definition 1, $T_A(x), I_A(x), F_A(x)$ are real standard or non-standard subsets of $]^{-}0, 1^{+}[$ and hence, $T_A(x), I_A(x), F_A(x)$ can be subintervals of $[0, 1]$.

Definition 2 ([14]): The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued NeutrosophicNumber* (SVNN) is symbolized by$N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3 [14-16]:The *single-valued triangular neutrosophic number* $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \le a_3 \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \beta_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & x = a_2 \\ \frac{\left(x - a_2 + \beta_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_2 < x \le a_3 \\ 1, & \text{otherwise} \end{cases} \tag{2}$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \gamma_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & x = a_2 \\ \frac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_2 < x \le a_3 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3$.

Definition 4 ([14-16]): Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued triangular neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
3. Inversion: $\tilde{a}^{-1} = \langle (a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
4. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$
5. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 > 0 \; and \; b_3 > 0 \\ \langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \; and \; b_3 > 0 \\ \langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \; and \; b_3 < 0 \end{cases}$$
6. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 > 0 \; and \; b_3 > 0 \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 > 0 \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 < 0 \end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm, [17].

Let $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ be a single-valued triangular neutrosophic number, then,

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{4}$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \tag{5}$$

They are called the score and accuracy degrees of $\tilde{a}$, respectively.

Let $\{\tilde{A}_1, \tilde{A}_2, \cdots, \tilde{A}_n\}$ be a set of n SVTNNs, where $\tilde{A}_j = \langle (a_j, b_j, c_j); \alpha_{\tilde{a}_j}, \beta_{\tilde{a}_j}, \gamma_{\tilde{a}_j} \rangle$ (j = 1, 2, …, n), then the *weightedmean of the SVTNNs* is calculated with the following Equation:

$$\widetilde{A} = \sum_{j=1}^{n} \lambda_j \widetilde{A}_j \tag{6}$$

Where λ_j is the weight of A_j, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} \lambda_j = 1$.

2.2 NeutroAlgebra and PROSPECTOR combination function

Definition 5 ([3, 4]): Let X be a given nonempty space (or simply set) included into a universe of discourse U. Let <A> be an item (concept, attribute, idea, proposition, theory, etc.) defined on the set X. Then, through the process of neutrosophication, we split the set X into three regions [two opposite ones <A> and <antiA>, and one neutral (indeterminate) <neutroA> between them], regions which may or may not be disjoint – depending on the application, but they are exhaustive (their union equals the whole space).

A *NeutroAlgebra* is an algebra with at least one *NeutroOperation* or one *NeutroAxiom* (axiom that is true for some elements, indeterminate for other elements, and false for other elements).

The NeutroAlgebra is a generalization of *Partial Algebra*, an algebra with at least one *Partial Operation*, while all its Axioms are true (classical axioms).

Definition 6 ([3, 4]): A function f: X → Y is called a *Partial Function* if it is well-defined for some elements in X, and undefined for all the other elements in X. Therefore, there exist some elements $a \in X$ such that $f(a) \in Y$ (well-defined), and for all other element $b \in X$ we have $f(b)$ is undefined.

Definition 7 ([3, 4]): A function f: X → Y is called a *NeutroFunction* if it has elements in X for which the function is well-defined {degree of truth (T)}, elements in X for which the function is indeterminate {degree of indeterminacy (I)}, and elements in X for which the function is outer-defined {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1,0,0)$ that represents the (Total) Function, and $(T, I, F) \neq (0,0,1)$ that represents the AntiFunction.

Classification of Functions

i) (Classical) Function, which is a function well-defined for all the elements in its domain of definition.

ii) NeutroFunction, which is a function partially well-defined, partially indeterminate, and partially outer-defined on its domain of definition.

iii) AntiFunction, which is a function outer-defined for all the elements in its domain of definition.

Definition 8 ([3, 4]): A (classical) *Algebraic Structure* (or Algebra) is a nonempty set *A* endowed with some (totally well-defined) operations (functions) on *A*, and satisfying some (classical) axioms (totally true) - according to the Universal Algebra.

Definition 9 ([3, 4]): A (classical) *Partial Algebra* is an algebra defined on a nonempty set *PA* that is endowed with some partial operations (or partial functions: partially well-defined and partially undefined). While the axioms (laws) defined on a Partial Algebra are all totally (100%) true.

Definition 10 ([3, 4]): A *NeutroAxiom* (or *Neutrosophic Axiom*) defined on a nonempty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for another set of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1,0,0)$ that represents the (classical) Axiom, and $(T, I, F) \neq (0,0,1)$ that represents the AntiAxiom.

Classification of Algebras

i) A (classical) *Algebra* is a nonempty set *CA* that is endowed with total operations (or total functions, i.e. true for all set elements) and (classical) Axioms (also true for all set elements).

ii) A *NeutroAlgebra* (or *NeutroAlgebraic Structure*) is a nonempty set *NA* that is endowed with: at least one *NeutroOperation* (or *NeutroFunction*), or one *NeutroAxiom* that is referred to the set (partial-, neutro-, or total-) operations.

iii) An *AntiAlgebra* (or *AntiAlgebraic Structure*) is a nonempty set *AA* that is endowed with at least one *AntiOperation* (or *AntiFunction*) or at least one *AntiAxiom*.

Additionally, the PROSPECTOR combination function is defined in the PROSPECTOR expert system in the following way; it is a mapping from $[-1,1]^2$ into $[-1,1]$ with formula, [18-20]:

$$P(x,y) = \frac{x+y}{1+xy} \tag{7}$$

This function is a uninorm with neutral element 0, thus it fulfills commutativity, associativity, and monotonicity, see the different types of uninorms in [19-25], which include those defined for offsets [26-28]. $P(-1,1)$ and $P(1,-1)$ are undefined.

3 Results

First of all, we use a scale of linguistic terms for respondents to evaluate their opinions about what we want to study, this scale and its corresponding single-valued triangular neutrosophic number is summarized in the table below:

Linguistic term	**SVTNN**
Very low (VL)	$\langle(0,0,1); 0.00, 1.00, 1.00\rangle$
Medium-low (ML)	$\langle(0,1,3); 0.17, 0.85, 0.83\rangle$
Low (L)	$\langle(1,3,5); 0.33, 0.75, 0.67\rangle$
Medium(M)	$\langle(3,5,7); 0.50, 0.50, 0.50\rangle$
High (H)	$\langle(5,7,9); 0.67, 0.25, 0.33\rangle$
Medium-high (MH)	$\langle(7,9,10); 0.83, 0.15, 0.17\rangle$
Very high (VH)	$\langle(9,10,10); 1.00, 0.00, 0.00\rangle$

Table 1: Scale of linguistic terms and neutrosophic triangular scale associated with them. Source: [29].

Let us note that the elements in Table 1 correspond to the agreement (positive) evaluations of the respondents. The disagreement scale is calculated based on the same elements such that its SVTNN is multiplied by the scalar $\lambda = -1$. For example, the term "very low agree" on the fulfillment of a certain criterion is associated with the SVTN $\langle(0,0,1); 0.00, 1.00, 1.00\rangle$, whereas "very low disagree" is calculated as $(-1)\langle(0,0,1); 0.00, 1.00, 1.00\rangle = \langle(-1,0,0); 0.00, 1.00, 1.00\rangle$.

On the other hand, for the aggregation of the survey values, the operator generated by the PROSPECTOR combination function [2] is used, which corresponds to Tables 2 and 3.

$x \odot y$	**-1**	**-0.9**	**-0.8**	**-0.7**	**-0.6**	**-0.5**	**-0.4**	**-0.3**	**-0.2**	**-0.1**	**0**
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-0.9	-1	-1	-1	-1	-1	-1	-1	-0.9	-0.9	-0.9	-0.9
-0.8	-1	-1	-1	-1	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8
-0.7	-1	-1	-1	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.7	-0.7
-0.6	-1	-1	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.7	-0.7	-0.6
-0.5	-1	-1	-0.9	-0.9	-0.8	-0.8	-0.8	-0.7	-0.6	-0.6	-0.5
-0.4	-1	-1	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.6	-0.5	-0.4
-0.3	-1	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.6	-0.5	-0.4	-0.3
-0.2	-1	-0.9	-0.9	-0.8	-0.7	-0.6	-0.6	-0.5	-0.4	-0.3	-0.2
-0.1	-1	-0.9	-0.8	-0.7	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1
undef.	-1	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0
0	-1	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0
0.1	-1	-0.9	-0.8	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1
0.2	-1	-0.9	-0.7	-0.6	-0.5	-0.3	-0.2	-0.1	0	0.1	0.2
0.3	-1	-0.8	-0.7	-0.5	-0.4	-0.2	-0.1	0	0.1	0.2	0.3
0.4	-1	-0.8	-0.6	-0.4	-0.3	-0.1	0	0.1	0.2	0.3	0.4
0.5	-1	-0.7	-0.5	-0.3	-0.1	0	0.1	0.2	0.3	0.4	0.5
0.6	-1	-0.7	-0.4	-0.2	0	0.1	0.3	0.4	0.5	0.5	0.6
0.7	-1	-0.5	-0.2	0	0.2	0.3	0.4	0.5	0.6	0.6	0.7
0.8	-1	-0.4	0	0.2	0.4	0.5	0.6	0.7	0.7	0.8	0.8
0.9	-1	0	0.4	0.5	0.7	0.7	0.8	0.8	0.9	0.9	0.9
1	undef.	1	1	1	1	1	1	1	1	1	1

Table 2: Cayley table of $\odot$.

$x \odot y$	**undef.**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	undef.
-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.7	-0.7	-0.5	-0.4	0	1
-0.8	-0.8	-0.8	-0.7	-0.7	-0.6	-0.5	-0.4	-0.2	0	0.4	1
-0.7	-0.7	-0.6	-0.6	-0.5	-0.4	-0.3	-0.2	0	0.2	0.5	1
-0.6	-0.6	-0.5	-0.5	-0.4	-0.3	-0.1	0	0.2	0.4	0.7	1
-0.5	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.3	0.5	0.7	1
-0.4	-0.4	-0.3	-0.2	-0.1	0	0.1	0.3	0.4	0.6	0.8	1
-0.3	-0.3	-0.2	-0.1	0	0.1	0.2	0.4	0.5	0.7	0.8	1
-0.2	-0.2	-0.1	0	0.1	0.2	0.3	0.5	0.6	0.7	0.9	1
-0.1	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1
undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.
0	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

0.1	undef.	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1
0.2	undef.	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1
0.3	undef.	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1
0.4	undef.	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1	1
0.5	undef.	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.9	1	1
0.6	undef.	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1	1
0.7	undef.	0.7	0.8	0.8	0.9	0.9	0.9	0.9	1	1	1
0.8	undef.	0.8	0.9	0.9	0.9	0.9	0.9	1	1	1	1
0.9	undef.	0.9	0.9	0.9	1	1	1	1	1	1	1
1	undef.	1	1	1	1	1	1	1	1	1	1

Table 3: Cayley table of $\odot$ (Continuation).

See that $\odot$ is not always associative, e.g. let $a = -0.9, b = 0.8, c = undefined$, then this implies $a \odot (b \odot c) = a$ and $(a \odot b) \odot c = -0.4 \neq a$. Let us note that we always choose the "worst" option, where negative is worst than "undefined" and "undefined " is worst than "positive". We have also some other properties that are not hard to prove. They are that $\odot$ is an internal function, it is commutative, and every element has an inverse. If x<0, then both e = 0 and e = "undefined" are the neutral elements, whereas, e = 0 is also the neutral value for x≥0.

A group of 384 Venezuelan emigrants in Ecuador were asked a series of questions to assess various criteria. The five criteria to evaluate (denoted by C_1, C_2, C_3, C_4, C_5) and the questions that were asked are detailed below, [1]:

C1. Integration into the labor market

1.1. Because of their economic status, Venezuelan migrants often work under less favorable conditions.
1.2. Young and less skilled Ecuadorian workers are affected by migration.
1.3. Venezuelan workers do not have access to jobs commensurate with their level of preparation.

C2. Schooling

2.1. Despite free access, many school-age Venezuelan migrants do not attend the education system.
2.2. The main informal barriers migrants face in accessing education are the lack of quotas and documentation.
2.3. The main barrier to the permanence of all students is the payment requested by educational centers.
2.4. Other barriers to access to education include discrimination and xenophobia.

C3. Health system

3.1. The migrant population has a more favorable state of health than the host population.
3.2. Free access to health services does not guarantee that the majority of the needed population will have access to a public or private facility.
3.3. Migration status is an impediment to access health services for migrants who attend more public establishments.
3.4. Migrants are dissatisfied with health services.
3.5. Migrants and host populations face different difficulties.

C4. Social risks

4.1. A significant proportion of foster and migrant households are affected by one or more of the following risks: poverty, chronic malnutrition, child labor, or adolescent pregnancy.
4.2. Migrants cannot benefit from financial transfers.
4.3. The Venezuelan population in mobility also benefited from school feeding, uniforms, and text programs. However, coverage is much lower for migrants in care services and even less in transfers than their Ecuadorian peers are.

C5. Discrimination

5.1. Discrimination is a problem that affects both, the Venezuelan population and Ecuadorians in the host communities.
5.2. Discrimination permeates all areas of society.
5.3. Most Ecuadorians believe that Venezuelan migrants have a negative impact on the economy and are a bad influence on the culture of society.
5.4. Although the crimes decreased in the last five years, Ecuadorians' perception of insecurity rose and is attributed to the arrival of migrants, as in other countries in the region.

The method that will be followed to evaluate Venezuelan migrants' situation in Ecuador is the following:

1. The survey is conducted based on the linguistic scale explained above. See Table 1 and the explanation.
2. Variables x_{ijk} are designated according to SVTNN associated with the linguistic scale, which is the opinion of the i-th surveyed (i=1,2,..., 384), on the j-th aspect to be evaluated (j = 1, 2,..., j_k) within the k-th criterion (k=1,2,..., 5).

3. For every i (i=1,2,...,384) and every k (k=1,2,...,5) it is calculated $\bar{x}_{ik} = \sum_{j=1}^{j_k} \lambda_j x_{ijk}$, where $\lambda_j = \frac{1}{j_k}$. That is, $\bar{x}_{ik}$ is the arithmetic mean of the SVTNN using formula 6, of each respondent for all aspects of each criterion.
4. Convert $\bar{x}_{ik}$ to crisp values by applying the accuracy degree formula 5, such that $\bar{y}_{ik} = \mathbf{A}(\bar{x}_{ik})$.
5. The values of $\bar{y}_{ik}$ are rescaled to $\bar{\bar{y}}_{ik} = \frac{\bar{y}_{ik}}{10}$ if $-10 \leq \bar{y}_{ik} \leq 10$, while $\bar{\bar{y}}_{ik} = -1$ or 1, if $\bar{y}_{ik} < -10$ or > 10.
6. The results are aggregated for all respondents, as follows:
   6.1. If < 20% of respondents satisfy that their opinions are extreme, i.e. $\bar{\bar{y}}_{ik} = -1$ or 1, then the following formula applies:
   $\tilde{y}_k = \odot_{i=1}^{n} \frac{\text{round}(\bar{\bar{y}}_{ik} * 10)}{10}$. Where n is the number of respondents with non-extreme opinions, i.e. $\bar{\bar{y}}_{ik} \neq -1$ or 1.
   Where round is the rounding function and $\odot$ is the NeutroOperator defined in Tables 2 and 3.
   6.2. If > 10% of opinion pairs of respondents about criterion k are of the type $(-1, 1)$ it is considered that there are contradictions between the results of the k-th aspect and the results are considered undefined, so this will need further analysis.
   6.3. If > 20% of respondents have extreme opinions of the same type, either -1 or 1, and do not fall in the case above, then $\tilde{y}_k = -1$ or 1 is considered, depending on the prevailing opinion.

According to the study, the result was summarized in Table 4.

Aspect to assess	Result
Integration into the labor market	1
Schooling	1
Health system	-0.6
Social risks	-0.7
Discrimination	1

Table 4: Results of the poll aggregated per criteria.

The results shown in Table 4 are interpreted as evidence of an unfavorable situation for Venezuelan migration in Ecuador in terms of integration in the labor market, schooling, and discrimination by the Ecuadorian population. In terms of health care and social risks, the results are more favorable.

Conclusion

The political, economic, and social situation in Venezuela has produced a migratory flow to neighboring countries, including Ecuador. As a result, migrants from this country needed special attention from the Ecuadorian authorities and citizens. This paper studied the situation of Venezuelan migrants who arrived in Ecuador in the last few years. To achieve this objective, 384 Venezuelans living in Ecuador were surveyed regarding five fundamental criteria of their lives: integration into the local labor market, their children's attendance at educational institutions, access to health, the social risks they may be subjected to within the new host society, and finally the discrimination they suffer. The mathematical tools used were the single-valued triangular neutrosophic number associated with a linguistic assessment scale. The use of linguistic scales allows the respondent to express more precisely what they think. For aggregation, a combination of the arithmetic means is used to evaluate the personal opinion, together with a NeutroOperator generated by the PROSPECTOR function to aggregate the collective opinion. The result is that there exists an unfavorable situation in terms of the labor market, schooling, and discrimination, while it is more favorable in terms of the health system and social risks. Measures should therefore be taken to improve the overall situation, particularly in the first three mentioned areas. Let us note that when we explicitely include the term “undefined” and we consider that if x>0, y<0, then $y \prec$ "undefined" $\sim 0 \prec x$, we obtain a non-associative Algebra, however this criteria have been proved to be accepted by experts for evaluating.

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University of New Mexico

Neutrosophic Analysis of the Origin of Domestic Violence

Julio César de Jesús Arrias Añez[1], Fernando Caicedo Bandera[2], Luis Ramiro Ayala Ayala[3], Juan Carlos Nevárez Moncayo[4] and Maura De La Caridad Salabarría Roig[5].

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador. Email: uq.julioarrias@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: direccionderecho@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.luisayala@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.juannevarez@uniandes.edu.ec
[5] Centro de Estudios para la Calidad Educativa y la Investigación Científica, Toluca, México. Email: maura1059@gmail.com

Abstract. In Ecuador, domestic violence is the government's priority as this affects the emotional balance of the injured people, leading them to the appearance of behavioral alterations. Therefore, any physical or psychological aggression damages the family nucleus. In the Constitution of the Republic of 2008, the right to personal integrity was established. However, there is still a social ignorance of the main elements that originate it and its effects on society. The incidence of violence against women, children, and adolescents reaches alarming global and national levels. According to the World Health Organization, 35% of women worldwide have been victims of physical and/or sexual violence by their partner or sexual violence by people other than their partner. It is worth mentioning that with the origin of COVID-19, it has increased problems in homes such as in the economic, family, and emotional sphere. This study's objective is to define the origin of domestic violence and its interrelation as a neutrosophic group and its modeling using neutrosophic statistics.

Keywords: Domestic violence, assault, victim, neutrosophic statistics.

1 Introduction

Domestic violence is considered any type of mistreatment generated by the aggressor or aggressors, either verbally or physically (Figure 1) [1].

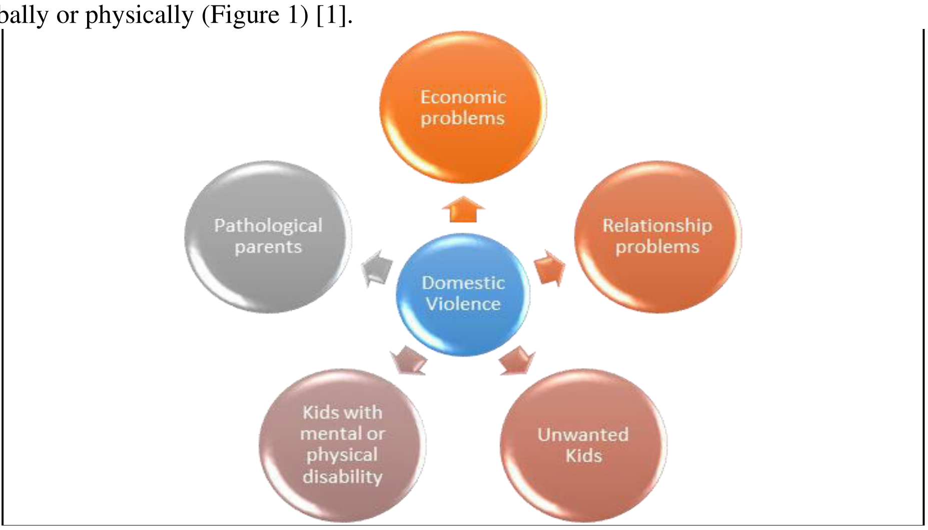

Figure 1. Causes that trigger domestic violence.

If there are high levels of violence in a home, there is a high probability that the descendants will apply this aggressive model in their lives as adults. This process begins in childhood when children learn by copying relatives' behavior and acquire their beliefs, styles of thoughts, and emotional coping. If the family has an aggressive model, the child will learn aggressiveness. Thus, both the family and the sociocultural environment in which the child develops are very influential in his conduct because children would learn to behave through imitation [2-4].

In the case of aggressive behavior, the same principle applies, since certain stimuli induce offensive behavior, which is fixed after continuous exposures in a violent environment and with toxic emotional relationships. In essence, this theory postulates that behaviors are learned by imitation (figure 2), especially when the child sees that such behaviors have been rewarded or reinforced. If a subject observes that the aggressive behavior of a person is reinforced or rewarded, he will learn it [5]

Children who grow up in a violent environment learn that violence is something normal that manifests itself between adults and as they mature, they include abuse in the development of their personality, internalizing the role of aggressor. UNICEF points out that children who hear or witness violence in their home would probably have psychological problems, and the International Convention on the Rights of the Child considers this a form of child abuse, collecting it in article 19 as "mental violence" [6].

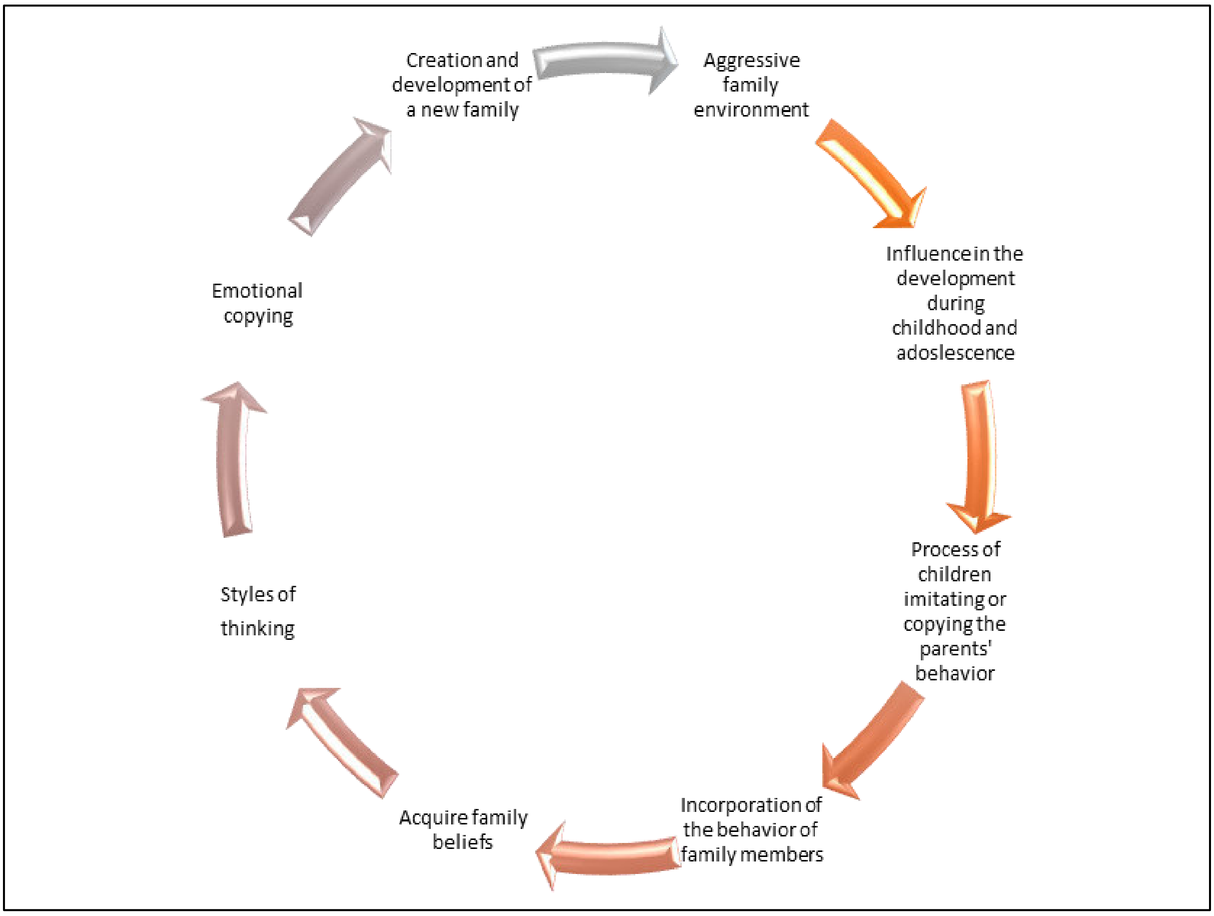

Figure 2. Influence of the aggressive family environment in childhood and adolescence. Adapted from [2]

Changes in behavior indicate that persistent frustration in the subject is reflected in the following deficiencies: social isolation, sudden changes in friendships, changes in eating habits, and sleep patterns [7].

The relevance of the environment on behavior is accepted since all conduct disorder manifests itself in the environment and is influenced by reinforcers existing in the environment (figure 3). The environment admits different levels of analysis, being the family and the context those that have the greatest weight for the child's mental health [8]. It will be essential to assess the environment and its interaction with the child's cognitive-affective structure because its behavior changes thanks to environmental circumstances [9, 10].

World Health Organization (WHO) refers that physical violence originates from physical and psychological damage, at the body level it leaves scratches, internal wounds, cuts, burns, fractures, and even death. The immediate effect of pain is pain; children who have suffered violence are exposed to persistent neurological problems and manifest in irritability, lethargy, tremors, and vomiting [11]. The frequent shaking syndrome in young children predisposes them to suffer from permanent deafness or blindness, paralysis, coma, or even death. Concerning psychological effects, after a certain amount of time, these become catastrophic since they induce the risk of addictive behaviors to psychoactive substances [12, 13]

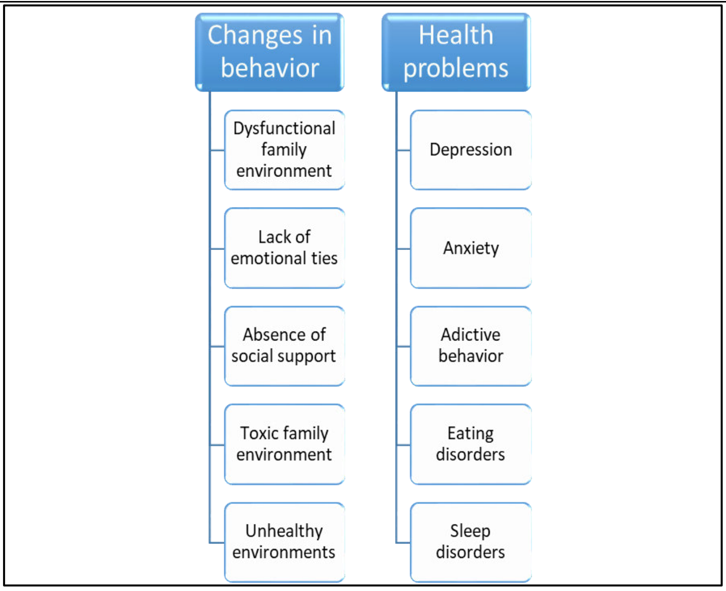

Figure 3. Changes in behavior and the presence of conduct disorders.

Among the anxiety disorders suffered by victims of abuse, we may find the following ones: obsessive-compulsive, panic, post-traumatic stress, generalized anxiety, agoraphobia, and other phobias among others [14] [15]. Pathological anxiety results from the daily confrontation between the attacked individual and the aggressor [16]. Pathological anxiety is also responsible for causing inadequate responses to certain conflicts [17].

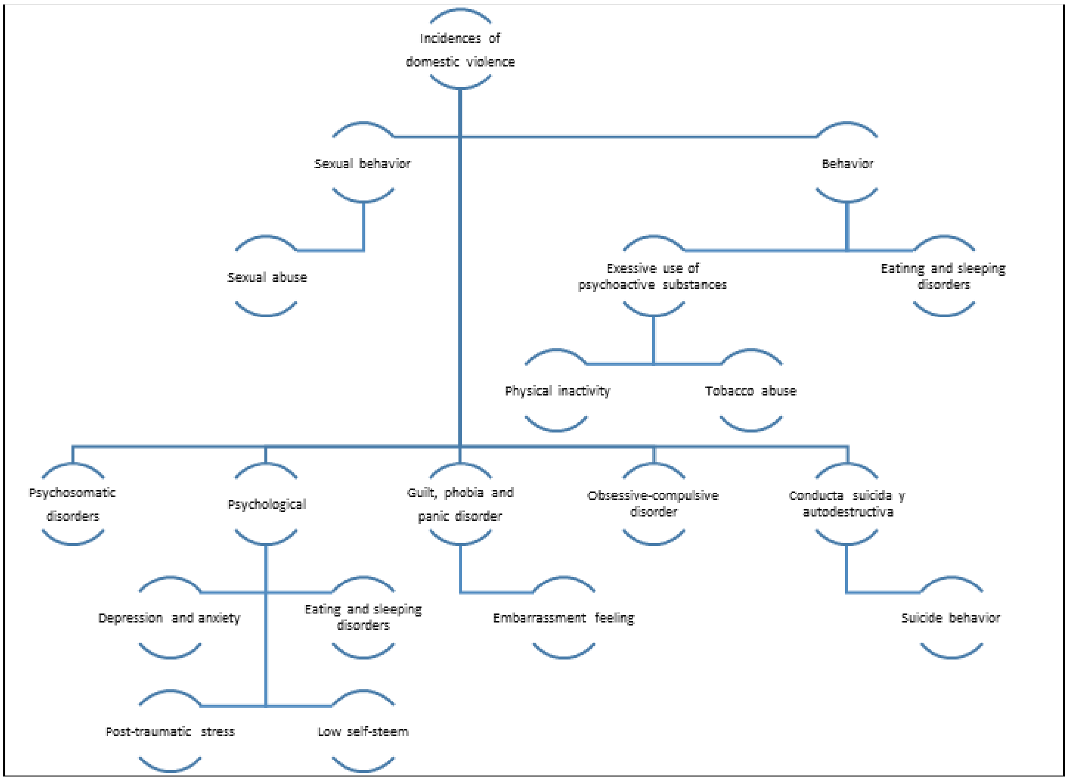

Figure 4. Psychological and behavioral consequences suffered by victims of violence.

According to Lorente, *machismo* in society takes place in various ways, and one of these is through the subjugation of women. The man uses some factors such as intimidation, abuse, control of money, the appropriation of space to try to subdue the woman and thus dominate her. It is about using psychological, economic, or personal moral force to convince her that they are right [18-20].

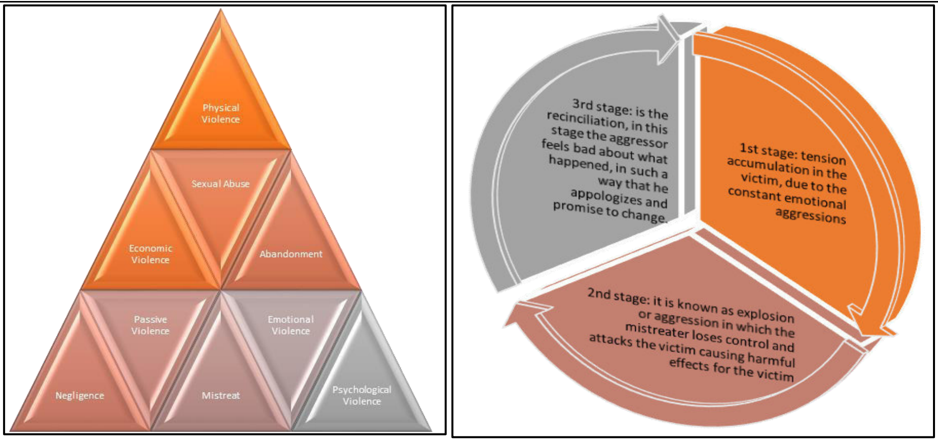

Figure 5. Types and cycle of violence and its interactions in the family environment.

Violence persists in the family because there are risk factors in the aggressor, the abused child, and the hostile environment (increased these days with COVID-19) [21]. Among the risk factors presented by the abuser are: having an antisocial personality disorder, a severe mental disorder such as schizophrenia in which violence occurs as a consequence of paranoid delusions or in response to auditory hallucinations; or have a manic disorder, which causes the subject to become aggressive in the face of minimal provocations; have an organic cause that generates the violent response, the abuse of psychoactive substance use, among others [22]. The risk factors that predispose the child to be abused are suffering from a complex mental illness or having irritable behavior. On the other hand, some of the environmental risk factors that induce domestic violence are economic or family problems, which leads to parents unloading violently with their children [23, 24].

It is considering that family violence is common in our environment and affects the psyche on the psychological development of children. In this research work, the conflictive family environment will be related to the appearance of behavioral disorders in the most vulnerable members of the affected family. The importance of this study lies in knowing the causes that lead to domestic violence and the consequences that occur in the members involved to create awareness in society [25, 26].

They consider that behaviors are created by associating a specific response to a specific stimulus. In the case of aggressive behavior, the same principle applies since certain stimuli induce offensive behavior, which is fixed after continuous exposures in a violent environment and with toxic emotional relationships. Albert Bandura's theory of social learning has been very useful to understand aggressive behavior, in essence, what this theory postulates is that behaviors are learned by imitation, especially when the child sees that such behaviors have been rewarded or reinforced. If the subject observes that a person's aggressive behavior is reinforced or rewarded, he will learn it [5].

Based on the analyzed antecedents, this study defines:

- Problem situation: increase in cases of domestic violence
- Objective: define the triggers of domestic violence
- Specific objectives:
    - Determine the causes that affect the analyzed variable
    - Carry out the measurement and modeling of the variable
    - Project potential alternatives to protect victims of domestic violence

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability [4, 27-47] of an event E is the probability that event E will occur [48], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup ≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x)), where$ T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [49], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them.

Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [50].

In short, the Neutrosophic Logic [51] [52], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development.

The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [53].

Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [54], while "I" is the indeterminacy part of the neutrosophic number N.

$N = a + bI.$

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the corresponding lower and upper level that the studied variable can reach in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \underline{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}, \underline{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N}, X_{iu} n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS), it can be calculated as follows

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\begin{bmatrix} \min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + bI_L), (a_i + b_i I_L)(\bar{a} + bI_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b}I_L), (a_i + b_i I_U)(\bar{a} + \bar{b}I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b}I_L), (a_i + b_i I_L)(\bar{a} + \bar{b}I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b}I_L), (a_i + b_i I_U)(\bar{a} + \bar{b}I_U)\end{pmatrix}\end{bmatrix}, I\epsilon[I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N}; S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance of the other factors are. NCV can be calculated as follows [55].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{x}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U] \tag{5}$$

3 Results

The study is developed from the interrelation of the group of experts and non-profit associations in support of victims of abuse. The modeling has 60 people who have been direct and indirect victims of domestic violence. Those involved receive e-mail surveys that address family violence according to types of abuse received, feelings, and behaviors experienced after exposure to abuse. The individuals surveyed come from the urban sector, aged between 18 and 25 years. The results obtained are presented to the team of experts to evaluate and define the main trends as the most frequent types of domestic violence.

From the results obtained, the following characteristics are determined:

Variable	Coding	Sample	Scale
Domestic violence	DV	60	$[0;\ 1], \forall F_n$ $IIE = 0$ (false) *IIE = 1 (True)* $0 \leq IIE \geq 1$ *(Indeterminacy on the increase* in VI)

Table 1. Characteristics of the domestic violence variable.

Variable analyzed: domestic violence For a sample of n = 60, for each factor (f)

Initials	Factors that promote Intrafamily violence	Factor	Source	Scale
PPR	Pathology presented by relatives	F1	Behaviors are learned by imitation when exposed to a violent family environment	[0; 7]
EPH	Economic problems within the home	F2	The lack of necessary resources creates a hostile environment with children	[0; 7]
RPH	Relationship problems that then spill over to the children	F3	Crossfire effect, they are victims of the differences between their tutors	[0; 7]
HUC	Having an unwanted child or one with a complication	F4	Unplanned children in the relationship. Abandonment processes and negative	[0; 7]

OC	Other causes	F5	All causes that are not included within factors 1 to 4	[0; 7]

Table 2: Characteristics of each factor that originate domestic violence.

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to relate to domestic violence.

	Neutrosophic frequencies				
Days	**PPR**	**EPH**	**RPH**	**HUC**	**OC**
1	[5 ; 6]	[0; 1]	[2 ; 2]	[1 ; 6]	[1 ; 2]
2	[4 ; 6]	[4 ; 6]	[2 ; 5]	[2 ; 3]	[0; 6]
3	[1 ; 3]	[3 ; 5]	[2 ; 4]	[0; 3]	[1 ; 1]
4	[0; 2]	[4 ; 4]	[0; 4]	[2 ; 5]	[0; 2]
5	[1 ; 2]	[1 ; 1]	[2 ; 4]	[2 ; 6]	[1 ; 3]
6	[2 ; 3]	[3 ; 4]	[3 ; 5]	[0; 2]	[1 ; 3]
7	[0; 0]	[4 ; 4]	[3 ; 7]	[0; 4]	[0; 2]
8	[2 ; 2]	[2 ; 2]	[3 ; 3]	[0; 5]	[1 ; 1]
9	[2 ; 3]	[4 ; 5]	[0; 0]	[1 ; 4]	[0; 0]
10	[4 ; 5]	[3 ; 6]	[3 ; 6]	[0; 0]	[0; 6]
11	[4 ; 5]	[1 ; 1]	[0; 2]	[0; 1]	[0; 2]
12	[3 ; 4]	[2 ; 5]	[1 ; 2]	[2 ; 2]	[0; 2]
13	[1 ; 2]	[0; 2]	[3 ; 7]	[1 ; 4]	[0; 5]
14	[1 ; 3]	[3 ; 4]	[1 ; 2]	[0; 5]	[0; 4]
15	[5 ; 7]	[1 ; 2]	[0; 1]	[0; 0]	[1 ; 6]
16	[4 ; 6]	[1 ; 4]	[0; 1]	[0; 3]	[1 ; 2]
17	[4 ; 4]	[1 ; 2]	[1 ; 2]	[2 ; 4]	[1 ; 7]
18	[4 ; 6]	[4 ; 4]	[0; 1]	[1 ; 4]	[1 ; 2]
19	[0; 0]	[2 ; 2]	[3 ; 3]	[2 ; 2]	[1 ; 1]
20	[5 ; 7]	[1 ; 4]	[3 ; 6]	[2 ; 7]	[0; 6]
0-60	**[143; 205]**	**[122; 202]**	**[105; 237]**	**[62; 219]**	**[26; 192]**

Table 3. Neutrosophic frequencies of each factor.

Table 3 studies the factors that promote domestic violence for 60 days, with a level of occurrence of for each factor per day, with a total indeterminacy level of $[0;\ 7] f_1 = 62, f_2 = 80, f_3 = 132, f_4 = 157, f_5 = 166$, with a level of representativeness of, on the days that 7 occurrences per factor are recorded, with a higher incidence of 60% in the $[30.24\%;\ 86.46\%]$ pathology presented by relatives. As a result of the existing indeterminacy, the use of classical statistics is not possible, so the use of neutrosophic statistics is necessary for its greater understanding.

<u>Neutrosophic statistical analysis</u>

In the modeling, it is observed that the *Pathology factor presented by relatives* is one of the causes that most influence the origin of domestic violence (Table 5). To understand which factor implies a representative mean $\underline{x}_f = \in \left[\underline{x}_{L_f}; \underline{x}_{U_f}\right]$, the values of the neutrosophic means and the variation of the variable are calculated to study the indeterminacies in the final result, with the incorporation of the values of the neutrosophic standard deviation for each factor $S_{N_f} \in \left[S_{L_f}; S_{U_f}\right]$. To determine which factor requires greater attention in the process of preventing possible acts of domestic violence through the values provided by the $CV_{N_f} \in \left[CV_{L_f};\ CV_{U_f}\right]$.

Factors	$\underline{x}_N$	*YN*	*CVN*
Pathology presented by relatives	[2.383; 3,417]	[1.849; 3.149]	[0.776; 0.922]
Economic problems within the home	[2.033; .,367]	[1.202; 2,573]	[0.591; 0.764]
Relationship problems that then spill over to the children	[1.75; 3.95]	[0.877; 2.68]	[0.501; 0.678]

Having an unwanted child or one with a complication	[1.033; 3.65]	[0.428; 2.642]	[0.414; 0.724]
Other causes	[0.433; 3.2]	[0.127; 2.622]	[0.293; 0.819]

Table 5. Neutrosophic statistics of the causes of domestic violence.

Each factor in the neutrosophic set has a strong interrelation with indeterminate elements, so that representatively in this group, the RPH factor has a greater incidence of repercussion, as it corresponds to the children as the weakest links in the family with a higher level of indeterminacy of occurrence, while for the *Pathology factor presented by relatives* is on average the one that most affects the origin of domestic violence on a neutrosophic scale [0; 1] (figure. 6). In affirmation, the value $CV_{N_{f_1}}$ of this factor is lower if compared to the rest. This represents that the PPR factor is more consistent and accurate than the other factors (Figure 6).

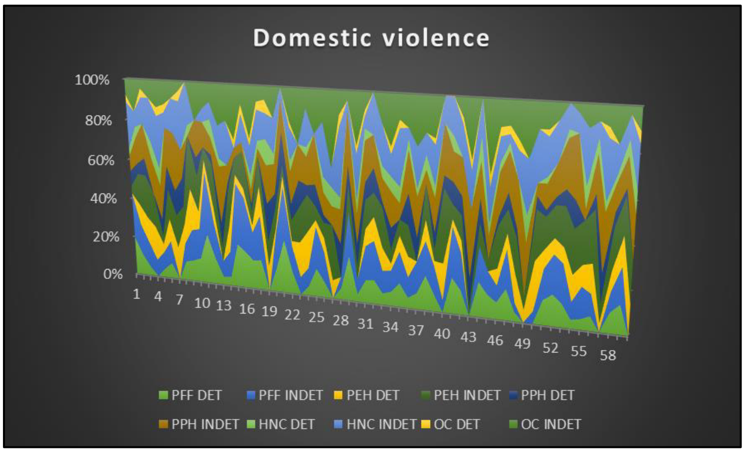

Figure 6.neutrosophic Stacked graph [0; 1] of the interrelationships of the factors in domestic violence.

<u>Comparative analysis</u>

To determine the associated referent indeterminacy measure for the form of neutrosophic numbers (Table 6). In the results obtained, it is observed that for the values they go from$\underline{x} = \in [\underline{x_L}; \underline{x_U}], S_N \in [S_L; S_U] CV_N \in [CV_L ; CV_U] CV_N$0.293 to 0.776 with the indeterminacy measure from 15.8% to 64.2%, which generates a relevant cause to be mitigated by having a lower level of indeterminacy, such as its influence on the other factors.

Factors	$\overline{x_N}$	*YN*	*CVN*
PPR	2.383 + 3.417 I; I ∈ [0; 0.30]	1.849 + 3.149 I; I ∈ [0; 0.41]	0.776 + 0.922 I; I ∈ [0; 0.15]
EPH	2.033 + 3.367 I, I ∈ [0; 0.39]	1.202 + 2.573 I; I ∈ [0; 0.53]	0.591 + 0.764 I; I ∈ [0; 0.22]
RPH	1.75 + 3.95 I; I ∈ [0; 0.55]	0.877 + 2.68 I; I ∈ [0; 0.67]	0.501 + 0.678 I; I ∈ [0; 0.26]
HUC	1.033 + 3.65 I; I ∈ [0; 0.71]	0.428 + 2.642 I; I ∈ [0; 0.83]	0.414 + 0.724 I; I ∈ [0; 0.42]
OC	0.433 + 3.2 I; I ∈ [0; 0.86]	0.127 + 2.622 I; I ∈ [0; 0.95]	0.293 + 0.819 I; I ∈ [0; 0.64]

Table 6: Neutrosophic forms with indeterminacy measure.

Preliminary solutions

The following is suggested from the result obtained and the interrelation of the PPR factor with the rest:

- The institutions and governing bodies in favor of protecting the family and the rights of children and adolescents should propose that victims who have been abused or mistreated in their family nucleus be investigated and treated, addressing the feelings that this situation has generated in them, and the thoughts that this problem has brought to them, suggesting a group dynamic aimed especially at children to prevent future acts of violence when they form a family.
- It is suggested that domestic violence be studied more deeply. The information must be socialized so that people can feel identified with any of them because they have similar cases or because they are victims.
- Expand the panorama of violence, where people place situations of abandonment and indifference towards their children as forms of psychological.

- The state must promote and modify policies and programs for the prevention, protection, punishment, and restitution of victims' rights of any type of violence.

Conclusions

- Even though domestic violence is a phenomenon that has physical and emotional consequences, it is important to identify that abandonment and lack of attention are other ways of child abuse. It is considered that this research creates awareness in readers since domestic violence is always seen as a problematic situation of physical abuse between the aggressor and the victim, leaving aside other types of existing aggressions such as psychological and passive violence.
- The analysis of the data carried out determined the causes that, in the form of a chain reaction, affect the victims and their families. When determining the causes that originate domestic violence with the use of neutrosophic statistics due to the degree of indeterminacy in the variable analyzed. The result shows a lower value of CV for the *Pathology presented by the relatives* as a key factor and trigger of domestic violence.
- The governing bodies must promote programs and actions aimed at breaking the cycle of family violence from generation to generation, in addition to creating a healthy family environment.

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A Novel Evaluative Method of the Subject "Education and Society" of the Autonomous University of the Andes, Ecuador, based on Plithogenic Numbers

Raúl Comas Rodríguez[1], Sharon Dinarza Álvarez Gómez[2], Edgar Ramón Arredondo Domínguez[3] , Lisenia Karina Baque Villanueva[4] and Karina Pérez Teruel[5]

[1] Business Management professor. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador, Email: ua.raulcomas@uniandes.edu.ec
[2] Finance Director. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador, Email: dirfinanciera@uniandes.edu.ec
[3] Business Management professor. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.edgararredondo@uniandes.edu.ec
[4] Business Management professor. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.liseniabaque@uniandes.edu.ec
[5]Universidad Abierta para Adultos (UAPA), Santiago de los Caballeros, República Dominicana.
Email: karinaperez@uapa.edu.do

Abstract. The subject "Education and Society" is part of the syllabus of the "Basic Education" program of the Autonomous University of the Andes, Ecuador. This subject has the complexity of linking different aspects of society, some of them not free from contradictions among themselves, and imprecision and uncertainties in assessing students' performance. For this reason, the concepts and aspects to be evaluated on this subject are represented through the use of plithogenic numbers. Plithogenic sets were defined to model concepts arising from the dynamic interaction among other simpler ones, which may have contradictions with each other and include neutralities or indeterminacies. This research aims to propose a novel method for the evaluation of the subject "Education and Society" through the use of plithogenic numbers and their operators. The lecturers will be able to perform the evaluations with the use of natural language; in the same way, the results will be given using a linguistic scale, which will facilitate the understanding and representation of the evaluations. On the other hand, plithogenic numbers will allow capturing the complexity, imprecision, and uncertainty that lecturers may face in their evaluations.

Keywords: Higher education, syllabus, plithogenic number, decision-making.

1 Introduction

The subject "Education and Society" is taught in the "Basic Education" program, at the Autonomous University of the Andes (UNIANDES), Ecuador. The main goal of this subject is that the student can recognize and creatively apply the fundamental principles of Social Sciences to the process of Education, increasing the complex and multidimensional interaction of the social and cultural phenomena on education.

The course will be carried out taking into consideration the theories of the cognitive psychology of constructivist learning by discovery [1]; learning and the significant assimilation [2, 3]; learning with a humanistic approach [4], focused on the pillars of UNESCO [5]. That is to say, the "learning to learn" in its various dimensions, learning to know; to know; to know how to be; to live; to know to undertake, which are the theories that are the basis of the pedagogical model of this University [6-11].

Theoretical bases:

- The position of the student as an active subject and builder of his knowledge, through the process directed and guided by teachers, the experiences that are provided through study activity and autonomous work, based on their cultural background and their willingness to continue learning;
- The cognitive reproduction for interpretation, construction, consolidation, and reconstruction of knowledge;
- The application of knowledge in experiential situations of their environment and the solution of real problems of the profession, through the development of motivation, interpersonal relationships, and communication capacity;
- The evaluation and self-evaluation of the products obtained in the processes of reproduction, construction, and reconstruction of knowledge.

Most of the above basis also integrate the technological, hermeneutic, and socio-critical approach of the contemporary education and special andragogical character, which are the object of our work: the teaching-learning process of higher education, which are reflected in the Pedagogical Model of UNIANDES, since this will contribute to the achievement of the learning outcomes set out in the profile of egress.

The approach to the subject "Education and society" through the idea of a system allows applying mathematical-logical modeling based on plithogenic sets. In addition to that, this type of combination allows the inclusion of indeterminacy [12-17].

Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and organic mergers of multiple contradictory and/or neutral and/or non-contradictory old entities. Plithogeny advocates for connections and unification of theories and ideas in any field. As "entities" are taken as the "knowledge" in various fields, such as the soft sciences, the hard sciences, the theories of the arts and letters, etc., [12, 18].

Plithogeny is the dynamics of many types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a kind of opposites: <A> and <antiA>), the Neutrosophy (dynamics of a kind of opposites and their neutral: <A> and <antiA>, and <neutA>), because the Plithogeny studies the dynamics of many types of opposites and their neutral and not opposite (<A> and <antiA>, and <neutA>, <B> and <antiB> and <neutB>, etc.), and many that are not opposites (<C>, <D>, etc.) altogether. A plithogenic set is a particular application and concept derived from Plithogeny, as it is an extension of the classical set, fuzzy set, intuitionist fuzzy set, and neutrosophic set, and has many scientific applications, [12, 19-21].

A plithogenic set P is a set whose elements are characterized by one or more attributes, and each attribute can have many values. Until now, these have mainly been applied in mathematical models of decision-making, [15, 22, 23]. This new theory fits the purpose of this paper since this is a tool to represent complex, systemic, and dynamic concepts, with degrees of indeterminacy, where different simpler concepts interact with each other.

Specifically, in our investigation, the plithogenic numbers are obtained from the evaluation of specialists, which are lectures on the subject "Education and Society" in UNIANDES. We propose a new method to assess the skills, and learning of students of this subject. Moreover, lectures do not directly use plithogenic numbers in their evaluations, they evaluate by using linguistic terms, which are associated with plithogenic numbers. Other applications of Plithogeny can be read in [24, 25]. Some papers where Neutrosophy is applied to pedagogy and education can be read in [26-29].

This paper is divided into the following sections: section 2 is devoted to exposing the main concepts of Plithogeny. Section 3 contains the details of the design of the method. And in the last section, we explain the conclusions.

2 Plithogenic sets

Let U be a universe of discourse, and P a non-empty set of elements, $P \subseteq U$. Let A be a non-empty set of *uni-dimensional* attributes $A = \{\alpha_1, \alpha_2, \dots, \alpha_m\}$, $m \geq 1$, and $\alpha \in A$ is a given attribute whose spectrum of all the possible values (or states) is the non-empty set S, where S can be a set of finite discrete, $S = \{s_1, s_2, \dots, s_l\}$, $1 \leq l < \infty$, or infinitely denumerable set $S = \{s_1, s_2, \dots, s_\infty\}$, or an infinitely uncountable set (continuous), $S =]a, b[$, $a < b$, where] ... [is any open, semi-open or a closed interval set of real numbers or of another set [13, 14, 22-28, 30-51].

Let V be a non-empty subset of S, where V is the range of all attribute values needed by experts for the application. Each element $x \in P$ is characterized by the values of all attributes in $V = \{v_1, v_2, \dots, v_n\}$, for $n \geq 1$.

In the set of values of the attribute V, in general, there is a dominant attribute value, which is determined by experts in its application. The dominant attribute value means the most important attribute value that experts are interested in.

Each attribute value $v \in V$ has a corresponding degree of membership $d(x, v)$ of the element x, to the set P, regarding some given criteria.

The degree of membership can be either a fuzzy degree of membership, or an intuitionistic fuzzy degree of membership, or a neutrosophic degree of membership to the plithogenic set.

Thus, the *attribute value* membership *degree function* is:

$$\forall x \in P, d: P \times V \to P\ ([0,1]^z) \qquad (1)$$

Such that $d(x, v)$ is a subset of $[0, 1]^z$, where $\mathcal{P}([0, 1]^z)$ is the power set of $[0, 1]^z$, where z = 1 (fuzzy degree of membership), z = 2 (intuitionistic fuzzy degree of membership), or z = 3 (neutrosophic degree of membership).

Let $|V| \geq 1$ be the cardinal. Let $c: V \times V \to [0, 1]$ be the *attribute value contradiction degree function* between any two attribute values v_1 and v_2, denoted by $c(v_1, v_2)$, and satisfying the following axioms:

1. $c(v_1, v_1) = 0$, the degree of contradiction between the same attribute values is zero;
2. $c(v_1, v_2) = c(v_2, v_1)$, commutativity.

We can define a fuzzy attribute value contradiction degree function (c as before, we denote by c_F to distinguish it from the following two), an intuitionistic fuzzy attribute value contradiction degree function ($c_{IF} : V \times V \rightarrow [0,1]^2$), or more generally, a neutrosophic attribute value contradiction degree function ($c_N : V \times V \rightarrow [0,1]^3$), the latter one can be used to increase the complexity of the calculation, but also to increase the accuracy.

We mainly calculate the degree of contradiction between the values of uni-dimensional attributes. For multidimensional attribute values, we divide them into their corresponding one-dimensional attribute values.

The attribute value contradiction degree function helps the plithogenic aggregation operators and the plithogenic inclusion (partial order) to obtain a more accurate result.

The attribute value contradiction degree function is designed in each field where a plithogenic set is used according to the application to be solved. If ignored, aggregations still work, but the result may lose accuracy.

So (P, a, V, d, c) is called a *plithogenic set*, [12, 52]:

1. Where "P" is a set, "a" is an attribute (multi-dimensional in general), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x to the set P regarding some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P;
2. "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.

Functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that experts need to solve.

Then, the following notation is used:

$x(d(x,V))$, where $d(x,V) = \{d(x,v), \text{for all } v \in V\}, \forall x \in P$.

The attribute value contradiction degree function is calculated between each attribute value with respect to the dominant attribute value (denoted by v_D) in particular, and other attribute values as well.

The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Longrightarrow$), equivalence ($\Longleftrightarrow$), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of values of the attribute based on a t-norm and a t-conorm, [53]).

Most plithogenic aggregation operators are linear combinations of one fuzzy t-norm (denoted by $\wedge_F$) with one fuzzy t-conorm (denoted by $\vee_F$), but nonlinear combinations can also be constructed.

If the t-norm is applied over the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then v_2 is applied over the attribute value as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2) \quad (2),$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2) \quad (3).$$

Similarly, if the t-conorm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2) \quad (4).$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2) \quad (5).$$

The *Plithogenic Neutrosophic Intersection* is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right) \quad (6),$$

The *Plithogenic Neutrosophic Union* is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right) \quad (7),$$

In other words, what applies to membership, the opposite applies to non-membership, while in indeterminacy the average between them applies.

The *Plithogenic Neutrosophic Inclusion* is defined as follows:

Since the degrees of contradiction are $c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5$, applies: $a_2 \geq [1 - c(a_1, a_2)]b_2$ or $a_2 \geq (1 - 0.5)b_2$ or $a_2 \geq 0.5b_2$ while $c(a_1, a_3) = c(b_1, b_3) = 1$.

Having $a_1 \leq b_1$ the opposite is done for $a_3 \geq b_3$, hence $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only if $a_1 \leq b_1$, $a_2 \geq 0.5b_2$, and $a_3 \geq b_3$.

3 Evaluative model of the subject "Education and Society"

To facilitate the evaluation of the aspects to be measured, two tables relate linguistic terms with plithogenic numbers. These plithogenic numbers consist of a vector of three components (T, I, F) such that T represents the degree of truthfulness of what is claimed, I represents the degree of its indeterminacy and F represents the degree of its falsehood. T, I, F are elements of the interval [0, 1]. Decision-makers make assessments using linguistic terms, which better express what they want to say, and then numerical calculations are carried out with the support of the associated plithogenic numbers. That is why this paper deals with two tables, Table 1 that associates linguistic evaluation terms with plithogenic numbers, and Table 2 that associates linguistic terms of weight or importance with plithogenic numbers.

Language expression	Plithogenic number (T, I, F)
Very poor (VP)	(0.10, 0.75, 0.85)
Poor (P)	(0.25, 0.60, 0.80)
Medium poor (MP)	(0.40, 0.70, 0.50)
Medium (M)	(0.50, 0.40, 0.60)
Medium good (MG)	(0.65, 0.30, 0.45)
Good (G)	(0.80, 0.10, 0.30)
Very good (VG)	(0.95, 0.05, 0.05)

Table 1: Linguistic values associated with plithogenic numbers for the evaluation of students. Source: [54].

Language expression	Plithogenic number (T, I, F)
Low significance (LS)	(0.10, 0.70, 0.80)
Equal significance (ES)	(0.30, 0.40, 0.80)
Robust significance (RS)	(0.50, 0.40, 0.60)
Very robust significance (VRS)	(0.70, 0.30, 0.10)
Absolutely significance (AS)	(0.90, 0.10, 0.10)

Table 2: Linguistic values associated with plithogenic numbers for the evaluation of the weight of the criteria. Source: [54].

Plithogenic numbers can be converted into crisp values using formula 8.

$$\mathcal{S}([\mathrm{T},\mathrm{I},\mathrm{F}]) = \frac{2+\mathrm{T}-\mathrm{I}-\mathrm{F}}{3} \qquad (8),$$

For evaluating, the following criteria are used for each type of scholar grade as is summarized below:

1. Oral/written exams (OWE):
   - OWEC1. Content mastery: demonstrates mastery of the required content. The information is relevant, accurate, and written (spoken) consistently.
   - OWEC2. Clear ideas and logical expression: the writing (speech) is clearly written (spoken), no ambiguities are presented in the written (spoken) expression.
   - OWEC3. Analysis: carries out a thorough analysis of technical-scientific development to fulfill competencies in the field of action.
   - OWEC4. Knowledge received: demonstrates correspondence very adequately with learning theories.
   - OWEC5. Identification of characteristics of topics and sub-topics.
   - OWEC6. Argumentation: the argumentations are complete, precise, demonstrate a total understanding of the contents, and identify all the elements beyond what is expected.
   - OWEC7. Vocabulary: full use of the appropriate lexicon. With identification, consistent and relevant terms that exceed the expected level.
2. Projects (P):
   - PC1. Identify the problem: identify the problem and its cause-effect relationship.
   - PC2. Structure of the work or project: the work or project is properly structured, its planning phases can be seen, and there is an agreement between objectives, activities, and goals.
   - PC3. Relationship of objectives: there is a correct definition of the overall objective, and the specific objectives ensure the achievement of the overall objective.
   - PC4. Purpose: The overall purpose of the work or project is clear and the activities that need to be developed to achieve its solution in the short, medium, or long term are easily appreciated.
   - PC5. Goals achieved: the work or project has a 100% level of compliance achieved.
3. Class participation (discussions, presentations) (CP)
   - CPC1. Attend regularly: meet 100% of attendance.
   - CPC2. Pay attention to the teacher and peers: be attentive to the concepts issued by the teacher and peers.

CPC3. Contributes to the class discussion: makes good contributions to class discussion.
CPC4. Ask questions about the topic dealt with in class: ask interesting questions about the topic dealt with in class.
CPC5. He/she has the materials to be used in class: He/she has all the materials necessary for the work in class.

4. Reports (R):
   RC1. Presentation and punctuality: delivered the report on the stipulated date and with adequate quality.
   RC2. Organization and structure of the report: the arguments are linked to the main idea and are organized logically.
   RC3. Information quality: the information presented in the work is clear, accurate, correct, and relevant.
   RC4. Drafting: it is adequate, clear, concise, and with technical vocabulary.
   RC5. Bibliography: it presents bibliographies consulted in alphabetical order, following the APA format.
5. Memories of practices/portfolio/heading (M)
   MC1. Introduction and objectives: properly drafts and sets general and specific objectives.
   MC2. Materials and methods: complete list of materials and equipment used according to the manual. Describe the experimental procedure correctly.
   MC3. Results: collects and sorts the data obtained by presenting them in clearly identified paragraphs, tables, or graphs.
   MC4. Bibliography: presents bibliographies consulted in alphabetical order, following the APA format.
6. Research/portfolio (RP)
   RPC1. Creative presentation: the presentation of the portfolio is creative.
   RPC2. Punctuality: the portfolio is delivered on the stipulated date.
   RPC3. Growth and development: in the presentation of the works of the portfolio it can be evidenced that there was learning.
   RPC4. Bibliography: presents bibliographies consulted in alphabetical order, following the APA format.
7. Tutoring report (TR)
   TRC1. Attitude: he/she comes to the tutoring with enthusiasm, a positive attitude, behaves kindly, respectful, recognize mistakes, and accepts suggestions.
   TRC2. Material resources: the student is presented with all materials required for tutoring, and he/she carries the bibliographic resources.
   TRC3. Knowledge of the topic: master the contents with accurate and relevant information for the development of the topic.
   TRC4. Organization: he/she keeps track of information and organizes it by topic.
8. Observation guide (OG):
   OGC1. Guide structure: all arguments are linked to the main idea and are organized logically.
   OGC2. Procedure: efficiently complies with the protocol to perform the procedure, following the procedures established in the manual practices promptly.
   OGC3. Information quality: the information is related to the main topic and provides several secondary ideas and/or examples.
   OGC4. Materials: he/she has the materials required for the procedure.
9. Exercise and problem resolutions (EPR):
   EPRC1. Obtaining and comparing results: the results of the exercises and problems were accurate, consistent, and logical.
   EPRC2. Resolution: the student understood the problem; he/she solved it and presented their information clearly and convincingly.
   EPRC3. Problem analysis: the student provides knowledge oriented to solving the problem.
   EPRC4. Knowledge contribution: the student provides clear and precise knowledge oriented to the analysis of the problem.
   EPRC5. Problem approach: the student identifies the problem.
   EPRC6. Evaluation: he/she checks the result obtained and proposes other ways to solve the problem.
10. Essay/Mind Map (E)
   EC1. Introduction: Students explain clearly what the essay is about, specifying the parts that compose them and a broad description of each one of them.
   EC2. Content: the student broadly presents all suggested points in the assigned topic.
   EC3. Organization: concepts are organized so that there is a logical connection between them.
   EC4. Presentation: the student presents well-defined and structured graphic supports.
   EC5. Analysis: a deep and thorough personal analysis of what the student describes is evidenced.

EC6. Conclusions: includes personal opinions supported by bibliographic arguments.

11. Mind maps (MM)
   MMC1. Presentation: the work is presented with visual stimuli and correctly associates the main and secondary ideas.
   MMC2. Articulations: use keywords that maintain consistency and are organized by categories.
   MMC3. Clarity of contents: the text is understandable and allows easy understanding of the subject, a logical order is maintained.
   MMC4. Understanding the topic: Students can explain the information without any difficulties or extra help.
12. Exhibition of works (EW):
   EWC1. Knowledge and preparation of the topic: solvency and confidence are appreciated when expressing their knowledge; student exposes accurate and relevant information for the development of the topic.
   EWC2. Structure and logical order: an organized exhibition is appreciated, respecting the established times, facilitating the capture of his/her speech from the beginning to the end of his/her intervention.
   EWC3. Mechanics and body expression maintain adequate body mechanics to present the subject, its body expression encourages confidence and stimulates the participation of the audience.
   EWC4. Formal use of language: establishes a permanent contact with the public through the mastery of an adequate linguistic record, a good tone of voice, gestural code, and eye contact.
13. Laboratory Practice Evaluation (LP):
   LPC1. Presentation (regulatory uniform): the uniform is worn clean and by practice. The hair is collected with mesh and has clean short nails.
   LPC2. Observation: the student carefully observes the procedure by applying knowledge to practice.
   LPC3. Attitude: the student enters the laboratory with enthusiasm, a positive attitude, behaves kindly, is respectful, recognizes mistakes, and accepts suggestions.
   LPC4. Participation in practice: the student actively participates in practice by showing interest in it.

The median is calculated by using the following formula:

$$\mathrm{median}_{i=1}^{m}\{PN_i\} = \left(\mathrm{median}_{i=1}^{m}\{T(PN_i)\}, \mathrm{median}_{i=1}^{m}\{I(PN_i)\}, \mathrm{median}_{i=1}^{m}\{F(PN_i)\}\right) \quad (9),$$

Where, PN_i are m plithogenic numbers, $T(PN_i)$ the truth components, $I(PN_i)$ the indeterminate components, and $F(PN_i)$ the falseness components.

Let x be the student to be evaluated on the subject "Education and Society". Then, each of the professors, lecturers, and teachers evaluate each of the exams corresponding to the 13 aspects mentioned above. Specifically for P, CP, R, M, RP, TR, OG, EPR, E, MM, EW, and LP, there are 12 reports obtained from applying Equation 9 to each of the partial assessments that are applied to the student during the school year on the scale shown in Table 1. Let us illustrate this procedure with an example to make it clearer:

Example 1: If 3 projects P_1, P_2, P_3 are carried out during the course, such that the school grades for x are as follows:

Criteria of evaluation\Project	P_1	P_2	P_3
PC_1	MP (0.40, 0.70, 0.50)	MG (0.65, 0.30, 0.45)	G (0.80, 0.10, 0.30)
PC_2	M (0.50, 0.40, 0.60)	G (0.80, 0.10, 0.30)	G (0.80, 0.10, 0.30)
PC_3	MG (0.65, 0.30, 0.45)	G (0.80, 0.10, 0.30)	G (0.80, 0.10, 0.30)
PC_4	G (0.80, 0.10, 0.30)	G (0.80, 0.10, 0.30)	G (0.80, 0.10, 0.30)
PC_5	M (0.50, 0.40, 0.60)	G (0.80, 0.10, 0.30)	VG (0.95, 0.05, 0.05)
Aggregated evaluation by project using Equation 6	(0.40, 0.33125,0.60)	(0.65, 0.10625,0.45)	(0.80, 0.075,0.30)

Table 3: Evaluation of student x for projects P_1, P_2, P_3 during the course for every criterion.

Equation 6 is used to obtain the evaluation of each project, aggregating assessment of the 5 criteria, see that we used $\wedge_p = min$ and $\vee_p = max$, [53]. The aggregated x's grades for the aspect Project is obtained using formula 9, thus, $P = \mathrm{median}\{(0.40, 0.33125, 0.60), (0.65, 0.10625, 0.45), (0.80, 0.075, 0.30)\} = (0.65, 0.10625, 0.45)$.

For the OWT aspects the same procedure above applies, except that these exams are applied in the course on three occasions, two partial exams (with an oral part and a written part) and a final exam (with an oral part and a written part), let us denote by OT1, WT1, the results of the first partial exam of x; OT2, WT2, the results of the second partial exam; and OT3, WT3, the results of the final exam. Where OT1, WT1, OT2, WT2, OT3, WT3, are the results of aggregating the results of the OWTC1 - OWTC7 criteria with the help of Equation 6, as it was shown in.

Example 1.

So, we obtain a partial grade 1 $\mathrm{OWT1}$ for x with formula $\mathrm{OWT1} = \mathrm{mean}(\mathrm{OT1}, \mathrm{WT1})$, a partial grade 2 $\mathrm{OWT2}$ with formula $\mathrm{OWT2} = \mathrm{mean}(\mathrm{OT2}, \mathrm{WT2})$, and a final evaluation $\mathrm{OWT3}$ with formula $\mathrm{OWT3} = \mathrm{mean}(\mathrm{OT3}, \mathrm{WT3})$.

Thus, the grades of x are 15, viz., in order of importance: OWT3, OWT2, OWT1, P, CP, R, M, RP, TR, OG, EPR, E, MM, EW, and LP.

The final score for x is obtained from aggregating the 15 values using the weighted mean, as follows:

1. By consensus of specialists, OWT3 has importance of "Absolutely significance (AS)" according to Table 2. Therefore, by converting plithogenic number $(0.90, 0.10, 0.10)$ to a crisp value by using Equation 8, we have an importance $w_{OWT3} = 0.9$.
2. By consensus of specialists, OWT1 and OWT2 have a "Very robust significance (VRS)" according to Table 2. Therefore, by converting their plithogenic numbers $(0.70, 0.30, 0.10)$ to crisp values by using Equation 8, they have an importance $w_{OWT1} = w_{OWT2} = 0.76667$.
3. By consensus of specialists, P, CP, R, M, RP, TR, OG, EPR, E, MM, EW, and LP have a "Robust significance (RS)" according to Table 2. Therefore, by converting its plithogenic number $(0.50, 0.40, 0.60)$ into a crisp value by utilizing Equation 8, we have an importance $w_P = w_{CP} = w_R = w_M = w_{RP} = w_{TR} = w_{OG} = w_{EPR} = w_E = w_{MM} = w_{EW} = w_{LP} = 0.5$.

   $\mathrm{N_x}$, the final score of x is calculated by Equation 10:

$$\mathrm{N_x} = \frac{0.9\ \mathrm{OWT3} + 0.76667(\mathrm{OWT2} + \mathrm{OWT1}) + 0.5\left(\mathrm{P} + \mathrm{CP} + \mathrm{R} + \mathrm{M} + \mathrm{RP} + \mathrm{TR} + \mathrm{OG} + \mathrm{EPR} + \mathrm{E} + \mathrm{MM} + \mathrm{EW} + \mathrm{LP}\right)}{8.4333} \quad (10),$$

4. $\mathrm{N_x} = \left(\mathrm{T}(\mathrm{N_x}), \mathrm{I}(\mathrm{N_x}), \mathrm{F}(\mathrm{N_x})\right)$ is compared with each of the plithogenic numbers in Table 1, using formula 11.

$$\mathrm{d}(\mathrm{N_x}, \mathrm{TV_v}) = \sqrt{\left(\mathrm{T}(\mathrm{N_x}) - \mathrm{T}(\mathrm{TV_v})\right)^2 + \left(\mathrm{I}(\mathrm{N_x}) - \mathrm{I}(\mathrm{TV_v})\right)^2 + \left(\mathrm{F}(\mathrm{N_x}) - \mathrm{F}(\mathrm{TV_v})\right)^2} \quad (11).$$

   Where$\left(\mathrm{T}(\mathrm{TV_v}), \mathrm{I}(\mathrm{TV_v}), \mathrm{F}(\mathrm{TV_v})\right)$ are the plithogenic numbers in Table 1, with v = 1, 2, ..., 7.
5. The linguistic term is selected in Table 1, such that $\mathrm{d}(\mathrm{N_x}, \mathrm{TV_v})$ is minimal and this is the linguistic value that is associated with student x about the subject "Education and Society".

Let us end this section with one last example:

Example 2:

Let us suppose the x's scores are those summarized in Table 4, for every one of the aspects:

Aspect to evaluate	Result in form of plithogenic number
OWE3	(0.80, 0.10, 0.30)
OWE2	(0.80, 0.10, 0.30)
OWE1	(0.65, 0.30, 0.45)
P	(0.65,0.10625,0.45)
CP	(0.50, 0.40, 0.60)
R	(0.65, 0.30, 0.45)
M	(0.80, 0.10, 0.30)
RP	(0.65, 0.30, 0.45)
TR	(0.65, 0.30, 0.45)
OG	(0.50, 0.40, 0.60)
EPR	(0.80, 0.10, 0.30)

E	(0.80, 0.10, 0.30)
MM	(0.65,0.10625,0.45)
EW	(0.65, 0.30, 0.45)
LP	(0.80, 0.10, 0.30)

Table 4: School grades of student x with respect to all 15 aspects.

Thus, applying Formula 10, we have $N_x = (0.69743 \quad 0.20193 \quad 0.40257)$, comparing this plithogenic number with those shown in Table 1, using the distance function of Equation 11, we have that the minimum distance (equals to 0.11881) is obtained for "Medium Good (MG)", and this is the final qualification of x in the course.

See that formulas 2 or 4 can be applied to compare the dominant criteria OWT3, with any of the other evaluations always that a value is fixed for the attribute value contradiction degree function.

Conclusion

This paper proposed a novel method for the evaluation of students in the subject "Education and Society" of the "Basic Education" program at the Autonomous University of the Andes, Ecuador. Plithogeny and plithogenic numbers were used to perform this evaluation. Plithogeny is a new theory that allows modeling complex systems obtained from the interaction, sometimes nonlinear, among simpler components, not necessarily free of contradictions, to obtain a new element. In this evaluative model, professors, lecturers, and teachers offer their qualitative assessments in the form of linguistic terms, and the final result of evaluating each student is also offered in the form of a linguistic term. This way of representing and obtaining the qualification of each student is comprehensible to both, students and teachers.

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Neutrosophic Statistical Analysis of Arthrofibrosis of the Knee Rehabilitation

Sara Guerrón Enríquez [1], Zuly Ribel Nazate Chugá[2], Ruth Isabel Tavera[3] María Clemencia Villareal Gel[4] and Darvin Manuel Ramírez Guerra[5]

[1]Universidad Regional Autónoma de los Andes (UNIANDES), Troncal de la Sierra. Tulcán, Carchi, Ecuador. E-mail: ut.saraxge69@uniandes.edu.ec
[2]Universidad Regional Autónoma de los Andes (UNIANDES), Troncal de la Sierra. Tulcán, Carchi, Ecuador. E-mail: ut.zulynazate@uniandes.edu.ec
[3]Universidad Regional Autónoma de los Andes (UNIANDES), Troncal de la Sierra. Tulcán, Carchi, Ecuador. E-mail: ut.ruthtavera@uniandes.edu.ec
[4]Universidad Regional Autónoma de los Andes (UNIANDES), Troncal de la Sierra. Tulcán, Carchi, Ecuador. E-mail: ut.mariavillareal@uniandes.edu.ec
[5]Universidad de Holguín, Cuba, Email: dramirezg@uho.edu.cu

Abstract. This research aims at deepening the validation of knee arthrofibrosis rehabilitation techniques. It begins with a bibliographic review and an initial diagnosis that justifies the need to investigate these issues, and aspects that give consistency to them. We designed both a pre-test and a post-test, where the patient is physically examined, as well as a questionnaire is applied about the degree of pain or degree of independence. In the study we proposed to the patients to answer questions about the pain degree in form of intervals rather than single values, this allows us to assess most accurately what patients feel, however, we gain in imprecision. To this end, we use the Neutrosophic Statistics theory, which extends the classical statistical methods to the interval-valued domains. Finally, after applying the t-Student's test we concluded the effectiveness of the treatment.

Keywords: Neutrosophic Statistics, rehabilitation, knee arthrofibrosis.

1 Introduction

Trauma to the knee causes a forced valgus or varus and results in a separation-type fracture. Axial trauma causes a collapse fracture. The combination of both causes a collapse-separation type fracture, aspects that affect the patient's locomotion, [1].

Knee deformities are one of the most relevant pathologies within the osteomyoarticular system since quadriceps muscle atrophy and joint instability can be more significant when the patient is standing and walking. This undoubtedly affects the daily activities and the work of the patient. These diseases are multiple, but Arthrofibrosis of the Knee (AFK) is one of those that cause the greatest disability and medical prescription.

Arthrofibrosis of the Knee is also known in the medical literature as the loss of joint movement after having suffered trauma or surgical intervention. Due to the disabling nature that it produces and the limitation in daily activities that it causes, it is one of the most difficult complications to manage in this joint, [1,2].

In accordance with the above-mentioned, the interest of the scientific community in conducting studies aimed at first avoiding it as much as possible has increased. This is known as *prevention* and then managing it in the most appropriate way, that is, its *treatment*.

This disease can be presented in a localized or diffuse way in the compartments of the knee with intra-, extra-articular, or both, and its cause involves mechanical and biological factors, [3].

A prolonged period of immobilization, caused by this alteration of the osteomyoarticular system for more than two weeks, causes damage to the articular cartilage, bone structure, and soft tissues, which is why at the beginning of the process the significant rehabilitation is recommended by most researchers on this topic as soon as possible, [4]. The most important clinical picture is loss of joint movement, generally accompanied by quadriceps atrophy, increased volume, and pain. That is why this disease is a serious problem for human health [3,5].

Among the factors that most contribute to the development of this disease is the delay in the rehabilitation process when the first symptoms appear [6,7]. An important role is to explore the kneecap to verify that its mobilization is not blocked and does not cause pain.

When conducting a bibliographic search to enter the investigative process, we identified that the classification is dissimilar and has solid arguments that support it. However, in the present investigation, the one proposed by Del Pizzo is shared, since it is considered to allow a greater quantification to be based on the degree of limitation of joint movement since it helps to define prognosis [8].

So, this author suggests that this disease is grouped into three main groups: the group one in which there is an extension of <5° and a flexion of > 110° is considered to have a *slight* severity, the second group is considered to have an extension of 5-10°, and a flexion of 90-110°. Here the patient has a *moderate* degree of severity, so the doctor must be attentive to avoid complications that may occur in the next group. The third group has an extension level of > 10° and a flexion level of < 90°. As we can appreciate, at this time the patients present a great affectation that leads to the disease that is considered as *severe*.

In the bibliography, it is recommended as a fundamental pillar of the treatment, prevention, and then rehabilitation as soon as possible [8]. Other authors prefer conservative treatments, manipulations under anesthesia, arthroscopy, quadriceplasties, among others, [3,5], including open surgical therapies [6,7]. These treatments are not available to everyone; some of them have major complications, and all eventually need rehabilitation.

According to Gerd-WihlhemBöger and collaborators in their book "Physiotherapy for orthopedics and rheumatology", cryotherapy, thermotherapy, electrotherapy, and a group of exercises aimed at strengthening the internal vastus musclesare posed as the main treatments for AFK in physiotherapy. The same treatment is valid for quadriceps femoris, as well as stretching the rectus anterior muscle and quadriceps femoris muscle, hamstring, and calf muscles, [6,7].

Several cases refer to prevention as an important component in most secular processes of joint trauma. Generally, patients need some type of temporary immobilization, which must be kept for the necessary time, since its prolongation can produce some type of joint stiffness, which we must prevent with rehabilitation exercises. It proposes a group of exercises to gain all possible joint amplitude, they are: passive and self-passive mobilizations using arthromotor pole therapy, special techniques such as manual therapy, rhythmic mobilizations, and rhythmic sequential mobilizations, and postural treatments of the joint, slightly forced [8].

Authors who have systematized this disease suggest that the most important prevention measures are to avoid prolonged bed rest and carry out early mobilization by performing active, active-assisted, or passive joint mobility exercises. A joint that performs a single daily movement throughout its entire travel will be free of contractures and stiffness. Special attention must be paid to the biarticular muscles [3].

The rehabilitation of this disease plays a leading role, that is why it is essential to assess its behavior in practice. An initial diagnosis is made in a sample of the Pastaza canton, where methods such as the survey of patients; observations to rehabilitation sessions and revision of the rehabilitation protocol, and the need to evaluate the follow-up of these patients, to continue the rehabilitation process and the use of statistical methods to quantitatively identify their level of recovery.

This study has the objective to carry out a neutrosophic statistical analysis on the rehabilitation of arthrofibrosis of the knee. Neutrosophic Statistics was introduced by F. Smarandache, which constitutes an interval-valued generalization of the classical Statistic. Thus, we designed a questionnaire where the interviewed patient could respond in an interval-value to express its degree of pain. We preferred to use this kind of scale to guarantee the accuracy of this study. This is because it is more comfortable to express a pair of limits values of subjective evaluation than using only one.

2 Materials and Methods

2.1 Population under study

In this study we use the following elements of classical statistics:

- p = approximate proportion of the phenomenon in the reference population,
- q = proportion of the reference population that does not present the phenomenon (1-p).
- The desired confidence level (Z). Indicates the degree of confidence that the true value of the parameter in the population will be found in the calculated sample.
- The absolute precision (d). It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points).
- N is population size.

Some results of the treatment were assessed on the degree of a scale between 0 and 10. Intervals are also allowed. So, we have a Neutrosophic Statistics problem, whose main concepts we explain in the next subsection.

Additionally, we use a confidence level of 95%, $z = 1.96$, $d = 0.05$ and $N = 321$. Then, the neutrosophic sample is $n = 175.12 \approx 176$.

The traumatologist diagnosed 321 patients with arthrofibrosis of the knee belonging to the Pastaza canton of the Republic of Ecuador, 176 of them were selected using simple random sampling with the raffle procedure.

Within the sample, 105 are male and 71 are female. With a mean age of 44.7 ± 11.2. All patients signed the informed consent. Therefore, in this research, the protocols of the Declaration of Helsinki for research with human beings were followed. It is necessary to clarify that all the selected patients underwent a 12-week treatment. The first measurement was made at week 0 and the second at week 12.

Where muscle conditioning, flexion, and extension exercises were applied to aquatic activities (hydrokinecytherapy). In addition to receiving physical agents such as paraffin twice a week and in the final moments of the session they received occupational therapy.

Therefore, under these conditions, Neutrosophic Statistics were used.

2.2 Basic Notions of Neutrosophic Statistics

Definition 1:

([9]) Let X be a universe of discourse. Three membership functions characterize a Neutrosophic Set (NS), $u_A(x), r_A(x), v_A(x) : X \to]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ is the membership functions of truthfulness, indeterminacy, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

Definition 2:

([9]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \qquad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate, and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Neutrosophic Statistics extends the classical statistics, such that we deal with set values rather than crisp values, [10].

Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics.

Neutrosophic Inferential Statistics consists of methods that permit the generalization from a neutrosophic sampling to a population from which the sample was selected.

Neutrosophic Data is the data that contains some indeterminacy. Similarly to classical statistics, it can be classified as:

- Discrete neutrosophic data, if the values are isolated points.
- Continuous neutrosophic data, if the values form one or more intervals.

Another classification is the following:

- Quantitative (numerical) neutrosophic data; for example a number in the interval (we do not know exactly), 47, 52, 67, or 69 (we do not know exactly);
- Qualitative (categorical) neutrosophic data; for example: blue or red (we don't know exactly), white, black or green, or yellow (not knowing exactly).

The univariate neutrosophic data is neutrosophic data that consists of observations on a neutrosophic single attribute.

Multivariable neutrosophic data is neutrosophic data that consists of observations on two or more attributes.

A Neutrosophic Statistical Number N has the form $N = d + I$, [11], where d is called determinate part and I is called indeterminate part.

A Neutrosophic Frequency Distribution is a table displaying the categories, frequencies, and relative frequencies with some indeterminacy. Most often, indeterminacies occur due to imprecise, incomplete, or unknown data related to frequency. As a consequence, relative frequency becomes imprecise, incomplete, or unknown too.

Neutrosophic Survey Results are survey results that contain some indeterminacy.

A Neutrosophic Population is a population not well determined at the level of membership (i.e. not sure if some individuals belong or do not belong to the population).

A simple random neutrosophic sample of size n from a classical or neutrosophic population is a sample of n individuals such that at least one of them has some indeterminacy.

A stratified random neutrosophic sampling is the pollster groups of the (classical or neutrosophic) population by a stratum according to a classification; afterward, the pollster takes a random sample (of appropriate size according to a criterion) from each group. If there is some indeterminacy, we deal with neutrosophic sampling.

Additionally, we describe some concepts of interval calculus, which shall be useful in this paper.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as follows, [12]:

$N_1 + N_2 = a_1 + a_2 + (b_1 + b_2)I$ (Addition),

$N_1 - N_2 = a_1 - a_2 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1a_2 + (a_1b_2 + b_1a_2 + b_1b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1+b_1I}{a_2+b_2I} = \frac{a_1}{a_2} + \frac{a_2b_1-a_1b_2}{a_2(a_2+b_2)}I$ (Division).

Additionally, given $I_1 = [a_1, b_1]$ and $I_2 = [a_2, b_2]$ we have the following operations between them ([12]):

1. $I_1 \leq I_2$ if and only if $a_1 \leq a_2$ and $b_1 \leq b_2$.
2. $I_1 + I_2 = [a_1 + a_2, b_1 + b_2]$ (Addition);
3. $I_1 - I_2 = [a_1 - b_2, b_1 - a_2]$ (Subtraction),
4. $I_1 \cdot I_2 = [\min\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}, \max\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}]$ (Product),

$\frac{I_1}{I_2} = \left[\frac{a_1}{b_1}, \frac{a_2}{b_2}\right]$, always that $0 \notin I_2$ (Division).

5. $\sqrt{I} = [\sqrt{a}, \sqrt{b}]$, always that $a \geq 0$ (Square root).
6. $I^n = \underbrace{I \cdot I \cdot \cdots \cdot I \cdot I}_{\text{n times}}$

2.3 Instruments

To carry out the research, it was necessary to select and apply a set of theoretical, empirical, and statistical methods that are discussed below.

Analytic-synthetic: allowed to carry out a study on the theoretical and methodological foundations that support the neutrosophic statistical analysis on the rehabilitation of knee arthrofibrosis. It was used for the systematization, generalization, and specification of the processed information. It was useful in interpreting the empirical information obtained, as well as in preparing the proposal.

Inductive-deductive: used to make inferences and generalizations of the neutrosophic statistical analysis on the rehabilitation of knee arthrofibrosis, as well as the interpretation of the data obtained, from which new logical conclusions are deduced.

Participant scientific observation: it was used to directly observe the rehabilitation process of patients with arthrofibrosis of the knee, through an immediate perception of it, which made it possible to know quickly the reality and was used during the research process.

Measurement: it was used to identify the transformations that occurred in the selected sample through the use of the tests and instruments for evaluating the pathology and emphasis was placed on its critical assessment

Survey: it was carried out on 100% of the members of the sample, as this was the instrument used to assess patients regarding their behavior in carrying out daily activities. The questionnaire is the following:

Questions

1-How do you rate your performance in daily activities? (Check the option that best describes the situation)

-----Independent

----- With some limitations

----- With external help

----- I cannot perform daily activities

2-How do you assess your performance as a result of the discomfort caused by this pathology in your work activity? (Check the option that best describes the situation)

----- Well

----- Regular

----- Bad

The analysis is guided by a workflow of three activities. Statistical analysis is based on a neutrosophic environment to model uncertainty.

The analysis is supported by a neutrosophic statistical scheme that can address criteria of different nature in a neutrosophic environment [13-15]. The logic followed in the activities carried out in the investigation is shown below:

Moment 1. Application of the visual analog scale of pain, Moment 2. Analysis of the goniometric measurements,

Moment 3 Application of a survey to patients.

The patients can respond to the questionnaire on an interval-valued scale if necessary. The scale is a subinterval of [0, 10]. Thus, the answer can be 5 (a medium value) or [3, 4]. Then, the patient can express his feeling more precisely than if using a one-valued scale. On the other hand, the results in Question 2 are processed in the way that "Well" is converted into [7, 10], "Regular" into [4, 6], and "Bad" into [0, 3]. Next, these data are scaled to [0, 1] dividing by 10.

The statistical analysis of the method is designed to verify the experimental significance of the implementation of the proposal. The different activities of the analysis are described below.

The experimental design proposal is guided by a sequence of steps proposed by Grau [16-18]. The proposed steps to experiment are described below:

Step 1: Decide how many and which independent and dependent variables are included in the experiment.

Step 2: Choose the manipulation levels (measurement level) of the independent variables and translate them into experimental treatments.

Step 3: Choose or develop an instrument or tools to measure the dependent variables.

Step 4: Select the experimental design to carry out. For true experiments, decide whether participants are randomized or matched on some variable (s).

Step 5: Select a sample of people to carry out the pre-experiment.

Step 6: Analysis of the results

The level of neutrosophic significance α could be a set, not necessarily a neat number as in classical statistics [19]. A neutrosophic p-value is defined in the same way as in classical statistics: the smallest significance level at which a null hypothesis H_0 can be rejected.

The distinction between the classical p-value and the neutrosophic p-value is that the neutrosophic p-value is not a neat number as in classical statistics, but a set (in many applications it is an interval).

To know the validity of the results, the following was taken into account: Neutrosophic p-value = p (z $< z_{critical\_value}$, when H_0 is true). Where p(*) means classical probability calculated assuming that H_0 is true, the probability of observing a test statistical value is more extreme than what was obtained.

Statistical analyzes were performed with SPSS v. 20 (SPSS Inc, Chicago, IL, United States). The data relating to the descriptive statistics will be presented through the distribution of frequencies, while the t-Student test was used since the data are normally distributed. For which a confidence level of 95% and a maximum error of 5% were taken into account, considering a value of $p \leq 0.05$ as statistically significant.

3 Results

This section describes the results of the neutrosophic method applied.

1. We defined two variables:
- Independent variable: treatment developed,
- Dependent variable: improvement in the execution of daily activities.

The answers may contain interval-valued data representing that the patient is not sure what to answer. This possibility to answer in form of an interval allows more accuracy even though there is more imprecision.

International validated instruments are used for this pathology, such as:

- The visual analog scale of pain, goniometric measurements, and surveys of activities of daily living.
- A measurement is performed in the pre-test and post-test, all were tabulated with the SPSS computer software for Windows version 20.

2. Select the experimental design to carry out. In this case, a pre-experiment with a pre and post-test is carried out on the same group. Where the aforementioned parameters are evaluated in the second and sixth after the treatment is finished.
3. G O1 represents the results after the second week after treatment, whereas XO2 represents the sixth week after treatment.

Where:

- G represents the group that was selected
- O1 O2 Represent the pre and post-test applied to the group
- X Experimental condition (independent variable of the hypothesis)

4. Select a sample of people to carry out the pre-experiment (this coincides with section 2.1 of this document).
5. Analyze the results.

When observing the results of Table 1, it can be argued that there was an increase from pre to post-test. Then, at the first time of measurement, only 18 patients (approximately 10% of the sample) reported an absence of pain. This tendency was increased to 88 (50%), making it evident that the rehabilitation program improves pain over time. Mild and moderate pain also had improvements in the second measurement.

Assessment	Pre-test		Post-test	
Pain intensity	Quantity	Percentage	Quantity	Percentage
Absence	18	10	88	50
Mild	[123, 126]	[69.89,71.59]	[65, 70]	[36.93, 39.77]
Moderate	[32, 35]	[18.18, 19.89]	[18, 23]	[1.023, 13.07]
Severe	0	0	0	0

Table 1: Results of the application of the visual analog scale of pain.

Results of goniometric measurements

Table 2 refers to the results obtained in the goniometry. Where the existence of improvements was found in the second measurement. Thus, in the extension movement in the pre-test, it could only be carried out completely 53 (approximately 30% of the sample). While the rest (123 or 70%) did not complete it. However, in the second moment of measurement, there was a transformation in this aspect; since 158 patients (approximately 90%) performed it completely and only 18 (10%) did not complete it. Therefore, it becomes evident that in the second moment of evaluation the results are better.

On the other hand, the bending movement also obtained satisfactory results in the second moment of evaluation. In the first measurement, only 36 patients performed this movement completely and the rest (140 or 80%) did not complete it. In the second measurement, an increase was evidenced, since 140 patients were able to perform the movement completely and only 20% were not completed.

	Pre-test		Post-test	
Movement	Complete	Not complete	Complete	Not complete
Extension	53	123	158	18
Flexion	36	140	140	36

Table 2: Results of goniometric measurements

Results of the patient survey

The survey evaluated the performance of patients in daily activities (DA). Where table 3 and 4 show the results of both questions that this non-blood contains. Therefore, an analysis of them is carried out below.
Results of question 1 (Table 3).

In the first assessment, only 52 patients (30%) reported that they carried out these activities independently. However, after reapplying the instrument in the second measurement, it was increased to 123 patients. Aspects that denote the transformation that occurred in the sample in the second measurement.

The category with some limitations, at the initial moment of the investigation 88 patients (50% of the sample) considered that they had difficulties. While in the second measurement, it was reduced to 35, which makes evident the improvement of patients in ADL. For its part, the category with external help also had a decrease, since from 36 patients at the initial moment, only 18 obtained this evaluation.

Assessment	Pre-test		Post-test	
AVD	Quantity	Percentage	Quantity	Percentage
Independent	52	30	123	70
With some limitations	88	50	35	20
With outside help	36	20	18	10
I can not do them	0	-	0	-

Table 2: Results of question 1 of the survey

The results of question 2 (Table 4) obtained in the first one, only 35 patients (approximately 20%) say that this pathology does not affect work activities, while 53 (30%) consider that their performance is regular. While the majority, 88 (50%), refer to it as bad, as this disease causes ailment and affects physically, functionally, and psychologically.

While once the treatment was applied, 123 patients (70%) consider that at the moment their performance is good, as this is logical by reducing pain and improving the movements of this joint, its results in this aspect are obvious. Only 53 (30%) considered that their performance is regular and none stated that it was bad after receiving treatment.

Assessment	Pre-test		Post-test	
AVD	Quantity	Percentage	Quantity	Percentage
Well	35	20	123	70
Regular	53	30	53	30
Bad	88	50	0	0

Table 3: Results of question 2 of the survey

Study validation

Before delving into the results of inferential statistics, the following statistical hypothesis is proposed:

H_0: treatment developed does not significantly improve the daily activities in patients with arthrofibrosis of the knee (MD≤ MA).

H_a: treatment developed if it significantly improves the daily activities in patients with arthrofibrosis of the knee (MD≤ MA).

For the interval-valued data, we processed the mean of the interval. When processing the data with the SPSS for Windows version 20 computer software, it is obtained through the t-Student's test that there are significant differences in the second measurement with a confidence level of p = .000 in all the variables in the studies. So, H_a is accepted and thus the results of this investigation are validated.

Conclusion

The results obtained lead us to the following conclusions:

1. The analysis of the theoretical and methodological references on the rehabilitation of arthrofibrosis of the knee shows the existence of different bibliographic sources on the subject, however, tools are required to promote a correct evaluation.
2. The followed methodological logic was based on the general methods of science for the application of clinical scales such as visual analog pain, functional tests such as goniometry, and a survey to know the performance of patients.
3. The interpretation of the results offers validity to the research since by using a statistical analysis of the t-Student test, the effectiveness of the received treatment was confirmed. Let us note that we used imprecise data, for achieving more accuracy, patients can express with more fidelity what they feel.

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University of New Mexico

Assessment of Barriers to Access Public Services for Immigrants in Ecuador using a NeutroAlgebra-based Model

Walter Vayas Valdivieso[1], Juan Alberto Viteri Rodríguez [2], Marcelo Fernando Viteri Villa[3] , Enrique Ramón Rodríguez Reyes [4] and José Segundo Niño Montero[5]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.waltervayas@uniandes.edu.ec
[2]Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.juanviteri@uniandes.edu.ec
[3]Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.marceloviteri@uniandes.edu.ec
[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.enriquerodriguez@uniandes.edu.ec
[5]Universidad San Mayor San Marcos, Lima Perú. Email: jninom@unmsm.edu.pe

Abstract. As in other countries, public services in Ecuador are of great importance to ensure the effective functioning of society. Among these services, we have public housing, health, and education. These services are financed by the public treasury, which proceeds from taxes to citizens residing in the country, to specifically benefit these citizens. However, 2.21% of the Ecuadorian population is immigrant, mainly from Colombia and Peru, with a marked increase from Venezuela. This paper aims to analyze the situation of immigrants in Ecuador, in terms of theaccess to public services. Thus, 200 immigrants from Latin American and Caribbean countries who arrived in the Ecuadorian territory were interviewed in the last 4 years. We identified this sector of migration as the most vulnerable and, therefore, the greatest interest to our research. For this purpose, we use a new theory called NeutroAlgebra. NeutroAlgebra is an algebra that has at least one NeutroOperation or one NeutroAxiom, where some cases are indeterminate. Although NeutroAlgebra may seem to be only a mathematical theory with no practical application, there is a recent model of application of this theory in the study of immigrant barriers to public health services in Chile. A variant of this model is the one that we apply in our study because it has proven its usefulness.

Keywords: public services,migration, NeutroAlgebra, NeutroOperation, PROSPECTOR function.

1 Introduction

Public services are the set of activities and subsidies permitted, reserved, or required of public administrations by legislation in each state, and whose purpose is to respond to different imperatives of the functioning of society, and, ultimately, to promote the effective realization of personal and economic development, equality and social welfare. Usually, they are essential services, as taxpayers bear the costs through the State (Public Expenditure). They have a particularly significant presence in countries with mixed economies that follow political-economic models such as the social state or welfare state. It is often treated in international bodies as a fundamental element within the welfare state.

Generically, an essential service is an activity carried out by a public or private institution to satisfy a basic need of the society as a whole without wasting public resources. Consumers and users of public services are protected by the consumer protection act, to protect them against the service providers, such as gas, electricity, or phone, and it establishes that when the consumer claims faults in the service, the companies are obliged to register their claim by any means available.

In the daily life routine of any moderately developed society, we can find innumerable public services, from the oldest, such as the post office, to the most modern ones. The most well-known public services are, among others, the following: water supply, public library, education, electricity, emergency, gas, waste management, law, urban planning, order, health, social security, telecommunication, public transportation, sewage treatment, and public housing.

Today, thanks to technology we can also name a considerable number of modern companies, from radio stations and television stations to internet access companies among others that could fall under the definition of Public Service, although some disagree with their insertion in the same category.

On the other hand, the phenomenon of migration is the movement of a population that occurs from a place of origin to another destination and it brings with it a change of habitual residence in the case of individuals.

Immigrants are people who suddenly change to a society that is not their own and therefore require a degree of adaptation, they must find housing, work, access to social security and financial services, as well as education and health services. All these needs are part of the public services provided by the host countries, but they are designed to meet the needs of citizens residing in the country and not for immigrants. The latter usually present problems when arriving in the new country due to lack of documentation, xenophobia on the part of the native population, poor adaptation of the immigrant to the customs of the host country, etc., that is why immigration can affect the public service, although it must be recognized that immigrants are also a source of wealth within a society [1-4].

According to United Nations (UN) data corresponding to the year 2019, Ecuador has 381,507 immigrants, which represents 2.21% of the country's population. If we compare it with the rest of the countries we see that it is the 127th country in the world by percentage of immigration. Immigration to Ecuador comes mainly from Colombia, 50.21%, United States, 6.92%, and Peru, 3.54%. In recent years, the number of immigrants living in Ecuador has decreased by 17,561 people, or 4.4%, [5]. There has been a sharp increase in Venezuelan immigration with around 400,000 due to this neighboring country's political, economic, and social situation[6].

In the context of Good Living, the Constitution recognizes migration as a right, and therefore proposes not to identify any human being as illegal because of his or her migratory status (Art. 40 EPC) and, in the context of international relations (Title VIII), appeals to the "principle of universal citizenship" (Art. 416 EPC), [7].

The Constitution is the basis of the "National Plan for Good Living 2009-2013". This Plan includes the diagnosis on Human Mobility and Human Rights, which is generally in line with constitutional principles when referring to the exercise of rights, and the principle of universal citizenship, in which it is stated that firm steps have been taken to respect it.

Public policies on human mobility show us a model of social integration from a perspective of respect for Human Rights. Currently, foreign citizens do not require a visa to enter Ecuador for 90 days for tourism purposes; except citizens of the People’s Republic of China, Afghanistan, Bangladesh, Eritrea, Ethiopia, Kenya, Nepal, Nigeria, Pakistan, and Somalia, who do require a visa.

In any case, when the stay is going to be longer than 90 days, they must approach the Department of the Ministry of Foreign Affairs to regularize their situation. Those who do not comply with this process must voluntarily leave the country or may otherwise be deported.

This study aims to analyze the barriers to public services faced by immigrants who migrated to Ecuador. To this end, we selected 200 immigrants who live in the country for a maximum of four years, and those who come from Latin American and Caribbean countries, including Colombians, Peruvians, and Venezuelans, were chosen. We believe that immigrants from First World countries may present a different situation to those whose countries of origin are selected for our study because those countries' political and economic realities are very different.

Within the services to be studied we select those that are essential for human life in modern societies, such as health, public transport, education, public housing, among others. An approach of Neutrosophy to assess migration phenomenon can be read in [8].

We apply a variation of the model that appeared in [9], which is a method based on NeutroAlgebra theory. In this model, the respondents evaluate on a scale from -10 to 10. A NeutroAlgebra is an algebra ([10-14]) which has at least one NeutroOperation or one NeutroAxiom (axiom that is true for some elements, indeterminate for other elements, and false for the other elements), [9, 15, 16]. Especially, this model uses a NeutroOperation based on uninorms, [17, 18] generated from the PROSPECTOR function defined for MYCIN, [19-21].

This paper has the following structure; section 2 exposes the main concepts used in this research like NeutroAlgebra. Section 3 contains the method we utilized for studying migrants’ access to public services in Ecuador. The last section draws the conclusions of this paper.

2. NeutroAlgebra and PROSPECTOR function

Definition 1

([19]): Let X be a given nonempty space (or simply set) included into a universe of discourse U. Let <A> be an item (concept, attribute, idea, proposition, theory, etc.) defined on the set X. Through the process of neutrosophication, we split the set X into three regions [two opposite ones <A> and <antiA>, and one neutral (indeterminate) <neutA> between them], regions which may or may not be disjoint – depending on the application, but they are exhaustive (their union equals the whole space).

A *NeutroAlgebra* is an algebra that has at least one *NeutroOperation* or one *NeutroAxiom* (axiom that is true for some elements, indeterminate for other elements, and false for other elements).

The NeutroAlgebra is a generalization of *Partial Algebra*, which is an algebra that has at least one *Partial Operation*, while all its Axioms are true (classical axioms).

Definition 2

([19]): A function f: X → Y is called a *Partial Function* if it is well-defined for some elements in X, and undefined for all the other elements in X. Therefore, there exist some elements $a \in X$ such that $f(a) \in Y$ (well-defined), and for all other element $b \in X$ we have $f(b)$ is undefined.

Definition 3

([19]): A function f: X → Y is called a *NeutroFunction* if it has elements in X for which the function is well-defined (degree of truth (T)), elements in X for which the function is indeterminate {degree of indeterminacy (I)}, and elements in X for which the function is outer-defined {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1, 0, 0)$ that represents the (Total) Function, and $(T, I, F) \neq (0, 0, 1)$ that represents the AntiFunction.

Classification of Functions

i) (Classical) Function, which is a function well-defined for all the elements in its domain of definition.

ii) NeutroFunction, which is a function partially well-defined, partially indeterminate, and partially outer-defined on its domain of definition.

iii) AntiFunction, which is a function outer-defined for all the elements in its domain of definition.

Definition 4

([19]): A (classical) *Algebraic Structure* (or Algebra) is a nonempty set *A* endowed with some (totally well-defined) operations (functions) on *A*, and satisfying some (classical) axioms (totally true) - according to the Universal Algebra.

Definition 5

([19]): A (classical) *Partial Algebra* is an algebra defined on a nonempty set *PA* that is endowed with some partial operations (or partial functions: partially well-defined, and partially undefined). While the axioms (laws) defined on a Partial Algebra are all totally (100%) true.

Definition 6

([19]): A *NeutroAxiom* (or *Neutrosophic Axiom*) defined on a nonempty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for another set of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1, 0, 0)$ that represents the (classical) Axiom, and $(T, I, F) \neq (0, 0, 1)$ that represents the AntiAxiom.

Classification of Algebras

i) A (classical) *Algebra* is a nonempty set *CA* that is endowed with total operations (or total functions, i.e. true for all set elements) and (classical) Axioms (also true for all set elements).

ii) A *NeutroAlgebra* (or *NeutroAlgebraic Structure*) is a nonempty set *NA* that is endowed with: at least one *NeutroOperation* (or *NeutroFunction*), or one *NeutroAxiom* that is referred to the set (partial-, neutro-, or total-) operations.

iii) An *AntiAlgebra* (or *AntiAlgebraic Structure*) is a nonempty set *AA* that is endowed with at least one *AntiOperation* (or *AntiFunction*) or at least one *AntiAxiom*.

Additionally, the PROSPECTOR combination function is defined in the PROSPECTOR expert system in the following way; it is a mapping from $[-1,1]^2$ into $[-1,1]$ with formula,[20, 22]:

$$P(x,y) = \frac{x+y}{1+xy} \qquad (1)$$

This function is a uninorm, [18, 19, 23, 24], with neutral element 0, thus it fulfills commutativity, associativity, and monotonicity. Here we respect the condition that $P(-1,1)$ and $P(1,-1)$ are undefined.

3 Study of immigrants' access to public services in Ecuador

This section contains the results of this investigation, for this we explain some characteristics of the method defined in [9].

First of all, for convenience $P(x,y)$ is extended to $\bar{P}(x,y)$ such that:

$\bar{P}(x,y) = P(x,y)$for all $(x,y) \in [-1,1]^2 \setminus \{(-1,1),(1,-1)\}$,

$\bar{P}(-1,1) = \bar{P}(1,-1) = undefined$,

$\bar{P}(undefined, undefined) = undefined$.

$$\bar{P}(undefined, x) = \bar{P}(x, undefined) = \begin{cases} \text{undefined, if x} > 0 \\ \text{x, if x} \leq 0 \end{cases}.$$

Definition 7

([9]): Let S be a finite set defined as $S = \left\{(x,y): x, y \in \left\{\frac{k}{10}, undefined\right\},\ k \in \mathbb{Z} \cap [-10,10]\right\}$.

The operator $\odot$ is defined for every $(x,y) \in S$, such that:

1. If $\bar{P}(x, y)$ is not undefined, then $x \odot y = \frac{round(\bar{P}(x,y)*10)}{10}$, where *round* is the function that outputs the integer nearest to the argument.
2. If $\bar{P}(x, y)$ is undefined then $x \odot y = undefined$.
Then $\odot$ is a finite NeutroAlgebra. This is because $\odot$ is commutative and associative for the subset of elements of S without any undefined component, but it is not associative otherwise.

E.g., if $a = -0.9$, $b = 0.8$, $c = undefined$, then $a \odot (b \odot c) = a$ and $(a \odot b) \odot c = -0.4 \neq a$, therefore associativity is a NeutroAxiom. Additionally, it is easy to ckeck that $\bar{P}$ is well-defined, it is commutative, 0 is the neutral element and also "undefined" is a neutral element for the negative values. Moreover, every element has an inverse.

Function *round* is used for guarantying $\odot$ is an inner operator.

For the sake of clarity, we use the elements of Tables 2 and 3 in [9] of Caley tables multiplied by 10. The idea is to output data in the same scale used in input data, i.e., from -10 to 10. See Tables 1 and 2, nevertheless, $\odot$ is still a NeutroAlgebra. Now it is based on Neutrosophic Off-uninorms ([25]) defined for offsets, [26-28].

$x \odot y$	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
-9	-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9
-8	-10	-10	-10	-10	-9	-9	-9	-9	-9	-8	-8
-7	-10	-10	-10	-9	-9	-9	-9	-8	-8	-7	-7
-6	-10	-10	-9	-9	-9	-8	-8	-8	-7	-7	-6
-5	-10	-10	-9	-9	-8	-8	-8	-7	-6	-6	-5
-4	-10	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4
-3	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4	-3
-2	-10	-9	-9	-8	-7	-6	-6	-5	-4	-3	-2
-1	-10	-9	-8	-7	-7	-6	-5	-4	-3	-2	-1
undef.	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
0	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
1	-10	-9	-8	-6	-5	-4	-3	-2	-1	0	1
2	-10	-9	-7	-6	-5	-3	-2	-1	0	1	2
3	-10	-8	-7	-5	-4	-2	-1	0	1	2	3
4	-10	-8	-6	-4	-3	-1	0	1	2	3	4
5	-10	-7	-5	-3	-1	0	1	2	3	4	5
6	-10	-7	-4	-2	0	1	3	4	5	5	6
7	-10	-5	-2	0	2	3	4	5	6	6	7
8	-10	-4	0	2	4	5	6	7	7	8	8
9	-10	0	4	5	7	7	8	8	9	9	9
10	undef.	10	10	10	10	10	10	10	10	10	10

Table 1: Cayley table of $\odot$multiplied by 10.

$x \odot y$	**undef.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	undef.
-9	-9	-9	-9	-8	-8	-7	-7	-5	-4	0	10
-8	-8	-8	-7	-7	-6	-5	-4	-2	0	4	10
-7	-7	-6	-6	-5	-4	-3	-2	0	2	5	10
-6	-6	-5	-5	-4	-3	-1	0	2	4	7	10
-5	-5	-4	-3	-2	-1	0	1	3	5	7	10
-4	-4	-3	-2	-1	0	1	3	4	6	8	10
-3	-3	-2	-1	0	1	2	4	5	7	8	10
-2	-2	-1	0	1	2	3	5	6	7	9	10
-1	-1	0	1	2	3	4	5	6	8	9	10
undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.	undef.
0	0	1	2	3	4	5	6	7	8	9	10
1	undef.	2	3	4	5	6	7	7	8	9	10
2	undef.	3	4	5	6	6	7	8	9	9	10
3	undef.	4	5	6	6	7	8	8	9	9	10
4	undef.	5	6	6	7	8	8	9	9	10	10
5	undef.	6	6	7	8	8	8	9	9	10	10
6	undef.	7	7	8	8	8	9	9	9	10	10
7	undef.	7	8	8	9	9	9	9	10	10	10
8	undef.	8	9	9	9	9	9	10	10	10	10
9	undef.	9	9	9	10	10	10	10	10	10	10
10	undef.	10	10	10	10	10	10	10	10	10	10

Table 2: Cayley table of $\odot$ multiplied by 10 (Continuation).

These are the questions asked to immigrants:

1. Immigrants find support networks upon arrival and during the first year of their stay in the country.
2. When immigrants arrive in the country, they are low vulnerable, with economic resources for their arrival and adaptation while accessing employment, with basic services for them and their family.
3. Immigrants are aware of the Ecuadorian labor market, the regularization process, general information about the country, recruitment processes, regulations, selection processes, rights and duties, and their benefits.
4. Immigrants arrive in Ecuador with complete studies, profiles that meet the requirements of employers, languages, and specific skills.
5. Immigrants’ qualifications obtained in their countries of origin can be validated in Ecuador despite they are regulated professions; there is no lack of resources to cover the costs of validation or not lack of documents to advance the process of validation and homologation.
6. Immigrants have skills certification, the resources to cover the certification costs, know the fields of action of their skills, and know where the certification is obtained.
7. Immigrants arrive with no low work experience.
8. There are not extensive processes in Ecuador to access regularization and services.
9. Immigrants are aware of the existence of the Public Employment Service and its network of providers, of the mechanisms for access to employment, and the portfolio of job management and placement services.

10. Immigrant's adjustment processes are sufficient despite factors such as climate, culture, language, country structure, work patterns, and hourly intensity.
11. There are not situations that migrants face because of discrimination based on nationality, accent, gender, age, or disability.
12. From the institutional point of view, there is sufficient socialization about the regulations, there are not wasteful procedures of the financial sector and neither lack of social security due to non-opening of products.
13. There is an articulated and sufficient supply of services.
14. There is not a risk of loss of investment in migrants.
15. Immigrants have not difficulty accessing public transport due to fear of being arrested when they do not have up-to-date documents, fear of being attacked by xenophobia, for not having sufficient economic means to pay, not knowing the city, and not having a guide to help them.
16. Migrants have enough knowledge about the Ecuadorian health system.
17. They have access to the health system; they know where to go or who to tell them.
18. Migrants are well cared for by local doctors, who have no prejudices against them.
19. Migrants have easy access to medicines because they can afford them or because they have sufficient knowledge about them.
20. The children of school-age migrants have easy access to the education system; do not have limitations because of the level of education (more advanced or more backward than in their countries of origin), economic limitations, and legal limitations, among others.

The method that we use is as follows, which is the one introduced in [9]:

1. For each previous question, the opinion of the 200 selected migrants is collected. They are asked to rate each statement on a scale of 0 to 10 if they have a favorable or neutral opinion about access to public health from the point of view of the access that is measured. On the other hand, they are asked to evaluate on a scale of -10 to -1 if they have an unfavorable opinion.
2. Let us denote by v_{ij}, $(i = 1,2,\ldots,200;\ j = 1,2,\ldots,20)$ the evaluation of the i-th migrant on the j-th aspect.

   We calculate $\bar{v}_i = \left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}, \frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0}, \frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$, where v_{ij}^+ are positive answers by i-th migrant about j-th aspects, v_{ij}^0 are neutral answers, so $\frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0} = 0$, and v_{ij}^- are negative answers. n^+, n^0, and n^- are the numbers of positive answers, neutral answers, and negative answers, respectively, where $n^+ + n^0 + n^- = 20$. This new treatment guarantees more accuracy in the results than simply calculating the arithmetic mean.

2.1. Then, we calculate $\hat{v}_i = round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) \odot round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$, where the well-known round function is used. In case that both $round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) = 10$ and $round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$=-10, define $\hat{v}_i = -10$.

3. It is decided on two different situations:

3.1. If less than 30% of the respondents show contradictory results for each fixed j, that is, if there are 30 pairs or less of values $(-10,10)$ or $(10,-10)$, i.e., the combination function is "undefined" these values are eliminated for aggregating.

3.2. Otherwise, the j-th aspect is evaluated as "undefined" and it should be reviewed in more detail why there is such a contradiction.

4. When we have case 3.1. the aggregation of $\hat{v}_i$ is calculated by using $\odot$.

Let us note that even thougt it is not a classical algebra, but a NeutroAssociativity one, this is useful to explicitely consider the indeterminacy. In case of clearly contradiction in the pair (-10, 10), we used the term "undefined" instead of 0, in Tables 1,2. If only one of the evaluations is "undefined" the rest of the evaluations are also "undefined" or "negatives". Then, when more than 30% of that assesses are "undefined" we consider the total aggregation as "undefined", which indicates a clear contradiction in the final result. The way to resolve this problem is to reanalize the assesses.

Table 3 contains the grouped data of the results obtained for each question asked to the 200 migrants surveyed:

Question / Interval	[-10, -5)	[-5, 0)	[0, 5)	[5, 10]
1	8	26	74	92
2	28	28	77	67
3	31	40	55	74
4	38	40	60	62
5	5	10	31	154
6	5	7	33	155
7	48	45	61	46
8	55	50	59	36
9	17	26	76	81
10	5	8	88	99
11	85	70	33	12
12	58	57	28	57
13	40	63	43	54
14	16	18	80	86
15	6	44	15	135
16	18	2	61	119
17	22	52	53	73
18	20	55	69	56
19	39	7	46	108
20	97	62	2	39

Table 3: Grouped data on survey results.

After we applied the method, we obtained the value 10 as the final aggregation value. This means that the situation is more favorable than unfavorable; however, according to Table 3 some public services are not good for immigrants, e.g., education system and labor, and there exists discrimination.

Conclusion

This paper studied the situation of immigrants arriving in Ecuador. We surveyed 200 immigrants who came to the country from Latin American and Caribbean countries, in the last 4 years. NeutroAlgebra was used as a tool, which had been successfully applied in a similar problem; however,the used method was slightly changed in this paper to achieve greater accuracy. In addition, the Caley table of this NeutroAlgebra has been rescaled on a scale of -10 to 10, to match the scale used in the input data. The number of questions asked was 20. It was concluded that the situation is more favorable than unfavorable. Although from the data collected it can be inferred that not all services comply with this, such as employment and education; moreover, there is a degree of discrimination and xenophobia in the Ecuadorian population. We have showed from the definition of this NeutroAlgebra in Tables 1 and 2 that this is not an associative structure, due to the explicit precense of the term “undefined” and the combination of one “undefined” with a negative one is negative, nevertheless, we also showed that this term is useful for gaining in accuracy in the proposed method. When, more than 30% of the evaluations are contradictories, it is preferable that experts reconsider their evaluations. This is the advantage obtained with the cost of eliminating classical associativity.

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Evaluation of Assertive Communication Competencies in Nurses using Neutrosophic Statistics

María Isabel Fong Betancourt[1], Lotty Rosita Ramírez López[2], Rosita Elizabeth del Carmen Olivo Torres[3] and Fanny del Rocío Pérez Naranjo [4]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.mariafong@uniandes.edu.ec

[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.lottyramirez@uniandes.edu.ec

[3] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.rositaolivo@uniandes.edu.ec

[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.fannyperez@uniandes.edu.ec

Abstract. Assertiveness, as an important element of interpersonal competency, is essential in effective conflict resolution. The nursing profession is associated with intense contacts in the therapeutic team, so this profession recognizes the need to use an assertive attitude, which allows defending one's dignity, expressing opinions and emotions for another person. This research aims to assess the assertive competencies of nurses in the city of Guayaquil through neutrosophic statistics. The neutrosophic population proportion was estimated with 99% of reliability, which leads us to conclude that assertive communication skills in nurses in the city of Guayaquil are generally very good in terms of empathy and the ability to work with emotions, assertiveness in conflict situations, and communication skills.

Keywords: Assertive communication, nursing, neutrosophic statistics, neutrosophic confidence interval.

1 Introduction

Nursing is a profession that requires adequate medical knowledge, responsibility, resistance to stress, patience, reliability, and the ability to act as part of a medical team consisting of co-workers and patients [1, 2]. In this profession, the development of social skills is very important.

The main social competencies, understood as the ability to face desired interpersonal relationships, in nursing work include interpersonal communication, empathy, and assertiveness in conflict situations [5, 8]. According to [10], assertiveness turns out to be the most important and useful interpersonal communication competency to solve problems and conflicts between members of the therapeutic team.

Assertiveness is the ability to formulate and communicate your thoughts, opinions, and wishes, directly, and non-aggressively. Its goal is to effectively initiate social interactions so that positive interpersonal relationships can be maintained. It is also the facility to say "no" in situations that exceed our expectations, competency, or capabilities. It allows us to maintain the boundaries between the interlocutors. The ability to assertively express negative emotions is an expression of respect for oneself and other interlocutors. Thanks to assertiveness, communication becomes sincere and open, which makes each of its participants feel satisfied and not offended [3].

The concept of assertiveness is defined slightly differently by social competency training professionals and humanistic psychologists. They point out that a person will be truly assertive when he trusts himself deeply and, feeling self-acceptance, rationally trusts other people with whom he will be authentic, sincere, open, and honest. The authors of this approach to the topic indicate that the assertive person expresses a mature and integrated personality and that assertive behavior is dictated by an awareness of personal dignity, self-respect, and self-acceptance. Therefore, it is not a manifestation of selfishness, and can even serve to achieve prosocial goals [2].

Assertiveness can be confused with aggressiveness, especially at work. However, the main difference between assertiveness and aggression is the approach to the situation or problem. An assertive person faces the difficulty instead of the interlocutor so that everyone respects each other. An aggressive attitude, on the other hand, will have little effect in changing the thoughts and feelings of others to solve the problem and an assertive person does not respect moral and personal limits during a conversation. The situation is reversed when the interlocutor uses assertive conflict resolution skills [5].

According to the World Health Organization, one of the five factors necessary for a healthy and happy life is effective communication [10]. The ability to communicate properly and to be assertive is invaluable in the medical profession as it involves intense interpersonal contact.

The work of a nurse also requires great responsibility, the need to make immediate decisions, direct contact with patients and their emotions, and shift work, that is, sleep deprivation. The mental workload usually affects the emotional sphere, so that the mentioned stressors do not infrequently cause mental health problems, depression, and job burnout. With good communication and an assertive attitude, these side effects can be avoided. This behavior allows us to cope with stress and is a form of emotional self-control. Being assertive in stressful situations gives us greater confidence in ourselves, in addition to inspiring respect for ourselves.

In addition, proper cooperation in the treatment team will affect satisfaction with professional life and mental health, as well as patient satisfaction and safety. On a professional level, assertiveness will help maintain the task-oriented nature of relationships between coworkers, and assertiveness will reinforce belief in specialized competencies and one's abilities. In addition, an assertive refusal allows one to transgress professional competency with tact, without offending the other party. Relationships in the therapeutic team that function in this way leads to mutual satisfaction, in which everyone respects each other, do not exceed personal limits and, as a result, the roles of the medical staff are appropriately divided [2, 4].

In short, an assertive nurse knows how to achieve what he expects from the environment with respect for others. He is a person who speaks openly, honestly, and directly about his personal feelings and thoughts with great tact. Assertiveness is used to defend one's position and the professional position. Thanks to this ability, he solves conflicts and problems without using aggressiveness, which gives him a sense of dignity. An assertive nurse inspires confidence both in your person and in your professional competency. He takes responsibility for his words and does not violate the rights of the patient, taking into account their expectations. By using assertive messages, you can deal with stress and avoid professional burnout, to which the medical profession is most exposed [1, 5].

Multiple research works have been carried out to evaluate assertive communication competencies in health professionals and in particular in nursing. Among them, the investigations of [1], [2], [4], [5], and [14] stand out.

The objective of this study is to evaluate the assertive communication skills of nurses in the city of Guayaquil, using neutrosophic statistics. We decided to choose neutrosophic statistics because it allows us to interpret and organize data that may be ambiguous, vague, imprecise, incomplete, or even unknown, to reveal the underlying patterns [12, 13].

2 Materials and methods

This section offers some of the definitions of Neutrosophy and neutrosophic statistics that are used in this research. The instrument and the procedure applied for the selection of the sample, the processing, and the analysis of the data are also detailed.

Let X be a universe of discourse, a Single Value Neutrosophic Set (SVNS) A over X has the following form [11-14]:

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d \tag{1}$$

Where

$u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ v_a(x): X \to [0,1]$

with

$$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \forall\, x \in X$$

The intervals $u_a(x), r_a(x)$ y $v_a(x)$ denote the memberships to true, indeterminate, and false from x in A, respectively. For convenience a SVNS will be expressed as A = (a, b, c), where a, b, c ∈ [0.1] and satisfies 0 ≤ a + b + c ≤ 3. Let $\{A_1, A_2, \dots, A_n\}$∈ SVNS(x), where $A_j = (a_j\,, b_j\,, c\,_j)$ (j = 1, 2, …, n), then, the Single Valued Neutrosophic Weighted Average Operator is defined by:

$$P_w(A_1, A_2, \dots, A_n) = \langle 1 - \prod_{j=1}^{n}\left(1 - T_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(I_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(F_{A_j}(x)\right)^{w_j}\rangle \tag{2}$$

Where: $w = (w_1, w_2, \dots, w_n)$ is vector of $\mathrm{A_j}(j = 1,2, \dots, n)$ such that $w_n \in [0,1]$ y $\sum w_j = 1$.

5. Let A = (a, b, c) be a single neutrosophic number, a score function S of a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and falsity membership degree is defined by:

$$S(A) = \frac{1 + a - 2b - c}{2} \tag{3}$$

Where: $S(A) \in [-1,1]$

Neutrosophic Statistics refers to a set of data so that the data or a part of them are indeterminate to some degree and to the methods used to analyze the data [15-21]. A Neutrosophic Frequency Distribution is a table showing the categories, frequencies, and relative frequencies with some indeterminacies. Most of the time, indeterminacies occur due to imprecise, incomplete, or unknown frequency-related data. As a consequence, the relative frequency also becomes imprecise, incomplete, or unknown [15]. A neutrosophic statistical number has the form [15]:

$$N = d + i \tag{4}$$

with$i \in [i_a, i_b]$

Where

d: is the determinate (sure) part of N,

i: is the indeterminate (unsure) part of N.

i_a: is the lower limit of i range

i_b: is the superior limit of i range

So (4) is equivalent to:

$[N + i_a, N + i_b]$

Setting and, the expression we will use to represent the estimated neutrosophic frequencies is: $min_{nf} = N + i_a max_{nf} = N + i_b$

$$[min_{nf}, max_{nf}] \tag{5}$$

To calculate the total of the neutrosophic frequencies, we calculate the minimum and maximum total of m categories of estimated frequencies using the following equations:

$$tmin_{nf} = \sum_{j=1}^{m} min_{nfj} \tag{6}$$

$$tmax_{nf} = \sum_{j=1}^{m} max_{nfj} \tag{7}$$

Where:

$tmin_{nf}$ is the total minimum of the estimated frequencies for m possibilities.

$tmax_{nf}$ is the total maximum of the estimated frequencies for m possibilities.

min_{nfj} is the lower limit of the neutrosophic estimated frequency range for the possibility j.

max_{nfj} is the superior limit of the neutrosophic estimated frequency range for the possibility j.

To calculate the neutrosophic relative frequency of each possibility:

$$min_{nrfj} = \frac{min_{nfj}}{tmax_{nf}} \tag{8}$$

$$max_{nrfj} = \frac{max_{nfj}}{tmin_{nf}} \tag{9}$$

Where:

min_{nrfj} is the inferior limit of the neutrosophic relative frequency for the possibility j.

max_{nrfj} is the superior limit of the neutrosophic relative frequency for the possibility j.

The large sample Neutrosophic Confidence Interval for the population proportion is calculated:

$$p - (z\ critical\ value) \cdot \sqrt{\frac{p(1-p)}{n}} < \pi < p + (z\ critical\ value) \cdot \sqrt{\frac{p(1-p)}{n}} \tag{10}$$

For the case when: and$min\{np\} \geq 5 min\{n \cdot (1-p)\} \geq 5$

Where:

p = proportion of the sample = number of individuals in the sample who possess the property of interest divided by the size of the sample;

n = sample size;

π = proportion of the population = number of individuals in the population who own the property of interest divided by the size of the population.

The formula for calculating the sample size for a finite population

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq}$$

(11)

The Assertive Communication Questionnaire developed by [3] was used, which consists of 19 statements. The statements were evaluated on the scale of linguistic terms associated with SVNS that are presented in Table 1.

Linguistic term	Evaluation	SVNS
Always	AL	(1,0,0)
Usually	US	(0.8, 0.15, 0.20)
Many times	MT	(0.60, 0.35, 0.40)
Sometimes	ST	(0.50, 0.50, 0.50)
On a few occasions	FO	(0.40, 0.65, 0.60)
Rarely	RA	(0.20, 0.85, 0.80)
Never	NE	(0; 1; 1)

Table 1. Linguistic terms used in the questionnaire and their associated SVNS

With the results obtained in the survey, each respondent was evaluated on the dimensions: 1) Empathy and ability to work with emotions, 2) Assertiveness in conflict situations and 3) Communication skills. These dimensions were evaluated according to the scale of linguistic terms associated with SVNS shown in Table 2.

Linguistic term	Evaluation	SVNS
Excellent	E	(1,0,0)
Very good	VG	(0.8, 0.15, 0.20)
Good	G	(0.60, 0.35, 0.40)
Regular	R	(0.50, 0.50, 0.50)
Regular tending to bad	RB	(0.40, 0.65, 0.60)
Bad	B	(0.20, 0.85, 0.80)
Very bad	VB	(0; 1; 1)

Table 2. Linguistic terms used in the assessment of dimensions and their associated SVNS

The evaluations of each dimension were also added using equation (2). Once the aggregations were obtained, the scoring function (3) was used to obtain a single evaluation value in assertive communication competencies, for each respondent. For this, the evaluative category was assigned according to the belonging of the individual score value to the intervals (for each category), which are shown in Table 3.

Scoring intervals	Evaluation	Linguistic term
[0 - 0.429)	VB	Very bad
[0.429-0.857)	B	Bad
[0.857-1.286)	RB	Regular tending to bad
[1,286 - 1,714)	R	Regular
[1,714-2,143)	G	Good
[2,143 - 2,571)	VG	Very good
[2,571-3]	E	Excellent

Table 3. Intervals for evaluation according to score function value

With the evaluation results in assertive communication competencies, the neutrosophic confidence interval of the population proportion was estimated for each level of assertive communication competency of the population of nurses in the city of Guayaquil.

4 Results

To meet the stated objective, a voluntary and anonymous survey was carried out in a group of nurses employed in the hospitals of the city of Guayaquil. To determine how many nurses to survey, it was estimated that there is a population of between 3,500 and 4,000 nurses in the city of Guayaquil. With this and through equation (11), the sample size was calculated with an estimated error of between. The result was a Neutrosophic Sample Size of $[4\%, 5\%][252{,}383]$

A sample composed of 294 randomly selected nurses was surveyed. The sample is statistically significant in terms of size (252 <294 <383). The results of the aggregate evaluation of each dimension are shown in Figure 1.

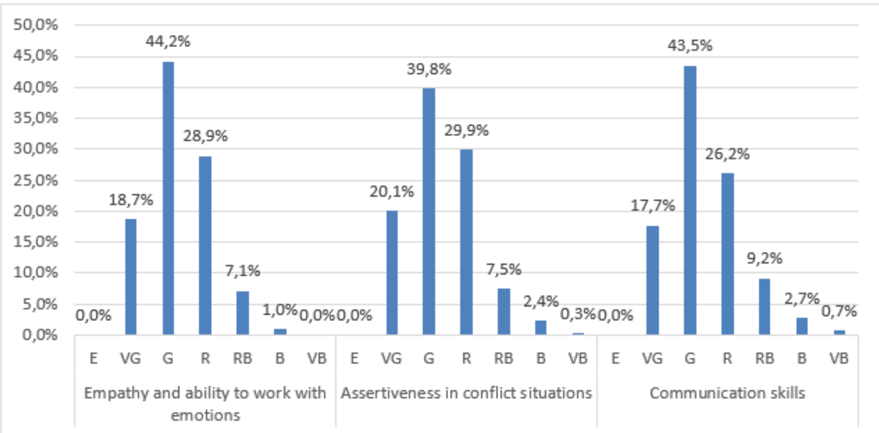

Figure 1. Percentage results of the evaluations of the three dimensions analyzed

These results show positive evaluations higher than 60% in the three dimensions. The remaining 40% of evaluations are predominantly Regular (R), with some from Regular tending to Bad (RB). Bad (B) and Very Bad (VB) evaluations are very scarce. The worst performing dimension was Assertiveness in conflict situations, although in reality, it is only slightly lower than the others.

The aggregation of the results in the three dimensions to obtain a global assessment of the assertive communication competency of each of the surveyed is sown in table 3

Surveyed	***Pw (A1...An)***	**Surveyed**	***Pw (A1...An)***	**Surveyed**	***Pw (A1...An)***
1	(0.44,0.6,0.5)	99	(0.6,0.35,0.4)	197	(0.5,0.5,0.5)
2	(0.34,0.71,0.58)	100	(0.54,0.44,0.46)	198	(0.66,0.3,0.34)
3	(0.66,0.3,0.34)	101	(0.57,0.39,0.43)	199	(0.75,0.2,0.25)
4	(0.07,0.95,0.93)	102	(0.57,0.39,0.43)	200	(0.57,0.39,0.43)
5	(0.75,0.2,0.25)	103	(0.57,0.39,0.43)	201	(0.6,0.35,0.4)
6	(0.47,0.55,0.5)	104	(0.57,0.39,0.43)	202	(0.57,0.39,0.43)
7	(0.54,0.44,0.46)	105	(0.6,0.35,0.4)	203	(0.6,0.35,0.4)
8	(0.75,0.2,0.25)	106	(0.68,0.26,0.32)	204	(0.47,0.55,0.5)
9	(0.68,0.26,0.32)	107	(0.8,0.15,0.2)	205	(0.34,0.71,0.58)
10	(0.75,0.2,0.25)	108	(0.6,0.35,0.4)	206	(0.68,0.26,0.32)
11	(0.68,0.26,0.32)	109	(0.68,0.26,0.32)	207	(0.6,0.35,0.4)
12	(0.6,0.35,0.4)	110	(0.2,0.85,0.8)	208	(0.57,0.39,0.43)
13	(0.34,0.71,0.58)	111	(0.51,0.48,0.46)	209	(0.75,0.2,0.25)
14	(0.47,0.55,0.5)	112	(0.54,0.44,0.46)	210	(0.75,0.2,0.25)
15	(0.66,0.3,0.34)	113	(0.44,0.6,0.5)	211	(0.5,0.5,0.5)
16	(0.54,0.44,0.46)	114	(0.6,0.35,0.4)	212	(0.75,0.2,0.25)
17	(0.6,0.35,0.4)	115	(0.6,0.35,0.4)	213	(0.51,0.48,0.46)
18	(0.75,0.2,0.25)	116	(0.68,0.26,0.32)	214	(0.6,0.35,0.4)
19	(0.5,0.5,0.5)	117	(0.5,0.5,0.5)	215	(0.6,0.35,0.4)
20	(0.51,0.48,0.46)	118	(0.68,0.26,0.32)	216	(0.68,0.26,0.32)
21	(0.57,0.39,0.43)	119	(0.57,0.39,0.43)	217	(0.57,0.39,0.43)
22	(0.75,0.2,0.25)	120	(0.68,0.26,0.32)	218	(0.57,0.39,0.43)
23	(0.57,0.39,0.43)	121	(0.57,0.39,0.43)	219	(0.75,0.2,0.25)
24	(0.54,0.44,0.46)	122	(0.57,0.39,0.43)	220	(0.4,0.65,0.5)
25	(0.57,0.39,0.43)	123	(0.6,0.35,0.4)	221	(0.6,0.35,0.4)
26	(0.8,0.15,0.2)	124	(0.5,0.5,0.5)	222	(0.8,0.15,0.2)
27	(0.68,0.26,0.32)	125	(0.68,0.26,0.32)	223	(0.44,0.6,0.5)
28	(0.38,0.65,0.58)	126	(0.5,0.5,0.5)	224	(0.54,0.44,0.46)
29	(0.27,0.78,0.68)	127	(0.57,0.39,0.43)	225	(0.6,0.35,0.4)
30	(0.68,0.26,0.32)	128	(0.47,0.55,0.5)	226	(0.6,0.35,0.4)
31	(0.8,0.15,0.2)	129	(0.68,0.26,0.32)	227	(0.6,0.35,0.4)
32	(0.5,0.5,0.5)	130	(0.54,0.44,0.46)	228	(0.8,0.15,0.2)
33	(0.66,0.3,0.34)	131	(0.6,0.35,0.4)	229	(0.68,0.26,0.32)
34	(0.8,0.15,0.2)	132	(0.54,0.44,0.46)	230	(0.6,0.35,0.4)
35	(0.66,0.3,0.34)	133	(0.5,0.5,0.5)	231	(0.68,0.26,0.32)
36	(0.68,0.26,0.32)	134	(0.6,0.35,0.4)	232	(0.75,0.2,0.25)
37	(0.8,0.15,0.2)	135	(0.6,0.35,0.4)	233	(0.5,0.5,0.5)
38	(0.5,0.5,0.5)	136	(0.5,0.5,0.5)	234	(0.6,0.35,0.4)
39	(0.75,0.2,0.25)	137	(0.8,0.15,0.2)	235	(0.68,0.26,0.32)
40	(0.75,0.2,0.25)	138	(0.54,0.43,0.43)	236	(0.57,0.39,0.43)
41	(0.57,0.39,0.43)	139	(0.68,0.26,0.32)	237	(0.5,0.5,0.5)
42	(0.6,0.35,0.4)	140	(0.68,0.26,0.32)	238	(0.75,0.2,0.25)
43	(0.54,0.44,0.46)	141	(0.54,0.44,0.46)	239	(0.5,0.5,0.5)
44	(0.75,0.2,0.25)	142	(0.68,0.26,0.32)	240	(0.6,0.35,0.4)

45	(0.8,0.15,0.2)	143	(0.5,0.5,0.5)	241	(0.6,0.35,0.4)
46	(0.5,0.5,0.5)	144	(0.5,0.5,0.5)	242	(0.6,0.35,0.4)
47	(0.47,0.55,0.5)	145	(0.44,0.6,0.5)	243	(0.6,0.35,0.4)
48	(0.6,0.35,0.4)	146	(0.34,0.71,0.58)	244	(0.47,0.55,0.5)
49	(0.6,0.35,0.4)	147	(0.75,0.2,0.25)	245	(0.47,0.55,0.5)
50	(0.75,0.2,0.25)	148	(0.6,0.35,0.4)	246	(0.66,0.3,0.34)
51	(0.68,0.26,0.32)	149	(0.6,0.35,0.4)	247	(0.6,0.35,0.4)
52	(0.54,0.44,0.46)	150	(0.5,0.5,0.5)	248	(0.5,0.5,0.5)
53	(0.27,0.78,0.68)	151	(0.75,0.2,0.25)	249	(0.5,0.5,0.5)
54	(0.68,0.26,0.32)	152	(0.5,0.5,0.5)	250	(0.6,0.35,0.4)
55	(0.57,0.39,0.43)	153	(0.4,0.65,0.5)	251	(0.6,0.35,0.4)
56	(0.8,0.15,0.2)	154	(0.8,0.15,0.2)	252	(0.6,0.35,0.4)
57	(0.75,0.2,0.25)	155	(0.66,0.3,0.34)	253	(0.5,0.5,0.5)
58	(0.47,0.55,0.5)	156	(0.6,0.35,0.4)	254	(0.75,0.2,0.25)
59	(0.68,0.26,0.32)	157	(0.57,0.39,0.43)	255	(0.54,0.44,0.46)
60	(0.6,0.35,0.4)	158	(0.8,0.15,0.2)	256	(0.6,0.35,0.4)
61	(0.54,0.43,0.43)	159	(0.5,0.5,0.5)	257	(0.54,0.44,0.46)
62	(0.66,0.3,0.34)	160	(0.57,0.39,0.43)	258	(0.68,0.26,0.32)
63	(0.34,0.71,0.58)	161	(0.54,0.44,0.46)	259	(0.57,0.39,0.43)
64	(0.54,0.44,0.46)	162	(0.8,0.15,0.2)	260	(0.5,0.5,0.5)
65	(0.57,0.39,0.43)	163	(0.6,0.35,0.4)	261	(0.34,0.71,0.58)
66	(0.68,0.26,0.32)	164	(0.75,0.2,0.25)	262	(0.5,0.5,0.5)
67	(0.8,0.15,0.2)	165	(0.57,0.39,0.43)	263	(0.75,0.2,0.25)
68	(0.54,0.44,0.46)	166	(0.8,0.15,0.2)	264	(0.47,0.55,0.5)
69	(0.5,0.5,0.5)	167	(0.5,0.5,0.5)	265	(0.6,0.35,0.4)
70	(0.68,0.26,0.32)	168	(0.6,0.35,0.4)	266	(0.68,0.26,0.32)
71	(0.54,0.44,0.46)	169	(0.66,0.3,0.34)	267	(0.68,0.26,0.32)
72	(0.44,0.6,0.5)	170	(0.51,0.48,0.46)	268	(0.6,0.35,0.4)
73	(0.54,0.44,0.46)	171	(0.6,0.35,0.4)	269	(0.47,0.55,0.5)
74	(0.5,0.5,0.5)	172	(0.5,0.5,0.5)	270	(0.47,0.55,0.5)
75	(0.68,0.26,0.32)	173	(0.68,0.26,0.32)	271	(0.5,0.5,0.5)
76	(0.68,0.26,0.32)	174	(0.8,0.15,0.2)	272	(0.68,0.26,0.32)
77	(0.54,0.44,0.46)	175	(0.54,0.44,0.46)	273	(0.47,0.55,0.5)
78	(0.54,0.44,0.46)	176	(0.47,0.55,0.5)	274	(0.4,0.65,0.5)
79	(0.6,0.35,0.4)	177	(0.6,0.35,0.4)	275	(0.54,0.44,0.46)
80	(0.47,0.55,0.5)	178	(0.75,0.2,0.25)	276	(0.8,0.15,0.2)
81	(0.44,0.6,0.5)	179	(0.6,0.35,0.4)	277	(0.47,0.55,0.5)
82	(0.8,0.15,0.2)	180	(0.54,0.44,0.46)	278	(0.68,0.26,0.32)
83	(0.54,0.44,0.46)	181	(0.5,0.5,0.5)	279	(0.68,0.26,0.32)
84	(0.75,0.2,0.25)	182	(0.4,0.65,0.5)	280	(0.8,0.15,0.2)
85	(0.57,0.39,0.43)	183	(0.6,0.35,0.4)	281	(0.6,0.35,0.4)
86	(0.75,0.2,0.25)	184	(0.47,0.55,0.5)	282	(0.6,0.35,0.4)
87	(0.57,0.39,0.43)	185	(0.54,0.44,0.46)	283	(0.47,0.55,0.5)
88	(0.68,0.26,0.32)	186	(0.57,0.39,0.43)	284	(0.5,0.5,0.5)
89	(0.57,0.39,0.43)	187	(0.6,0.35,0.4)	285	(0.66,0.3,0.34)
90	(0.57,0.39,0.43)	188	(0.5,0.5,0.5)	286	(0.57,0.39,0.43)
91	(0.8,0.15,0.2)	189	(0.47,0.55,0.5)	287	(0.54,0.44,0.46)
92	(0.5,0.5,0.5)	190	(0.57,0.39,0.43)	288	(0.54,0.44,0.46)
93	(0.6,0.35,0.4)	191	(0.6,0.35,0.4)	289	(0.6,0.35,0.4)
94	(0.47,0.55,0.5)	192	(0.8,0.15,0.2)	290	(0.6,0.35,0.4)
95	(0.57,0.39,0.43)	193	(0.38,0.65,0.58)	291	(0.8,0.15,0.2)

96	(0.75,0.2,0.25)	194	(0.75,0.2,0.25)	292	(0.29,0.75,0.63)
97	(0.57,0.39,0.43)	195	(0.34,0.71,0.58)	293	(0.46,0.53,0.54)
98	(0.54,0.44,0.46)	196	(0.61,0.37,0.37)	294	(0.6,0.35,0.4)
99	(0.6,0.35,0.4)	197	(0.5,0.5,0.5)	227	(0.6,0.35,0.4)
100	(0.54,0.44,0.46)	198	(0.66,0.3,0.34)	228	(0.8,0.15,0.2)
101	(0.57,0.39,0.43)	199	(0.75,0.2,0.25)	229	(0.68,0.26,0.32)
102	(0.57,0.39,0.43)	200	(0.57,0.39,0.43)	230	(0.6,0.35,0.4)
103	(0.57,0.39,0.43)	201	(0.6,0.35,0.4)	231	(0.68,0.26,0.32)
104	(0.57,0.39,0.43)	202	(0.57,0.39,0.43)	232	(0.75,0.2,0.25)
105	(0.6,0.35,0.4)	203	(0.6,0.35,0.4)	233	(0.5,0.5,0.5)
106	(0.68,0.26,0.32)	204	(0.47,0.55,0.5)	234	(0.6,0.35,0.4)
107	(0.8,0.15,0.2)	205	(0.34,0.71,0.58)	235	(0.68,0.26,0.32)
108	(0.6,0.35,0.4)	206	(0.68,0.26,0.32)	236	(0.57,0.39,0.43)
109	(0.68,0.26,0.32)	207	(0.6,0.35,0.4)	237	(0.5,0.5,0.5)
110	(0.2,0.85,0.8)	208	(0.57,0.39,0.43)	238	(0.75,0.2,0.25)
111	(0.51,0.48,0.46)	209	(0.75,0.2,0.25)	239	(0.5,0.5,0.5)
112	(0.54,0.44,0.46)	210	(0.75,0.2,0.25)	240	(0.6,0.35,0.4)
113	(0.44,0.6,0.5)	211	(0.5,0.5,0.5)	241	(0.6,0.35,0.4)
114	(0.6,0.35,0.4)	212	(0.75,0.2,0.25)	242	(0.6,0.35,0.4)
115	(0.6,0.35,0.4)	213	(0.51,0.48,0.46)	243	(0.6,0.35,0.4)
116	(0.68,0.26,0.32)	214	(0.6,0.35,0.4)	244	(0.47,0.55,0.5)
117	(0.5,0.5,0.5)	215	(0.6,0.35,0.4)	245	(0.47,0.55,0.5)
118	(0.68,0.26,0.32)	216	(0.68,0.26,0.32)	246	(0.66,0.3,0.34)
119	(0.57,0.39,0.43)	217	(0.57,0.39,0.43)	247	(0.6,0.35,0.4)
120	(0.68,0.26,0.32)	218	(0.57,0.39,0.43)	248	(0.5,0.5,0.5)
121	(0.57,0.39,0.43)	219	(0.75,0.2,0.25)	249	(0.5,0.5,0.5)
122	(0.57,0.39,0.43)	220	(0.4,0.65,0.5)	250	(0.6,0.35,0.4)
123	(0.6,0.35,0.4)	221	(0.6,0.35,0.4)	251	(0.6,0.35,0.4)
124	(0.5,0.5,0.5)	222	(0.8,0.15,0.2)	252	(0.6,0.35,0.4)
125	(0.68,0.26,0.32)	223	(0.44,0.6,0.5)	253	(0.5,0.5,0.5)
126	(0.5,0.5,0.5)	224	(0.54,0.44,0.46)	254	(0.75,0.2,0.25)
127	(0.57,0.39,0.43)	225	(0.6,0.35,0.4)	255	(0.54,0.44,0.46)
128	(0.47,0.55,0.5)	226	(0.6,0.35,0.4)	256	(0.6,0.35,0.4)
129	(0.68,0.26,0.32)	227	(0.6,0.35,0.4)	257	(0.54,0.44,0.46)
130	(0.54,0.44,0.46)	228	(0.8,0.15,0.2)	258	(0.68,0.26,0.32)
131	(0.6,0.35,0.4)	229	(0.68,0.26,0.32)	259	(0.57,0.39,0.43)
132	(0.54,0.44,0.46)	230	(0.6,0.35,0.4)	260	(0.5,0.5,0.5)
133	(0.5,0.5,0.5)	231	(0.68,0.26,0.32)	261	(0.34,0.71,0.58)
134	(0.6,0.35,0.4)	232	(0.75,0.2,0.25)	262	(0.5,0.5,0.5)
135	(0.6,0.35,0.4)	233	(0.5,0.5,0.5)	263	(0.75,0.2,0.25)
136	(0.5,0.5,0.5)	234	(0.6,0.35,0.4)	264	(0.47,0.55,0.5)
137	(0.8,0.15,0.2)	235	(0.68,0.26,0.32)	265	(0.6,0.35,0.4)
138	(0.54,0.43,0.43)	236	(0.57,0.39,0.43)	266	(0.68,0.26,0.32)
139	(0.68,0.26,0.32)	237	(0.5,0.5,0.5)	267	(0.68,0.26,0.32)
140	(0.68,0.26,0.32)	238	(0.75,0.2,0.25)	268	(0.6,0.35,0.4)
141	(0.54,0.44,0.46)	239	(0.5,0.5,0.5)	269	(0.47,0.55,0.5)
142	(0.68,0.26,0.32)	240	(0.6,0.35,0.4)	270	(0.47,0.55,0.5)
143	(0.5,0.5,0.5)	241	(0.6,0.35,0.4)	271	(0.5,0.5,0.5)
144	(0.5,0.5,0.5)	242	(0.6,0.35,0.4)	272	(0.68,0.26,0.32)
145	(0.44,0.6,0.5)	243	(0.6,0.35,0.4)	273	(0.47,0.55,0.5)
146	(0.34,0.71,0.58)	244	(0.47,0.55,0.5)	274	(0.4,0.65,0.5)

147	(0.75,0.2,0.25)	245	(0.47,0.55,0.5)	275	(0.54,0.44,0.46)
148	(0.6,0.35,0.4)	246	(0.66,0.3,0.34)	276	(0.8,0.15,0.2)
149	(0.6,0.35,0.4)	247	(0.6,0.35,0.4)	277	(0.47,0.55,0.5)
150	(0.5,0.5,0.5)	248	(0.5,0.5,0.5)	278	(0.68,0.26,0.32)
151	(0.75,0.2,0.25)	249	(0.5,0.5,0.5)	279	(0.68,0.26,0.32)
152	(0.5,0.5,0.5)	250	(0.6,0.35,0.4)	280	(0.8,0.15,0.2)
153	(0.4,0.65,0.5)	251	(0.6,0.35,0.4)	281	(0.6,0.35,0.4)
154	(0.8,0.15,0.2)	252	(0.6,0.35,0.4)	282	(0.6,0.35,0.4)
155	(0.66,0.3,0.34)	253	(0.5,0.5,0.5)	283	(0.47,0.55,0.5)
156	(0.6,0.35,0.4)	254	(0.75,0.2,0.25)	284	(0.5,0.5,0.5)
157	(0.57,0.39,0.43)	255	(0.54,0.44,0.46)	285	(0.66,0.3,0.34)
158	(0.8,0.15,0.2)	256	(0.6,0.35,0.4)	286	(0.57,0.39,0.43)
159	(0.5,0.5,0.5)	257	(0.54,0.44,0.46)	287	(0.54,0.44,0.46)
160	(0.57,0.39,0.43)	258	(0.68,0.26,0.32)	288	(0.54,0.44,0.46)
161	(0.54,0.44,0.46)	259	(0.57,0.39,0.43)	289	(0.6,0.35,0.4)
162	(0.8,0.15,0.2)	260	(0.5,0.5,0.5)	290	(0.6,0.35,0.4)
163	(0.6,0.35,0.4)	261	(0.34,0.71,0.58)	291	(0.8,0.15,0.2)
164	(0.75,0.2,0.25)	262	(0.5,0.5,0.5)	292	(0.29,0.75,0.63)
165	(0.57,0.39,0.43)	263	(0.75,0.2,0.25)	293	(0.46,0.53,0.54)
166	(0.8,0.15,0.2)	264	(0.47,0.55,0.5)	294	(0.6,0.35,0.4)

Table 3. Aggregate assessment of assertive communication competency of the surveyed nurses

The assessment of assertive communication competency, obtained through the calculation of the scoring function and its localization in the intervals defined in table 3, is shown in figure 2.

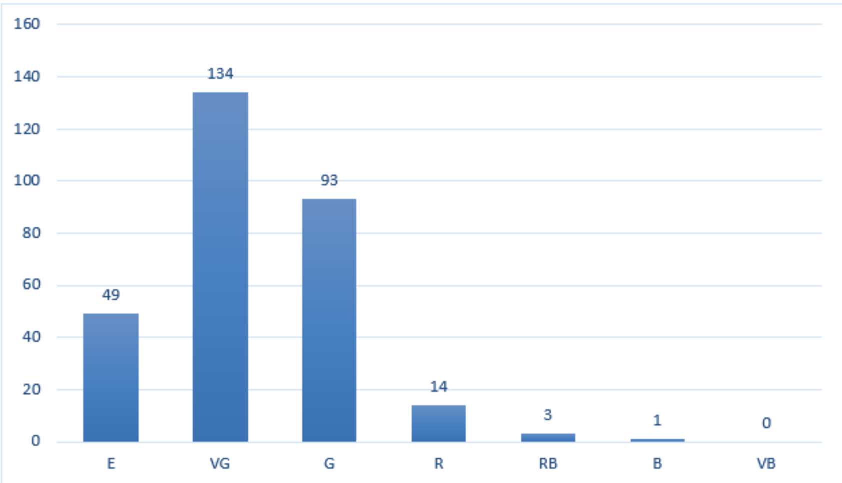

Figure 2. Absolute frequency of assertive communication competency assessments

The modal assessment is Very Good (VG), with an absolute frequency of 134 (for a relative frequency of 45.6%), followed by Good (G) category with (31.6%). It is worth remarking that only 18 surveyed have a category lower than Regular, which indicates that, in the selected simple, nursing specialists have an adequate assertiveness.

The results of the estimation of neutrosophic population proportion for a 99% of reliability of the assertive communication competency of nurses in Guayaquil are shown in table 4.

Linguistic term	Assessment	Confidence interval
Excellent	E	[12.4%, 20.9%]
Very good	VG	[39.9%, 51.3%]
Good	G	[26.3%, 36.9%]

Regular	R	[2.3%, 7.2%]

Table 4. Results of the estimation of the neutrosophic population proportion.

For the lower categories, the condition $min\{np\} \geq 5$ and $min\{n \cdot (1-p)\} \geq 5$ is not met, hence its population estimation could not be done, although evidence place it close to the zero value. It is then estimated that, at a population level, between 12.4% and 20.9% of nurses in Guayaquil reach outstanding assertive communication competency levels, while about half of them (between 49 and 51%) have an assessment that can be considered in the category of Very Good.

Conclusions

The development of assertive communication competencies allows nursing professionals to keep good relationships with their therapeutic team and the patient and avoid professional burnout. Through the neutrosophic study of a significant sample of nurses in Guayaquil, we obtained that assertive communication competencies of nurses in Guayaquil are in general Very Good as for empathy and the ability to work with emotions, assertiveness in conflict situations, and communication skills. The use of neutrosophic statistics and the linguistic terms associated with SVNS allowed a wider treatment of the assessments and the neutrosophic population proportion estimation with a 99% reliability.

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University of New Mexico

Case-based Legal Reasoning and Inductive Reasoning: Determination of the input parameters using Neutrosophic AHP

Edwin Bolívar Prado Calderón[1], Mario Aguilar Martínez[2], Tania Tupamara Camargo Martínez[3] and Lola Ximena Cangas Oña[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.edwinprado@uniandes.edu.ec

[2] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.marioaguilar@uniandes.edu.ec

[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.taniacamargo@uniandes.edu.ec

4 Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Ecuador. Email: ur.lolacangas@uniandes.edu.ec

Abstract. An Expert System as Case-Based Reasoning with the interaction of inductive reasoning is useful in predicting and evaluating domains that are difficult to formalize as is the case of the legal one. Since in this domain, a subjective environment is presented where the parties have contradictory points of view. Despite the multiple advantages of its implementation, the design of this type of system presents certain difficulties in establishing which are the predictive attributes that allow determining the similarity between a past situation and the current one, since they are mostly based on Boolean expressions. Which is in contradiction with the subjectivity of the process. To address this situation, the authors intend to establish the parameters to develop a Case-Based Legal Reasoning algorithm endorsed in a neutrosophic environment. Since the hypothesis states that its incorporation would guarantee a process where neutralities will be handled not by classical numbers but using neutrosophic numbers, which are the most natural form of measurement for human beings.

Keywords: case-based legal reasoning, subjectivity, Neutrosophy.

1. Introduction

The reasoning is a set of mental processes through which inferences are incorporated into knowledge. According to traditional philosophy, deductive and inductive methods exist to infer new information and enrich knowledge from premises and conclusions. The inference is derived from the premises, which leads to the conclusion in the inductive method. The results of induction may or may not be true, since their hypotheses have to be proved or disproved with other meanings. These hypotheses are based on personal experiences and beliefs. This leads to the key difference between deduction and induction: the first moves in the world of necessary truths and the second in probable truths [1, 2].

The validity of induction is a matter of degree and depends on the empirical support provided by the premises to reach a conclusion. Therefore, it can be said that one of the problems it faces is its justification. As a solution, it is accepted that its validity is based on the law of uniformity of nature, by which it can be assumed that the future will be similar to the past. Although it can be said that the method is a way of acquiring information through conclusions that always refer to reality, even though these are always provisional. That is, these inductive inferences are formed by empirical themes about past and future events [1].

According [3] cited in [1], for its conception the following phases are established:

1. Analysis of the elements, or the structure of the reasoning where the reasons that support the conclusion are identified.
2. Establishment of relationships between the elements determining if the relationships that may occur between the elements that make up the argument are convergent, chained, vertical, horizontal, etc. This can be achieved through answers to the following questions:
   - What are the relationships between the reasons and the conclusions?
   - How do the reasons support the conclusions?
3. Graphic representation of reasoning, both its elements and its relationships (concept maps, hierarchical diagrams, etc.). To facilitate understanding, information must be synthesized, storage and retrieval improved, and the efficiency of inference, problem-solving, and decision-making mechanisms increased.

4. Global assessment of the argument that can be carried out using in an orderly and systematic way the criteria of:
    a) degree of acceptability of the reasons that support the argument;
    b) relevance, that is, the importance of the relationships between reasons and conclusions;
    c) sufficiency, of significant reasons, whether qualitative or quantitative.

This type of reasoning is fundamental for the legal framework, where the resolution of sentences becomes a subjective process where induction is a fundamental part. According to [4]:

> Making a fair criminal decision can become an arduous task for those who administer justice to criminal offenders. This is because we are facing a subjective process, where the parties have contradictory points of view, and the one who imparts justice must be impartial before the facts, to determine the degree of guilt of the accused. Added to this is the possible lack of information on the facts, the multidisciplinary nature of the investigations, as it contains components of the natural, psychological, social, and criminal sciences. That is why an Expert System could serve as support for making this decision, although it does not replace it. (p. 1)

An Expert System as Case-Based Reasoning is useful in predicting and evaluating difficult to formalize domains as legal. In this world, casuistry is a valuable source of predictions, and therefore suitable for case-based approximations. Therefore, from a technical point of view, the main difficulty in developing this type of system lies in establishing the predictive attributes that allow determining the similarity between a past situation and the current one [5].

According to some authors, this situation can be corrected with the classification based on factors, which can be seen as an inadequate description of the reason for the decision of a case. However, from a practical point of view, a greater granularity in the factors will allow obtaining fewer arguments, which in turn will be more precise. The balance between quantity and precision can only be achieved through a set of factors established by experts in the domain being studied [6, 7].

It is important to remark that this issue underlies the problem of the recovery (location) of the information stored in databases. Which is subject to the procedure used for this purpose by combining keywords using Boolean expressions (True or False, [0; 1]). In the legal domain, users - mostly lawyers - have difficulties satisfactorily expressing their needs in Boolean terms; which usually leads to queries containing many references or irrelevant material. To make effective use of the database, this weakness must be overcome by finding a method that translates the information needs into a query expressed in technical terms that can distort the semantics of the requirements [6, 7], which is defined as the problem situation to analyze.

Therefore, it is proposed as a problem: how to develop a Case-Based Legal Reasoning (CBLR) algorithm according to inductive reasoning that provides users of the legal domain with a recovery method superior to Boolean expressions.

A bibliographic search made it possible to determine that developing this algorithm in a neutrosophic environment would suit the problem. This can be affirmed since Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities, which goes beyond Boolean expressions. Therefore, its incorporation would guarantee that the uncertainty of decision-making is taken into account, including neutralities through the neutrosophic single-valued numbers, which constitutes the most natural form of measurement in human beings [8-14].

Then, the main objective of this paper is *to establish the input parameters to develop an algorithm of Case-Based Legal Reasoning endorsed in a neutrosophic environment that favors inductive reasoning*. For which it will work as follows:

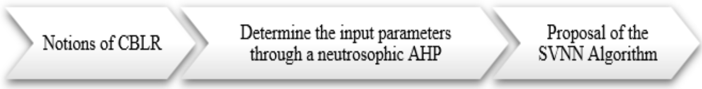

Figure 1: Specific objectives derived from the resolution of the problem raised.

2 Case-Based Legal Reasoning System

2.1 Case-Based Reasoning

Building smart systems somehow simulate the way humans solve problems. Within Artificial Intelligence there is a discipline called Knowledge Engineering that provides the methods and techniques to build computational systems called Knowledge-Based Systems [15]. These systems differ from others in their handling of large volumes of domain knowledge. Case-Based Reasoning is a set of techniques for the development of knowledge-based systems that recovers and reuses solutions from past experiences to solve similar problems and thus obtain the best results [5, 16-23].

A case-based reasoning system is a reasoning model that allows solving problems, understanding situations, and learning. These systems start from a problem already solved (case) hosted in a library of cases. These tasks are what a lawyer usually performs in everyday life, etc. A lawyer appeals to legal precedents to defend a cause, then it is said that he is using reasoning based on cases since it is a way of reasoning by making analogies [15].

According to [3], these reasoning models allow solving problems, understanding situations, and learning using memorization mechanisms, overlapping problems, and optimality criteria. They are based on three basic principles:

- Overlapping Troubleshooting - Applies to cases that use minor resolved cases.
- Bellman's optimality principle: memorize the best solution, after a selection process.
- Memorization: memorize the solutions obtained in the case library for later use.

Where its essential parts are the case base (also called the case library) and the similarity engine [5].

In general, it can be said that they have some advantages compared to traditional systems such as [3]:

- Acquisition of knowledge: The acquisition of knowledge is carried out from the previous experience stored in the case library.
- Knowledge maintenance: This allows the library to increase new cases without the intervention of the expert, making the maintenance process of the knowledge base unnecessary, lowering the cost.
- Efficiency in problem-solving: Reusability is a basic principle of computing that supports that similar cases can be solved without having to redo the knowledge base.
- Solution quality: by applying the optimality principle, it is guaranteed to memorize the best solution or what has happened in a given context.
- User acceptance: Using solutions based on cases that have already been used and tested gives confidence and acceptance to the user, which does not happen in solutions such as neural networks and case-based reasoning systems, since they can be incomprehensible to users.

Restrictions:

1. The domain of application of the cases must be regular, that is, it must not be changeable. What is true today must also be true tomorrow.
2. The problems must be recurring, that is, they must occur regularly; otherwise, it will not be necessary to memorize a case.

Solving such a system requires the following steps [15]:

Figure 2: Phases of the design of a case-based reasoning system. Source: Adapted from[15]

In cases description, the "case" itself is the main element of a case library. This allows organizing the cases of situations in a structured way. The organization must allow: first, the recovery of a subset of cases that can be applied to the problem posed, and then apply similarity measures to select from among the set of cases, the one that is closest to the problem posed. The simplest realization of the case library is through a flat memory (list or arrangement), although it can also be implemented using hierarchical memory (graph or trees).

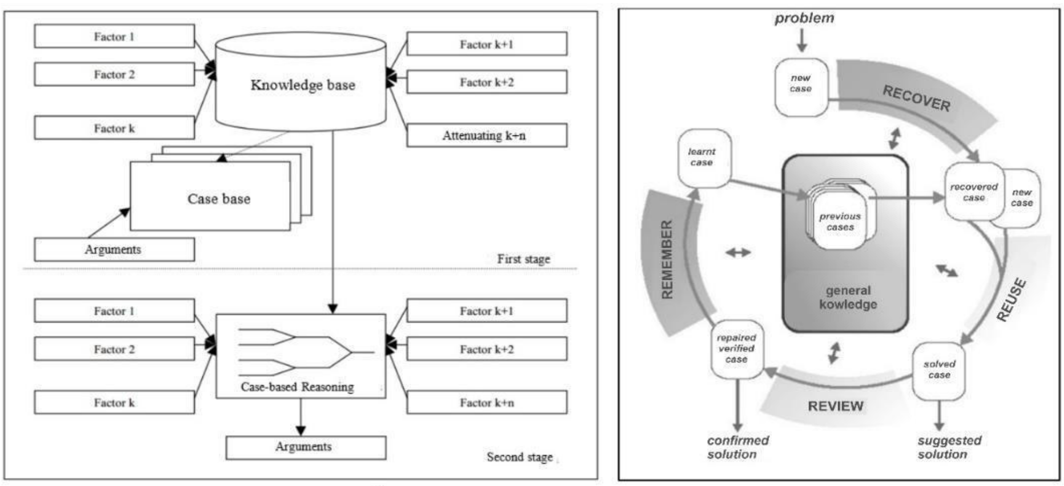

Figure 3: Case-based reasoning. Source: [5, 6]

2.2 Inductive legal reasoning in case-based reasoning

A case can be defined as a particular set of empirical circumstances that constitute a problem that needs a decision, solution, or classification. It has the particularity of presenting the circumstances and situation of a discreet episode, action, person, or thing. In practically all systems that use artificial intelligence, a case is represented by a particular name, a set of empirical circumstances or facts, and an output represented by a decision, solution, or classification given to it [6].

Experience can be referred to as the set of all instances, which means: cases that have occurred in the past and may form the basis for predicting the output of a new case. Precedent is understood to be a legal decision made in a previous case. Precedents are a subset of cases, which are a subset of experience. Based on what has been established, the term "precedence or precedent-based reasoning" indicates a form of explicit legal reasoning, where the precedent determines the outcome of a case. Through the use of factors, cases are indexed based on concepts or legal issues, rather than using keywords. This approach helps users express their information needs more consistently with their thoughts [6, 7].

3 Methods

3.1 Neutrosophy

Definition 1. Be X a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow\ ]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of true, indeterminate, and false of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

Definition 2. Be X a universe of discourse. A Single Value Neutrosophic Set of (SVNS) A over X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \qquad (1)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x$ denotes the membership functions of true, indeterminate, and false of x in A, respectively. For convenience, a Single Value Neutrosophic Number (SVNN) will be expressed as A = (a, b, c), where a, b, c ∈ [0,1] and satisfies 0 ≤ a + b + c ≤ 3.

Definition 3. A Single Value Triangular Neutrosophic Number (SVTNN), which is denoted by: $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, is a NS on $\mathbb{R}$, whose membership functions of truthfulness, indeterminacy, and falsehood are defined below:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \leq a_3 \\ 0, & \text{otherwise} \end{cases} \qquad (2)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \beta_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}\ , & x = a_2 \\ \frac{\left(x - a_2 + \beta_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \qquad (3)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \gamma_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}\ , & x = a_2 \\ \frac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \qquad (4)$$

Where, $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R} a_1 \leq a_2 \leq a_3 \leq a_4$

Definition 4: ([24-27]) given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (5)

Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (6)

Inversion: $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ where $a_1, a_2, a_3, a_4 \neq 0$ (7)

Definitions 3 and 4 refer to single-valued triangular neutrosophic number when the condition $a_2 = a_3$, [28-30]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in [31].

3.2 Neutrosophic Analytic Hierarchy Process (NAHP)

The analytic hierarchy process was proposed by Thomas Saaty in 1980 [8]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [9, 10]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [11-13]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level, the decision options are placed [14]. The levels of importance or weighting of the criteria are estimated through paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6)[32].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \quad (9)$$

We can find in [31, 33-43] the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP, or NAHP for short. Equation 10 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (10)$$

The matrix must satisfy the condition based on the inversion operator of Definition 4. $\tilde{A}$ $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [31], are the so-called score and accuracy indexes, respectively, see Equations 11 and 12:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (11)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (12)$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle (1,1,1); 0.50, 0.50, 0.50 \rangle$
3	Slightly influential	$\tilde{3} = \langle (2,3,4); 0.30, 0.75, 0.70 \rangle$
5	Strongly influential	$\tilde{5} = \langle (4,5,6); 0.80, 0.15, 0.20 \rangle$
7	Very strongly influential	$\tilde{7} = \langle (6,7,8); 0.90, 0.10, 0.10 \rangle$
9	Absolutely influential	$\tilde{9} = \langle (9,9,9); 1.00, 1.00, 1.00 \rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle (1,2,3); 0.40, 0.65, 0.60 \rangle$
		$\tilde{4} = \langle (3,4,5); 0.60, 0.35, 0.40 \rangle$

	$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
	$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [44]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 10.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, ie, aik = aijajk for all i, j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 13 and 14. To get the score and the accuracy degree of the following equations are used:$\tilde{a}_{ji}$

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \tag{13}$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \tag{14}$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{15}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Note that Step 3 refers to consider the use of the calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ [45]}, \tag{16}$$

where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by equation:

$$CR = \frac{CI}{RI} \tag{17}$$

RI is given in table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated with every order.

If CR≤0.1 we may consider that experts' evaluation is sufficiently consistent and hence we can proceed to use NAHP. We apply this procedure to matrix "A" in Equation 17.

Other useful neutrosophic insights for the document:

Linguistic term	SVN
Extremely mild (EM)	(1,0,0)
Very very mild (VVM)	(0.9, 0.1, 0.1)
Very mild (VM)	(0.8, 0.15, 0.20)
Mild (M)	(0.70, 0.25, 0.30)
Medium mild (MDM)	(0.60, 0.35, 0.40)
Medium (MD)	(0.50, 0.50, 0.50)
Medium severe (MDS)	(0.40, 0.65, 0.60)
Grave (G)	(0.30, 0.75, 0.70)
Very grave (MG)	(0.20, 0.85, 0.80)

Very very grave (MMG)	(0.10, 0.90, 0.90)
Extremely grave (EG)	(0; 1; 1)

Table 3: Neutrosophic Unique Value Numbers. Source: [13].

Similarity function Si between n NNVU, (i = 1, 2,…, m) (j = 1, 2,…, n) and a vector of values. $A_{ij} = \langle a_{ij}, b_{ij}, c_{ij}\rangle B_j^* = \langle a_j^*, b_j^*, c_j^*\rangle$

$$S_i = 1 - \left(\left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij}-a_j^*\right)^2+\left(b_{ij}-b_j^*\right)^2+\left(c_{ij}-c_j^*\right)^2\right\}\right)^{\frac{1}{2}}\right) \tag{18}$$

4 Results

4.1 Determine the input parameters to the case library using NAHP

To start the design of the legal reasoning system based on cases from an inductive perspective, it is proposed to structure the information in a library of cases. For the elaboration of this base library of the system, a structure must be entered as a form. 8 experts (legal professionals) were consulted. The method was only applied to determine the fields referring to the legal parameters of interest for the information structure and to be able to design the user interface. Not so to the regulatory fields for the identification of cases: such as id, date (yyyy /mm/dd). The information processing was divided into two phases:

Phase 1: Details of the defendant

ID	Field	Description example
A1	Name	Juan Perez
A2	Age	Under 18, between 19-29, between 30-40
A3	Race/ethnicity	White, black, Indian
A4	Sex	M / F / other
TO 5	Educational level	None, Primary, Secondary
A6	Recidivist	Otherwise
A7	Municipality	Canton, Province
A8	Guilty plea	Whether or not you plead guilty in the first instance

Table 4: Defendant's data entry parameters to the library of cases and examples.

A1	A2	A3	A4	TO 5	A6	A7	A8
$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$	$\langle(6,7,8); 0.90,0.10,0.10\rangle$
$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$
$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$
$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$
$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$
$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$
$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$

$\frac{1}{\langle(6,7,8); 0.90,0.10,0.10\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$

Table: 5. Neutrosophic paired comparison matrix.

Criteria	A1	A2	A3	A4	TO 5	A6	A7	A8	Weight		
A1	0.52	0.77	0.58	0.40	0.38	0.23	0.27	0.27	**0.43**	**Eigenvalue**	
A2	0.07	0.11	0.25	0.28	0.27	0.23	0.19	0.19	**0.20**		8.83
A3	0.07	0.04	0.08	0.17	0.16	0.23	0.19	0.19	**0.14**	**IC**	0.12
A4	0.09	0.07	0.07	0.07	0.11	0.15	0.12	0.12	**0.10**	**RC**	0.08
TO 5	0.07	0.02	0.03	0.06	0.05	0.05	0.12	0.12	0.06		
A6	0.10	0.02	0.02	0.02	0.05	0.05	0.04	0.04	0.04		
A7	0.07	0.02	0.02	0.02	0.02	0.05	0.04	0.05	0.03		
A8	0.07	0.02	0.02	0.02	0.02	0.05	0.04	0.04	0.03		

Table: 6. Weighted matrix and consistency analysis.

Phase 2: Process data

ID	Field	Description example
P1	Crime	Involuntary manslaughter, Robbery, Intimidation
P2	Means of aggression	Gun, knife, none, hands
Q3	Appeal	No, Supreme Court
Q4	Mitigating causes	Mental state, a victim of abuse
P5	Damages	Death, loss of items valued at $ 1,000, psychological damage
Q6	Judgment	Deprivation of liberty for 3 years, USD 5,000 fine, Community work

Table 7. Process data input parameters to the library of cases and examples.

P1	P2	Q3	Q4	P5	Q6
$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(4,5,6);$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$
$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$
$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$
$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$	$\frac{1}{\langle(4,5,6); 0.80,0.15,0.20\rangle}$
$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(2,3,4); 0.30,0.75,0.70\rangle$
$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\langle(4,5,6); 0.80,0.15,0.20\rangle$	$\frac{1}{\langle(2,3,4); 0.30,0.75,0.70\rangle}$	$\langle(1,1,1); 0.50,0.50,0.50\rangle$

Table 8. Neutrosophic paired comparison matrix.

Criteria	P1	P2	Q3	Q4	P5	Q6	Weight		
P1	0.9375	5.1562	5.1562	5.1562	2.6437	2.6437	**0.334410**		
P2	0.2120	0.9375	5.1562	2.6437	0.3182	0.9375	**0.096940**	**Eigenvalue**	5.46869

Q3	0.2120	0.2120	0.9375	2.6437	0.3182	0.2120	0.050220	**IC**	0.058115
Q4	0.2120	0.3182	0.3182	0.9375	0.2120	0.2120	0.035719	**RC**	5.7863
P5	0.3182	2.6437	2.6437	5.1562	0.9375	2.6437	**0.208733**		
Q6	0.3182	0.9375	5.1562	5.1562	0.3182	0.9375	**0.127504**		

Table: 9. Weighted matrix and consistency analysis.

The results were exposed to the round of experts where it was determined that in the case of the defendant's data, it must be entered in the system interface: Name, Age, Race/ethnicity, and Sex. For the criteria of the process: Crime, Means of aggression, Damages, and Sentence.

4.2 System architecture design

For the system's design, the models exposed in [4, 6, 7, 15], to which the Neutrosophy will be inserted for the level of granularity with the SVNNs in the similarity equation. With which it will be possible to obtain in the function "Retrieve Argument" several cases that indicate not only the most similar stored, but the other less similar and so on. Of course, as long as it contains the factors specified in the rule. This way, the expert system can retrieve the foundation for the recommendations it issues. The granularity of the cases is determined by the number of factors involved in the formation of the rule.

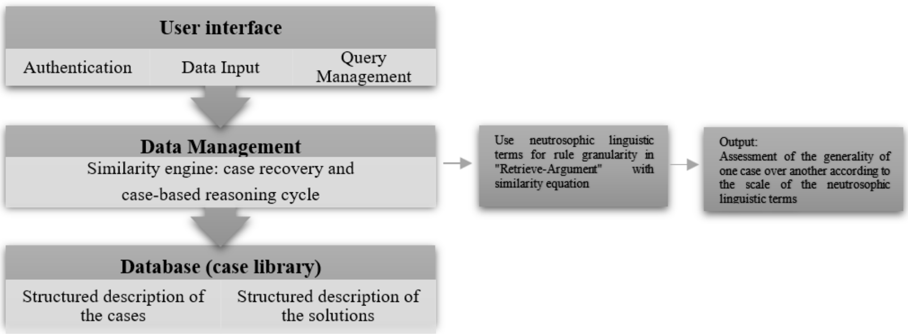

Figure 4: System design.

Conclusion

Reasoning based on precedents, as a technique to generate arguments, is easy to implement and highly useful in legal expert systems. These systems are based on the principles of overlapping problems, memorization, and the optimality principle. Likewise, it can be said that they are easily understood by the expert, since the system does not handle abstract concepts, but rather concrete situations (cases) of the domain known to the expert. With its implementation, an increase in the effectiveness of the legal expert's time management as well as of the system is evidenced, since over time it is nurtured by new cases. The advantage lies mainly in cost reduction, speed in software development, and risk reduction. However, its greatest limitation is the programming time required. Many times the translation of what is desired becomes complicated and its development and implementation take longer. But once materialized, it is widely accepted. The algorithm designed by the legal expert system will be able to apply the forward inference mechanism to recover the arguments linked to other cases and use them as the basis for the decision it generates. For this case, the use of factors instead of keywords was considered to guarantee the accuracy of the information displayed. A training action by the working group is recommended, which must be composed of legal, mathematical, and computer experts or related specialties. Explanation of recommendations is an essential feature for expert systems.

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Neutrosophic Sentiment Analysis in Transcriptions of in-depth Interviews for Action Research

Iruma Alfonso González[1], María Fernanda Latorre Barragán[2], Delia Marlene López Domínguez[3] and Adriana López Falcón[4]

[1] Regional Autonomous University of the Andes (UNIANDES); Ecuador. Email: ua.irumaalfonso@uniandes.edu.ec
[2] Regional Autonomous University of the Andes (UNIANDES); Ecuador. Email: ua.marialatorre@uniandes.edu.ec
[3] Regional Autonomous University of the Andes (UNIANDES); Ecuador. Email: ua.delialopez@uniandes.edu.ec
[4] Regional Autonomous University of the Andes (UNIANDES); Ecuador. Email: ua.adrianalopez@uniandes.edu.ec

Abstract. In-depth interviews are a method widely used by researchers, which are processed once transcribed. Currently, with the development of computer programming, the use of a natural language processing method to analyze such interviews has spread. There are dissimilar programs of various kinds, where lexicons offer highly useful benefits for researchers as they save time and increase efficiency. In essence, these expose how positive or negative a text related to a topic can be. Taking into consideration the usefulness of Neutrosophy for social phenomena and the treatment of indeterminacies, vagueness, and neutralities, it is convenient to establish as an objective of this paper: to develop a method for the sentiment analysis of the transcripts of in-depth interviews in Action Research based on natural language processing and Single Value Neutrosophic Numbers (SVNN). The most important characteristics to take into account in the in-depth interviews will be determined. Then the lexicon will be selected for the natural language processing of the research to fulfill its main objective.

Keywords: in-depth interviews, action research, SVNN, VADER.

1 Introduction

Action research is a form of collective introspective inquiry undertaken by the participant in social situations. It aims to improve the rationality and justice of these social or educational practices, as well as the understanding of the situations in which they take place. It is then said that the researcher mixes theoretical knowledge with knowledge of a specific context [1, 2]. This is especially important in the social sciences, where it is used in many investigations as a primary source of information to obtain meaningful knowledge and draw broad conclusions [3-5]. It generally sticks to the following process:

- Planning
- Action
- Observation
- Reflection
- Action Research Report

For its development, some techniques and instruments are included within the methodology such as:

- Participatory Research
- Thematic Concern
- Professional development
- Curricular Model
- In-depth interview
- Observation: field journal and interpretation

Among these, in-depth interviews are a method widely used by researchers since they allow collecting qualitative data and a large amount of information about the behavior, attitude, and perception of the interviewees. During in-depth interviews, researchers and participants are free to explore additional points and change the course of the process when necessary, as it is an independent research method that can be adopted by multiple disciplines depending on the research needs [6]. However, they have the following details [6]:

Advantages	Disadvantages
They allow the researcher and participants to have a comfortable relationship to generate more in-depth answers regarding sensitive topics.	They are time-consuming, as they must be transcribed, organized, analyzed in detail.
Researchers can ask follow-up questions, obtain additional information, and return to key questions	If the interviewer is inexperienced, the process can

to gain a better understanding of the attitudes of the participants.	be affected or slowed.
There is a lower quality of sampling compared to other data collection methods.	Participants must be chosen carefully to avoid bias, which can lengthen the process.
Researchers can monitor participants' changes in tone and word choice to gain a better understanding of opinions.	It is an expensive process compared to other methods.
Fewer participants are needed to obtain useful information.	Generally, participants decide to collaborate only when they receive an incentive in return.

Table 1. Advantages and disadvantages of in-depth interviews

As can be verified in Table 1, the transcriptions are an important part of this since it constitutes a disadvantage because, in addition to the inherent table work, the words used by each interviewee must be evaluated in terms of "measuring" the feelings. Therefore, the unconscious biases of the authors or researchers could affect the learning of each new interview and the proper use of the researchers' time. That is why for the present investigation we decided to apply Neutrosophy. This science is characterized by treating subjectivity and the concept of indeterminacy. Neutrosophic sets are used for interview sentiment analysis as a qualitative research tool [4, 5].

On the other hand, it is important to deal with the transcriptions, which raises a need to include a natural language processing method in the research. This discipline is convenient because its objective is to achieve communication between human beings and computers, obtaining the main idea of a text, document, or opinion, with the possibility of developing systems capable of carrying out tasks according to the language [7-14].

According to what has been proposed so far, the authors of this article agree on the need to include in the present investigation, the use of the benefits offered by Neutrosophy, a method of Natural Language Processing that exposes how positive or negative a sentiment can be. Consequently, the objective of the article is established to elaborate a method for the sentiment analysis for the transcriptions of in-depth interviews in action research based on natural language processing and the Single-Valued Neutrosophic Numbers (SVNN). The following specific objectives are established as a guideline for the investigation:

1. Determine the most important characteristics to take into consideration in in-depth interviews.
2. Select lexicon for research natural language processing
3. Develop a method for sentiment analysis in transcriptions including the selected lexicon fused with the SVNNs.

From now on, the document is developed in several sections: materials and methods where objectives 1 and 2 are met; then section 3, where the elaborated method is shown. Finally, the conclusions reached once the work is finished are presented and the bibliographic references are subsequently declared.

2 Materials and methods

2.1 In-depth Interview

The most important characteristics of in-depth interviews are [6]:

- In-depth interviews have a flexible structure. Although it is unstructured, it covers few topics based on a guide, which allows it to cover appropriate areas for the interviewee.
- This method is characterized by being interactive. The interview process, the material that is produced, and the interaction where the interviewer poses initial questions in a positive way for the respondent to be encouraged to answer.
- Many probing techniques are used in in-depth interviews, so understanding the results is achieved through exploration and explanation. The interviewer uses follow-up questions to gain a deeper perspective and understanding of the participants' meaning.
- The interview is generative, that is, new knowledge is developed. Researchers and participants present ideas for a specific topic and some solutions to the problems posed.

2.2 Natural language processing

Currently, we are working with the classification of the polarity of emotions since they can show the different points of view that a user has concerning what they are living in their current environment. They can be defined as "Agitations or states of mind produced by ideas, memories, desires, and feelings, helping people to react quickly to social or personal events, being positive or negative". [15] Mentions that natural language processing can be applied to sentiment analysis to classify documents, texts, or opinions from the identification and extraction of subjective information.

Sentiment analysis is a task contemplated within natural language processing and machine learning, which allows opinions to be analyzed to know the main needs of users. There are several programs for word processing. On [16], a comparison between them is exposed as shown in the following figures.

	Correlation to ground truth (mean of 20 humanraters)	3-class (positive, negative, neutral) Classification Accuracy Metrics: Overall Precision	Overall Recall	Overall F1 score	Ordinal Rank (by F1)		Correlation to ground truth (mean of 20 humanraters)	3-class (positive, negative, neutral) Classification Accuracy Metrics: Overall Precision	Overall Recall	Overall F1 score
Social Media Text (4,200 Tweets)							**Movie Reviews (10,605 review snippets)**			
Ind. Humans	**0.888**	0.95	0.76	0.84	2	1	0.899	0.95	0.90	0.92
VADER	0.881	**0.99**	**0.94**	**0.96**	1*	2	0.451	0.70	0.55	0.61
Hu-Liu04	0.756	0.94	0.66	0.77	3	3	0.416	0.66	0.56	0.59
SCN	0.568	0.81	0.75	0.75	4	7	0.210	0.60	0.53	0.44
GI	0.580	0.84	0.58	0.69	5	5	0.343	0.66	0.50	0.55
SWN	0.488	0.75	0.62	0.67	6	4	0.251	0.60	0.55	0.57
LIWC	0.622	0.94	0.48	0.63	7	9	0.152	0.61	0.22	0.31
ANEW	0.492	0.83	0.48	0.60	8	8	0.156	0.57	0.36	0.40
WSD	0.438	0.70	0.49	0.56	9	6	0.349	0.58	0.50	0.52
Amazon.com Product Reviews (3,708 review snippets)							**NY Times Editorials (5,190 article snippets)**			
Ind. Humans	0.911	0.94	0.80	0.85	1	1	0.745	0.87	0.55	0.65
VADER	0.565	0.78	0.55	0.63	2	2	0.492	0.69	0.49	0.55
Hu-Liu04	0.571	0.74	0.56	0.62	3	3	0.487	0.70	0.45	0.52
SCN	0.316	0.64	0.60	0.51	7	7	0.252	0.62	0.47	0.38
GI	0.385	0.67	0.49	0.55	5	5	0.362	0.65	0.44	0.49
SWN	0.325	0.61	0.54	0.57	4	4	0.262	0.57	0.49	0.52
LIWC	0.313	0.73	0.29	0.36	9	9	0.220	0.66	0.17	0.21
ANEW	0.257	0.69	0.33	0.39	8	8	0.202	0.59	0.32	0.35
WSD	0.324	0.60	0.51	0.55	6	6	0.218	0.55	0.45	0.47

Figure 1. VADER results for other lexicons. Source:[16].

Best lexicons	Assessment
VADER	0.96
Emoticons	0.92
SentiStrength	0.84
SentiWordNet	58.99
SenticNet	74.65
Hu-Liu (opinion lexicon)	65.2
SO-Cal	78.74

Figure 2. Analysis of the lexicons. [15]

It can be seen that the VADER method shows better levels of association, sometimes even higher than that of the reference human experts. On [15], VADER is also shown to have the best evaluation among the lexicons. Therefore, it is convenient to choose this lexicon as the basis for the design of the method to be elaborated in this research since the references consulted allowed to determine that VADER is successful since it not only talks about the positive or negative score but also, about how positive or negative a sentiment can be [16].

2.2.1 VADER

Over the years it has been possible to observe the development of various computational methods of sentiment analysis such as the Valence Aware Dictionary for Sentiment Reasoning text sentiment analysis (VADER) [15, 17]. Completely open-source licensed under the MIT license, it was designed for sentiment analysis on social media. The VADER method is based on rules that classify the polarity of the emotions of opinions using a list of words called a lexicon (it is convenient to say a priori that a lexicon is defined as an ordered series of words of a language, a person, a region, a subject or a specific time) [18, 19].

Lexical knowledge that a speaker possesses about a language, to classify those expressed on Twitter initially, but its use has spread. This supervised method exposes a lexicon that evaluates lexical characteristics such as acronyms, emoticons, abbreviations, and initials by rules which determine the classification of the opinion by the number of negative or positive words that the opinion contains. The VADER lexicon contains 7,517 words including emoticons, abbreviations, acronyms, and initials labeled by the valence of -4 to 4. The VADER lexicon was obtained by applying the Machine Learning methodology, Wisdom-of-Crowds (the group wisdom), and the use of lexicons (LIWC, ANEW, GI). Classification of the polarity (positive, negative, or neutral) of an opinion is done by the values of each word in the method lexicon.

2.3 Notions of Neutrosophy

Neutrosophy is a new branch of philosophy that studies the origin, nature, and scope of neutralities created by Professor Florentin Smarandache. Its incorporation guarantees that the uncertainty of decision-making is taken into account, including indeterminacies where experts will issue their criteria evaluating linguistic and non-numerical terms, which constitutes the most natural form of measurement in human beings [20-25]. Logic and neutrosophic sets, for their part, constitute a generalization of Zadeh's logic and fuzzy sets, and especially of Atanassov's intuitionist logic, with multiple applications in the field of decision-making and machine learning [21, 23, 26-28]. The truth value in the neutrosophic set is as follow [28-30]**:**

Let be $\boldsymbol{N} = \{(\boldsymbol{T}, \boldsymbol{I}, \boldsymbol{F}): \boldsymbol{T}, \boldsymbol{I}, \boldsymbol{F} \subseteq [\boldsymbol{0}, \boldsymbol{1}]\}\boldsymbol{n}$, be a neutrosophic evaluation of a mapping of a group of formulas propositional to $\boldsymbol{N}$, and for each sentence $\boldsymbol{p}$:

$$\boldsymbol{v}(\boldsymbol{p}) = (\boldsymbol{T}, \boldsymbol{I}, \boldsymbol{F}) \quad (1)$$

To facilitate the practical application in real-world problems [7], the use of Single-Value neutrosophic Sets (SVNS) was proposed, through which it is likely to use linguistic terms to obtain greater interpretability of the results[8]. Let X be a universe of discourse, an SVNS A over X has the following form [9]:

$$\boldsymbol{A} = \{\langle \boldsymbol{x}, \boldsymbol{u_a}(\boldsymbol{x}), \boldsymbol{r_a}(\boldsymbol{x}), \boldsymbol{v_a}(\boldsymbol{x}) \rangle : \boldsymbol{x} \in \boldsymbol{X}\} \quad (2)$$

Where $\boldsymbol{u_a}(\boldsymbol{x}): \boldsymbol{X} \to [\boldsymbol{0}, \boldsymbol{1}], \boldsymbol{r_a}(\boldsymbol{x}): \boldsymbol{X} \to [\boldsymbol{0}, \boldsymbol{1}]\ \boldsymbol{y}\ \boldsymbol{v_a}(\boldsymbol{x}): \boldsymbol{X} \to [\boldsymbol{0}, \boldsymbol{1}]$

With

$$\boldsymbol{0} \leq \boldsymbol{u_a}(\boldsymbol{x}), \boldsymbol{r_a}(\boldsymbol{x}), \boldsymbol{v_a}(\boldsymbol{x}) \leq \boldsymbol{3}, \forall\ \boldsymbol{x} \in \boldsymbol{X} \quad (3)$$

The intervals denote the memberships related to true, indeterminate, and false from x in A, respectively$\boldsymbol{u_a}(\boldsymbol{x}), \boldsymbol{r_a}(\boldsymbol{x})$ **y** $\boldsymbol{v_a}(\boldsymbol{x})$[10]. For convenience reasons, a Single Value Neutrosophic Number (SVN) is expressed as A = (a, b, c), where a, b, c∈ [0.1] and 0 ≤ a + b + c ≤ 3 [31].

Let A = (a, b, c) be a single-valued neutrosophic number, a score function S related to a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and falsity membership degree is defined [32]:

$$\boldsymbol{s}(\boldsymbol{V_i}) = \boldsymbol{2} + \boldsymbol{T_i} - \boldsymbol{F_i} - \boldsymbol{I_j} \quad (4)$$

3 Results

3.1 Model designed for the research

For this particular case, we developed the following model based on [7, 15-17].

Phase 1. Preparation of the data source

- Step 1.
  In-depth interviews: Interviews should not be structured; but facts, beliefs, feelings, norms of action, conscious reasons for beliefs, norms of conduct, and/or other aspects of interest to the researcher must be obtained with clarity. The use of a tape recorder or similar device is recommended, as well as a researcher's diary where both the information offered by the interviewee and the impressions of the interviewer are collected. It is important to maintain ethics throughout the process. For this purpose, you must:
  a) Make a script or list of topics of interest to obtain the necessary information about the respondent and the context in which he operates. All this is to add key and secondary questions as the interview takes place.
  b) Schedule the interview at a time and date that the interviewee chooses.
  c) Transmit security and confidence to the interviewee.
  d) Establish a maximum duration of the process.
  e) Observe and make notes on the body expressions and gestures of the interviewee. The annotations in the notebook, diary, or document must be made according to the rules.
- Step 2.
  Transcriptions: They are transcribed into text obtaining a set of data for training and tests related to implicit or explicit feelings according to the rules in table 3. The rules, as well as these conditions, must be strictly respected to normalize the transcription:
  a) Do not include emoticons or idiomatic phrases such as OMG (“Oh my God”) in their substitution, place the interviewer's impression or ask directly how it made them feel (euphoric, happy, sad, afraid, or furious). Although VADER works well with this type of character, it would imply great subjectivity if the transcriber is not the same person as the interviewer and errors could be inserted in the appreciation.

b) Transcribe the impressions of the popular Latin American slang of the region and of the social class of the interviewees, which many times replace the classic words of the Spanish language such as *chévere* or *divino*.

After those steps are taken, the authors of the research will verify the quality of the data, evaluations, and validations of collective origin.

Phase 2. Sentiment analysis processing

- Step 3.

  Processing planning

  a) Adaptation from [33]: the concepts will be divided into 6 and not 4 as the method exposes, but neutrosophic linguistic terms will be associated with each one as explained:

Examples of lexicons associated with polarity	Neutrosophic linguistic term for determining polarity	SVNN
Sharp capital letters, exclamation marks associated with phrases with positive words in the superlative (great, super, hyper, ultra, mega, terrific, incredible, phenomenal, amazing). Sentences that contain more than one word associated with these words or their family. Font size 12 points.	Extremely positive (EP)	(1,0,0)
Phrases that express positive feelings (good, well, pleasant, joy, wonderful, special, divine). Sentences that contain more than one word associated with these words or their family. Font size 10 points	Very positive (VP)	(0.8,0,15,0.20)
Phrases that express feelings of unhappiness (not very good, unpleasant, difficult, hard). Sentences that contain more than one word associated with these words or their family. Font size 10 points	Medium Negative Neutral (MNN)	(0.40,0.65,0.60)
Phrases that express feelings qualified as (bad, frightening, panic). Sentences that contain more than one word associated with these words or their family. Font size 10 points	Very negative (VN)	(0.20,0.85,0.80)
Sharp capital letters, exclamation marks associated with phrases with negative words, hate words in the superlative (lousy, terrible). Sentences that contain more than one word associated with these words or their family. Font size 12 points.	Extremely negative (EN)	(0,1,1)

Table 3. Association of SVNN to VADER

  b) Classify the polarity of the transcripts: a categorization adapted from that shown by [34, 35]:

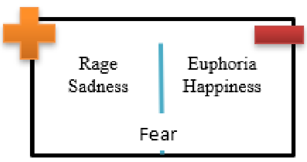

Figure 3. Adaptation of the polarities of the VADER method [34, 35]

c) Apply equation 4 for deneutrosophication as used in [19] to determine in a range of $\mathbf{0} \leq \boldsymbol{u_a}(\boldsymbol{x}), \boldsymbol{r_a}(\boldsymbol{x}), \boldsymbol{v_a}(\boldsymbol{x}) \leq \mathbf{3}$, the level of sentiment and thus evaluate the process to reach conclusions.

- Step 4.
  Processing: develop a workflow in Orange Data mining [36] to analyze the sentiment in the interviews incorporating the sentiment analysis according to table 3. The opinion analysis component predicts the opinion of each document in a corpus and processes the information using VADER and the programmed rules.

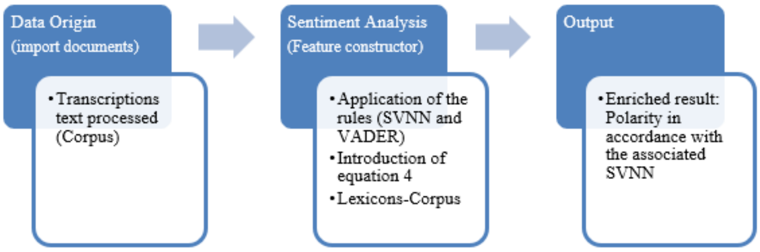

Figure 4. Workflow to be programmed in Orange Data mining. Source: Adapted from [15]

- Step 5.
  Final classification: the score function for single-valued neutrosophic sets is proposed to make the distinction between numbers in this scale $\mathbf{0} \leq \boldsymbol{u_a}(\boldsymbol{x}), \boldsymbol{r_a}(\boldsymbol{x}), \boldsymbol{v_a}(\boldsymbol{x}) \leq \mathbf{3}, \forall\, \boldsymbol{x} \in \boldsymbol{X}$. The designed method should show the sentiment score for every interview, that score function allows ranking single-valued neutrosophic numbers and gives a single numerical value. The authors processed a written interview transcript with observations and insights and quantified it using neutrosophy in conjunction with other research methods.

Phase 3. Method programming

As can be seen in figure 5, initially the dataset is loaded through a widget file, then it is processed by applying the single value neutrosophic numbers and the relevant equations through a Python Script and the Features Constructor. Finally, the results are shown in a Box Plot, to see in detail the values at the output of the process, a Data Table was placed to better analyze the results: apply filters, count, sort, etc.

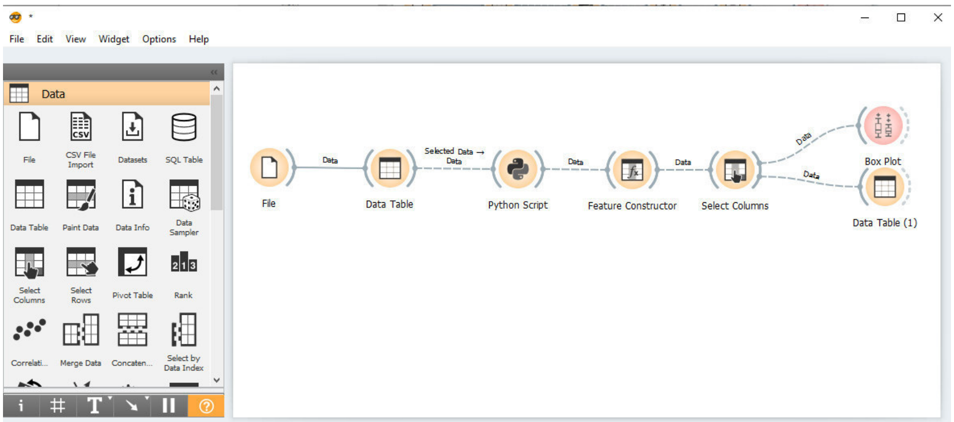

Figure 5. Workflow in Orange Data mining.

Conclusion

- During the conduct of the research, the importance of sentiment analysis in the metadata managed to carry out the action research methodology was verified. All this is due to the inherent subjectivity of the process. Its examination due to the amount of data processed requires a lot of time and resources that researchers often do not have. For this reason, the automated processing of this is extremely convenient since it can respond to the theoretical and epistemological foundations of action research as a type of qualitative research.
- An important part of qualitative research is the inductive logic of processes and the flexibility of their

application to recommend alternative processes in solving social problems in their professional environment. The foregoing is given in the verification carried out in this investigation, since for the analysis of feelings in the opinion mining process, thanks to this logic, it could be determined that VADER is very appropriate. In the same way, due to its programming, it is compatible with Neutrosophy, which is why it is fused for its enrichment with the single-valued neutrosophic numbers.

- In the present work, an opinion mining analysis was carried out where the results to be obtained with the VADER extension in a neutrosophic environment showed that it is more advantageous since metadata may partially belong to a segment of the indicated interval and its level of membership can be determined.
- The main rules, as well as the conditions of the study, were established taking into account the limitations of colloquial language.
- The methods show a sentiment score for every interview. That score function allows to rank single-valued neutrosophic numbers and offers a single numerical value. The researchers processed a written interview transcript with observations and insights and quantified it using neutrosophy in conjunction with other research methods.

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Hermeneutical Analysis of the Determinants of Obesity using Neutrosophic Cognitive Maps

María de Lourdes Llerena Cepeda[1], Jhofre Vinicio Prado Quilambaque[2], Alba Margot Núñez Quispe[3] , Edid Tatiana Mejía Álvarez[4] and José Felipe Ramírez Pérez[5]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.mariallerena@uniandes.edu.ec
[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.jhofrequilambaqu@uniandes.edu.ec
[3] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.albanunez@uniandes.edu.ec
[4] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.edidmejia@uniandes.edu.ec
[5] Universidad Autónoma de Baja California, México. Email: jramirez14@uabc.edu.mx

Resume. Obesity is a chronic, non-contagious disease to which attention has been paid worldwide at all times, but current studies are focused on childhood and adolescent obesity after the Covid-19 pandemic. The reason lies in the fact that the younger the child, the greater the risk of developing complications during his life. That is why it is established as a problem to be analyzed from various points of view. Consequently, this study aims to develop a causal analysis of the determinants of childhood and adolescent obesity in post-COVID-19 Ecuador using Neutrosophic Cognitive Maps from a hermeneutical point of view. The authors consider as an idea to defend that by analyzing the determining factors of childhood and adolescent obesity after the influence of Covid-19, it will be possible to strengthen the coordination and articulation mechanisms of the State, which allow the development of strategic actions to prevent overweight and obesity in the population. To achieve this, a referential framework for child-adolescent obesity was established, a working procedure was elaborated combining the hermeneutical method with neutrosophic cognitive maps for the causal analysis, and conclusions were issued where strategies were established according to the observed patterns and world trends in the face of the phenomenon that allow the development of strategic actions to prevent overweight and obesity.

Keywords: child-adolescent obesity, factors, neutrosophic cognitive maps, strategies.

1 Introduction

Overweight and obesity have become one of the main global health problems, affecting all age and socioeconomic groups [1]. According to UNICEF, the Covid-19 pandemic threatens to increase the number of overweight and obese children in countries like Ecuador. As stated in [2], 35 out of every 100 children between the ages of 5 and 11 are overweight or obese in Ecuador. It is predicted that in 2030 the number of deaths due to obesity will add 13,000 people to the 22,000 who currently die each year in Ecuador [2-12]. According to the data presented by [12], from 2012 to date there has been an increase in overweight and obesity at the national level and the problem is generalized to new-age groups. Previously, they were mainly presented in adults and older adults. Now it has even spread to children [12], as can be seen in the following figure:

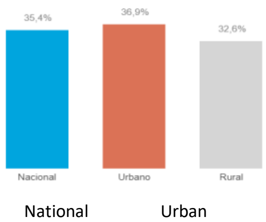

Figure 1. Overweight and obesity in Ecuador 2020, in children from 5 to 11 years old. Source: [2]

The causes of obesity are multiple and complex. In general, it is accepted as an energy imbalance between the calories consumed and the calories used through exercise and daily activities, so the body stores excess calories in the form of fat [13]. It is said to be a multifactorial disease, but it is mainly associated with inadequate eating habits and little physical activity. Various epidemiological studies hypothesize that obesity has its origin in fetal nutrition or lactation (programming theory) [14]. However, it can be said that it is not simply the result of overeating. Other factors lead to it [2, 12-18].

Obesity is a chronic, non-contagious disease to which worldwide attention has been paid at all times, but current studies are focused on childhood and adolescent obesity. The reason lies in the fact that the younger the child, the greater the risk of developing complications during his life. Moreover, the chances of persisting obesity into adulthood are 20% at 4 years of age, and 80% at adolescence. Therefore, the prevention of the disease from an early age plays an important and decisive role in human health [3, 14, 19, 20].

For all the above-mentioned, it is decided to focus this investigation mainly on these age groups. Due to the importance of prevention and the possibility of adopting proactive strategies. According to [2], child overweight is a structural problem since it reflects the poverty that exists in Ecuador, which has not been addressed from an integral perspective, so it is decided to expose this as a problem to be analyzed. It is necessary to say that the object and field of the present investigation have a certain level of subjectivity, so it is convenient to analyze the problem situation from various points of view. Consequently, it is advantageous to use the hermeneutical method in an environment of uncertainty to establish a quantitative causal analysis.

After a review of the bibliography and consultation with several authors [21-36], it is decided that, due to its versatility in the investigation of causal factors, the Neutrosophic Cognitive Maps (NCM) will be chosen from the theory of neutrosophy proposed by Florentin Smarandache, for the treatment of neutralities. Which generalizes theories [35] and it has numerous applications in many fields. Moreover, its use enriches the possibilities of analysis, mainly due to the addition of the notion of indeterminacy and the possibility of calculating using linguistic terms that is more natural for experts [37].

NCMs according to [13], are a way of representing knowledge using a graph, the strength between the relationship can be measured, which is why it is used in social studies [11] [14]. Due to this, the main objective of this research is to develop a causal analysis of the determinants of child and adolescent obesity in post-covid-19 Ecuador using NCM from a hermeneutical perspective. Furthermore, the authors consider it an idea to defend that when analyzing the determining factors of Child and adolescent obesity after the influence of Covid-19, the State's coordination and articulation mechanisms will be strengthened, allowing the development of the strategic actions necessary to prevent overweight and obesity.

To achieve this objective, the following specific objectives must be executed:

1. Establish a reference framework for childhood and adolescent obesity
2. Develop a working procedure combining the hermeneutical method with NCMs for causal analysis.
3. Partial conclusions where strategies are established according to the observed patterns and world trends in the face of the phenomenon.

From now on, the document is structured according to the stated objectives.

2 Referential framework of childhood obesity

Through a web search, we obtained the references shown in [1-20], about which can be said that:

1) 100% agree that obesity is a concern of all countries regardless of their economic status and that it affects all ages, triggering chronic health problems such as diabetes, high blood pressure, heart disease, and other non-contagious chronic diseases. This is the main concern of its condition in children so prevention is necessary.
2) 60% agree that this social problem has increased enormously after the pandemic in Ecuador, affecting especially children and adolescents.
3) Few studies have been done on children up to preschool age. From the study carried out in [14], it was detected that in the group of obese or overweight children it was evidenced that there was an association between the alteration of the state of nutrition due to excess and the variables: family history of obesity, birth weight, and abdominal circumference. It can be said that the highest values have been found in female infants and urban areas. It was also shown that there was a significant relationship between children born macro-fetus and obesity, so family history should also be considered. Parents reported physical activity and eating habits. Despite the lack of association between these variables, there was a trend towards a decrease in the intensity of physical activity in obese children. Although many parents think that preschoolers are very active, which would favor a higher energy expenditure, various studies show that physical activity is low [14].

4) Epidemiological studies, the experts consulted, as well as the interview with obsessed parents and children established the following as causal factors:

   a) Age: As you get older, hormonal changes and a less active lifestyle contribute to the arrival of obesity. Furthermore, in children, it has been perceived that insufficient maternal breastfeeding implies a tendency to obesity since breast milk is replaced by other nutritional components sometimes unsuitable for the infant. As people get older, their habits change, including eating habits. It has been noted that adolescents whose schools are close to unsuitable food sources tend to consume more of these during their teaching day.
   b) Female sex: mainly associated with pregnancy and menopause. Obesity also occurs in women who have polycystic ovary syndrome, which is an endocrine condition that prevents proper ovulation. Being a man would decrease the probability of being overweight by 6 percentage points
   c) Ethnicity: Obesity is highly prevalent in Afro-descendants and people of Hispanic origin. To have indigenous origin would increase the probability of being overweight or obese by about 9 percentage points.
   d) Unhealthy eating: in the last 50 years there has been a universal tendency to eat foods rich in fat, salt, and sugar. Too many calories are consumed, fast foods and high-calorie drinks are abused. Too high consumption of cereals (rice, pasta, bread), oils and fats, sugars, and sweets. In turn, it was found that the consumption of sweetened beverages exceeds the consumption of fruits and vegetables. Similarly, the consumption of meals prepared outside the home, which in the urban region consumption is higher, probably due to the greater access and availability of these foods compared to the rural area. This could be related to the high consumption of fats and sugars found in meals prepared outside the home. Consumption of packaged products, high-energy snacks, soft drinks, little intake of fruits and vegetables. It has been stated that adolescents tend to be the majority group in the consumption of these types of products.
   e) Sedentary lifestyle: a sedentary way of life due to the automation of work activities, modern means of transport, and a greater urban life, which influences the decrease in the practice of physical exercise. Sports activities at school are not relevant in the case of schoolchildren whose mothers have a high educational level. One possible explanation is that the homes of the schoolchildren that make up this group would have more resources to practice sports outside of school. On the other hand, schoolchildren belonging to groups with a lower socioeconomic level would face more restrictions to access instances for physical activity outside of school [19].
   f) Sociocultural and economic factors: it is associated with a lower level of education and a lower level of income to buy healthy food. Poverty in general, since it does not allow access to healthier food due to its price and is linked to the low educational level of parents, leads to promoting the consumption of canned, packaged, and chemically processed foods. In the same way, advertising affects this group, since they tend to be a victim of excess promotion for the consumption of this type of food. In the same way, the characteristics of the neighborhood, the population density, and the availability of healthy food. Among other characteristics, they can influence the creation of an environment that increases the probability that a person will be overweight or obese. The mother's education is influential in obesity only for the segment of schoolchildren with mothers with a high educational level, decreasing by 14.2 percentage points the probability that the schoolchild is overweight in relation to those who have mothers with a low educational level.
   g) Behavioral factors: that is, unhealthy lifestyles where there is incorrect food consumption, smoking, and alcohol intake, as well as incorrect sleeping habits. It is observed that a shorter distance between the school and the nearest fast food restaurant could be especially detrimental for schoolchildren of high socioeconomic status. This is possibly explained because, although the schoolchildren that make up this group have greater flexibility in choosing their diet, they also have greater purchasing power in relation to those with a lower socioeconomic level. To the detriment of their nutritional condition, schoolchildren with a high socioeconomic level are more likely to afford and consume this type of food without adult supervision.
   h) Genetic factors: some genetic studies have determined that obesity can be inherited with genes that influence the amount of body fat and its distribution.
   i) Certain medications: some medications can cause weight gain if not compensated by diet or exercise: among these medications are some antidepressants, anticonvulsants, steroids, antipsychotics, diabetes medications, and beta-blockers.

3 Methods

For the development of this research, a quantitative methodology was used because it allows precise analysis with numerical percentages. In addition, the method of documentary research, bibliographic, field and observational research, inductive/deductive method was used to conduct the hermeneutical analysis. This method allows establishing and analyzing different perspectives and compares them with the literature consulted. The following form of hermeneutical analysis was taken:

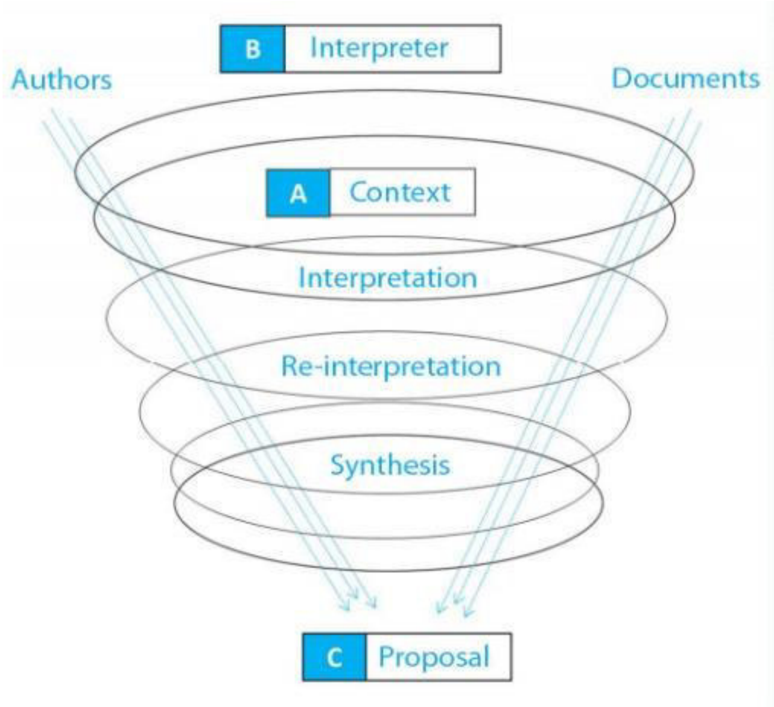

Figure 2. Hermeneutical spiral general design. Source: [38].

The literature consulted [38-48], allowed us to know that this method offers the possibility of interpreting the same problem from different points of view. With which it is possible to integrate the problem analyzed from various perspectives and adopt dynamic positions. In this reality of the author of the text, of the text itself, and the interpreter's environment, a dialogue is conjugated. Therefore, it is said that it is an interpretive activity and answers, between the horizons that merge, due to the close relationship between asking and understanding.

Reason for which it is said to be characterized by a high level of subjectivity and therefore there is uncertainty. In other words, hermeneutics tends to qualitative interpretation, which leads to subjectivity in knowledge, and although the scientific method owes its roots to hermeneutics, it seems a contrasting form of knowledge in which hermeneutics no longer has a place. That is why its fusion with neutrosophy and the NCMs is convenient.

For a better understanding of data processing with NCMs, the following is exposed:

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [36]. NCMs were introduced by [49] in 2003. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995 [21]. This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty.[21] exposes that FCMs constitute a technique that has received increasing attention due to its possibilities for representing causality. The following is a set of definitions necessary for working with NCMs. First, let formally expose the original definition of neutrosophic logic as it is shown in [31].

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ be a *neutrosophic set of evaluations*. v: $\boldsymbol{P}$→N is a mapping of a group of propositional formulas into N, i.e., each sentence p∈ is associated to a value in N, as it is exposed in Equation 1, meaning that p is T% true, I% indeterminate and F% false.

$$v(p) = (T, I, F) \tag{1}$$

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [30, 35].

Definition 2. (See[28, 29]) Let K be the ring of real numbers. The ring generated by K∪I is called a *neutrosophic ring* if it involves the indeterminacy factor in it, where I satisfies I^2 = I, I+I = 2I, and in general, I+I+...+I = nI, if k∈, then k.I = kI, 0I = 0. The neutrosophic ring is denoted by K(I), which is generated by K∪I, i.e., K(I) = <K∪I>, where <K∪I> denotes the ring generated by K and I.

Definition 3. A *neutrosophic matrix* is a matrix A = $[a_{ij}]_{ij}$ i =1, 2, …, m and j = 1, 2, …, n; m, n≥1, such that each a_{ij}∈K(I), where K(I) is a neutrosophic ring, see [32]. Let us observe that an element of the matrix can have the form a+bI, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example, $\begin{pmatrix} -1 & \mathrm{I} & 5\mathrm{I} \\ \mathrm{I} & 4 & 7 \end{pmatrix}\begin{pmatrix} \mathrm{I} & 9\mathrm{I} & 6 \\ 0 & \mathrm{I} & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21\mathrm{I} & 27\mathrm{I} & -6+25\mathrm{I} \\ -28+\mathrm{I} & 49+13\mathrm{I} & 35+6\mathrm{I} \end{pmatrix}$

Additionally, a *neutrosophic graph* is a graph that has at least one indeterminate edge or one indeterminate node [26, 31]. The *neutrosophic adjacency matrix* is an extension of the adjacency matrix in classical graph theory. a_{ij} = 0 means nodes i and j are not connected, a_{ij} = 1 means that these nodes are connected and a_{ij} = I, which means the connection is indeterminate (unknown if it is or if not). Fuzzy set theory does not use such notions. On the other hand, if the indetermination is introduced in a cognitive map as it is referred to in [25], this cognitive map is called a neutrosophic cognitive map, which is especially useful in representing causal knowledge [24, 35]. It is formally defined in Definition 4.

Definition 4. A *Neutrosophic Cognitive Map* (NCM) is a neutrosophic directed graph with concepts like policies, events, among others, as nodes and causalities or indeterminacy as edges. It represents the causal relationship between concepts.

The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [25]:

- Outdegree (v_i) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of the outgoing relationships (c_{ij}) of the variable:
$$od(v_i) = \sum_{i=1}^{n} c_{ij} \tag{2}$$
- Indegree (v_i) is the sum of the column elements. It reflects the strength of relations (c_{ij}) outgoing from the variable.
$$id(v_i) = \sum_{i=1}^{n} c_{ji} \tag{3}$$
- Total centrality (total degree td (vi)), is the sum of the indegree and the outdegree of the variable.
$$td(v_i) = od(v_i) + id(v_i) \tag{4}$$

The variables are classified according to the following criteria, see [50]:

a) The transmitting variables are those with od (vj)> 0 and id (vi) = 0.
b) The receiving variables are those with od (vj) = 0 and id (vi)> 0.
c) The ordinary variables satisfy both od (vj) ≠ 0 and id (vi) ≠ 0.

The static analysis is applied using the adjacency matrix, considering the absolute value of the weights [26]. Static analysis in Neutrosophic Cognitive Maps (NCM), see [24], initially contains the neutrosophic number of the form (a + bI), where I = indetermination [23]. Then, it requires a process of de-neutrosophication as proposed in [25], where I ∈ [0, 1] and it is replaced by their values maximum and minimum.

Finally, we work with the average of the extreme values, which is calculated using Equation 5, which is useful to obtain a single value as it is referred to in [25]. This value contributes to identifying the characteristics to be attended, according to the factors obtained, for our case study.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{5}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{6}$$

Then, the authors of the investigation, based on the exposure for the hermeneutical method and the NCM, decided to elaborate a work procedure. Equations 2-6 will merge with [41, 43] of the heuristic method, as shown below:

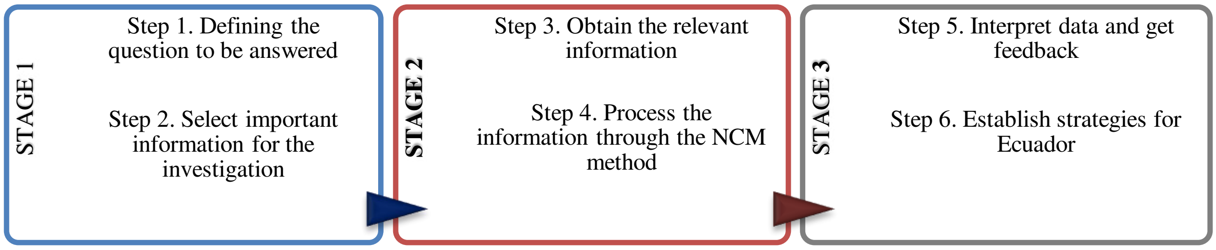

Figure 3. Elaborate procedure.

4 Application of the designed procedure

Step 1. Define the question to be answered: Which causal factor of obesity has the highest level of influence?

Step 2. Select the important information for the investigation: Information was selected from three different points of view:

- Medical: it was obtained from the medical repositories on the web.
- Ecuadorian news: in Ecuadorian news, magazines of national political interest were investigated, and experts' criteria.
- Patient perception: the criteria set out in the obese patient surveys were taken into account.

Step 3. Obtain the relevant information

The information was processed according to the perspectives selected in the previous step

- Medical: the main causal factors of obesity were obtained.
- Ecuadorian news: medical experts (10) and non-medical experts (5 teachers, 4 psycho-pedagogues) were taken.
- Patient perception: 7 patients diagnosed with obesity were consulted in an institution.

The information is shown in Figure 4.

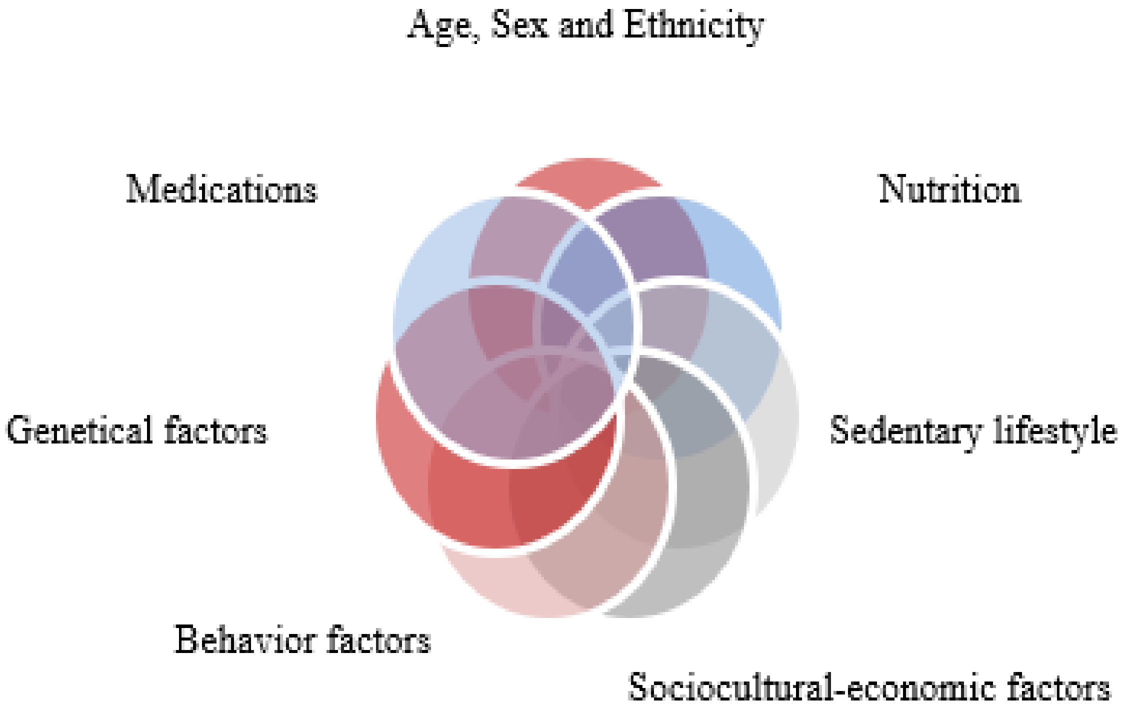

Figure 4. Diagnosed causal factors of obesity.

Step 4. Process the information using the neutrosophic method (NCM)

$$E(X)=\left\{\begin{matrix} 0 & 1 & 0.5 & 0.5 & 0.8 & 0.6 & I & 0.8 & 1 \\ 1 & 0 & 0.7 & I & 0.7 & I & 0 & 0.7 & 1 \\ 0.8 & 0.9 & 0 & 0 & 0.5 & 0 & 0 & 0.6 & 0.9 \\ 0.3 & 0 & 0 & 0 & 0 & 0 & 0.7 & I & I \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0.5 & 0.6 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0.8 & 0.9 \\ 0 & 0 & 0 & 1 & 1 & 0.4 & 0 & 0.7 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{matrix}\right\}$$

$$E(X)=\left\{\begin{matrix} 0 & 1 & 0.5 & 0 & 1 & 0.6 & 0 & 0.2 & 1 \\ 1 & 0 & 0.7 & 0 & 0.5 & 0.5 & 0 & 0.3 & 1 \\ 0.7 & 1 & 0 & 0 & 0 & 0 & 0 & 0.5 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0.5 & 1 \\ 1 & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & I & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 \end{matrix}\right\}$$

$$E(X)=\left\{\begin{matrix} 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0.5 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{matrix}\right\}$$

Figure 5. Neutrosophic adjacency matrix "Doctors", "Non-doctors" and "Patients".

Perspectives	*Doctors*			*Non-Medical Experts*			*Patients*		
Factors	*id*	*od*	*td*	*id*	*od*	*td*	*id*	*od*	*td*
Age	0.7625	0.7125	1,475	0.8142	0.6142	1.4285	0.5555	0.3333	0.8889
Sex	0.7375	0.6375	1,375	0.8571	0.5714	1.4285	0.6667	0.3889	1.0556
Race	0.65	0.4625	1.1125	0.7428	0.4571	1.2	0.5556	0.1111	0.6667
Medicines	0.5	0.25	0.75	**0**	0.1428	0.1428	0.3333	**0**	0.3333
Feeding	0.75	0.6375	1.3875	0.7857	0.7857	1.5714	0.7222	**1**	1,7222
Sedentary lifestyle	0.6875	1.0875	1,775	0.5857	0.8571	1.4428	0.6667	**1**	1.6667
Genetic factors	0.525	0.3875	0.9125	0.2857	0.2857	0.5714	0.4444	0.1111	0.5556
Factors Behavioral	0.7	0.875	1,575	0.5	**1**	1.5	0.3333	0.6667	**1**
Sociocultural-economic factors	0.7375	**1**	1.7375	1.1428	**1**	2.1428	0.2222	0.8889	1.1111

Table 1. Static analysis of the adjacency matrix by perspectives

Step 5. Interpret the data and get feedback

Question: Which causal factor of obesity has the highest level of influence?

Answer: Taking into account the perspectives analyzed, the factors are ordered according to their level of influence as follows:

Outlook	*Medical*		*Non-Medical Experts*		*Patients*	
Factors	**Order**	**Classification**	**Order**	**Classification**	**Order**	**Classification**
Age	4	Transmitter	5	Transmitter	6	Transmitter
Sex	6	Transmitter	6	Transmitter	4	Transmitter
Race	7	Transmitter	7	Transmitter	7	Transmitter
Medicines	8	Transmitter	9	Receiver	9	Receiver

Feeding	5	Transmitter	2	Transmitter	1	Transmitter *Highly influential*
Sedentary lifestyle	1	Transmitter	4	Transmitter	2	Transmitter *Highly influential*
Genetic factors	9	Transmitter	8	Transmitter	8	Transmitter
Behavioral factors	3	Transmitter	3	Transmitter *Highly influential*	5	Transmitter
Sociocultural-economic factors	2	Transmitter *Highly influential*	1	Transmitter *Highly influential*	3	Transmitter

Table 2. Analysis of the results.

Despite the existence of variability in the order of the results, the 3 groups agree in the first four places in the factors that, according to their criteria, promote obesity. The data was presented in a brainstorming session before the experts consulted in a general way. They all agreed with the results and expressed that there may be variations in the ratings given if the experts' panel is changed.

It was possible to know during the feedback that in the case of the assessments according to the sex and age factors, the experts were guided by the real conditions that women in Ecuador have. The high level of discrimination due to these factors is a trigger for situations that prevent a proper lifestyle. It was also possible to determine the role of educational centers as trainers since due to the very situation of discrimination and the presence of women of indigenous ethnic groups, there is a low educational level. Therefore, women generally responsible for the care of the home and children, do not assume a healthy lifestyle due to the lack of information and economic situation. That is why education centers, as well as women's aid centers, are so important in this matter.

At another point in the conversation, teachers and parents commented on the need to limit the exposure of children and adolescents to advertising and promoting packaged meals. The “information avalanche” regarding the consumption of this type of substance increases the risk of obesity since it encourages its regular intake. In addition, there is a closeness between the street vendors that offer this type of food in the vicinity of the schools.

Step 6. Establish strategies for Ecuador

1. Establish a communication strategy and social advertising campaign where people can learn about healthy lifestyles in poor communities. Focused mostly on those aimed at the adolescent, poor and female population.
2. Prepare and disseminate guides for proper nutrition and also for physical exercises at home.
3. Establish recreational programs in communities.
4. The sale of products to students should be regulated, which restricts the supply of foods high in fat, sugar, and sodium. More effective monitoring measures are required to ensure compliance.
5. Strengthen educational programs in preschool, primary and secondary centers related to healthy living: diet, physical activity, no alcoholism, and no discrimination. That the rights of children to a full life be advocated.

Conclusions

According to the bibliography consulted, obesity is a consequence of multiple factors such as inadequate eating habits, low consumption of fruits and vegetables, sedentary or unhealthy lifestyles, poverty, low schooling, null or insufficient breastfeeding, culture, advertising, among others. Ecuador is not free from that situation. Today there is an alarm among children and young people whose lives have been affected by the context of the pandemic since inappropriate eating behaviors and a low level of physical activity are some of the most important risk factors for developing obesity. This is why physical activity and proper eating habits should be encouraged. This environment alerts about the urgent need to adopt measures to increase the consumption of fruits and vegetables with respect to the consumption of sugars from food and beverages and packaged foods that contain high content of sugars, fats, and sodium. The sale of such products to students should be regulated. More effective monitoring measures are required to ensure compliance and the establishment of advertising strategies to educate children, adolescents, and mothers for the sake of a culture of healthy living. Including indigenous ethnic groups in this issue is urgent.

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Managing Contradictions in Software Engineering Investigations using the Neutrosophic IADOV Method

Vladimir Vega Falcón[1], John Luis Toasa Espinoza[2], Andrés Roberto León Yacelga[3] and Luis Orlando Albarracín Zambrano[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador
Email: ua.vladimirvega@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador
Email: up.johntoasa@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador
Email: ui.andresleon@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador
Email: uq.luisalbarracin@uniandes.edu.ec

Abstract: Software Engineering is a profession of a technological nature, which takes up theories and knowledge from various sources and addresses the development of quality software at an industrial level. Software Engineering builds knowledge around these software development practices, concretized in the definition of methods, models, and operating schemes that engineers can apply in their professional activities. However, research processes in Software Engineering lack sufficient clarity, mainly due to the level of maturity reached in this discipline. This element hinders the ability of novice researchers to design their research strategies or to recognize the research of excellence. The study is focused on evaluating the consensus and acceptance of the experts on the integration of software engineering sciences and the investigations carried out with the elements that make it up through the IADOV neutrosophic study.

Keywords: Research in software engineering, research processes, IADOV neutrosophic

1 Introduction

Research in software engineering is a subject that requires permanent reflection on the part of the groups that wish to undertake its realization [1], especially even when in some areas this type of activity is not considered as a type of research strictly or is confused with any type of software development process [2].

How these methods, models, and operating diagrams that constitute the own knowledge of Software Engineering (SI) are built [3], is based on the review and formalization of heuristics arising from real experience in software processes and products [4]. This situation requires the definition of research methods that address real problems and situations in the Software Industry, which seek to identify, formalize and theorize about its best practices and its general applicability in different companies at a regional and global level [5].

Although creativity could be seen as a characteristic of research, independent of the method, it is understood that there are sciences whose research requires a high degree of creativity as opposed to observation or experimentation [6]. Such is the arts and engineering case in terms of their artistic solid component [7]. When creativity marks the research process [8], creative methods are mentioned. These methods are based on characteristics such as imagination, premonition [9], visualization, and in them, the creative intelligence of the researcher intervenes above the rational (Table 1).

Science	Object of study	Scope	Method
Software Engineering Sciences	Construction of new objects	Engineer	Qualitative Creative
Software Sciences	Built object	Empirical	Quantitative
Information Systems Sciences	Implementation and use of built objects	Cultural and social	Qualitative

Table 1. Main objects of study, sciences, and methods used in the discipline of SI.

For some time, differences have been observed between the knowledge generated in the academic and research fields [10], and its real application in companies [9]. In many cases, problems and situations analyzed and solved at the investigative level still do not transcend the business level [11].

One of the examples of this situation, and the need for adaptations of theory to practice, was raised by Jacobson when he established differences between method and process [12]. The method refers to the sequence of activities that allow achieving a specific development in the laboratory, this as such cannot be applied directly and without differences in all organizations [13].

Due to its relatively short existence, SI (unlike other sciences: mathematics, chemistry, social sciences, etc.) does not have a consolidated research process that allows us to recognize that it is good to research within the field [14] [1]. Most researchers in SI do not describe the research paradigm used or the standards by which the quality of the research developed is measured [15]. Although some attempts have been made to fill in this gap [13], the results achieved have not been sufficient for the research community to reach a common position [16].

Intending to raise scientific production in the SI area, researchers, especially newcomers and universities [12], require research strategies and scientific writing following what is internationally accepted so that they can raise the quality of the research carried out [17].

The main difference between science and engineering lies in their object of study; while science studies natural aspects to know "how things are", engineering tries to determine how "things should be" so that they make possible the development of new objects [18]. Science studies existing objects and phenomena while engineering focuses on how to create new objects [15].

SI has a particular characteristic in terms of its object of study which, as previously expressed, consists of the methods for software development. Initially, the methods do not exist [19, 20], “They are not natural things” and therefore cannot be studied following the paradigm of science and the engineering approach must be used to determine how “they should be” [21]. But once created, these methods become "natural" objects that can and should be analyzed following the paradigm of science. Perhaps in this particularity lies to a great extent the difficulty that the research community has had to agree on a research paradigm in IS to such an extent that this subject has become an area of research in itself [18], [19], [11], [15], [22].

Regardless of the object of study or the method used, the research process in both science and engineering can be characterized by the type of question that is sought to be answered, the results that are offered in response to those questions, and the criteria used to evaluate the results [13, 23]. The conjunction of these characteristics determines the research strategy for each particular problem [11].

To undertake the research tasks, the research groups must define a work strategy that allows combining academic work in the laboratory with real experiences of applying technology in companies in the software industry [3].

The objective of this article is to evaluate the consensus and acceptance of experts on the integration of software engineering sciences and the research carried out with the elements that comprise it; to understand the use of software engineering research through the application of the neutrosophic IADOV method, as well as its advantages [24]. IADOV method stands out for the simplicity with which it can be applied to obtain the collective evaluation of experts on the subject at hand. Neutrosophy combined with the IADOV method allows to include the indeterminacy, contradiction, and ignorance of the evaluators, therefore, the results of the evaluation are more attached to the real knowledge of the specialists.

To evaluate the level of satisfaction of the experts with the methodology used, all of them with affinity to the subject were surveyed. The groups were made up of a total of 24, 15, and 21 experts respectively.

2 Materials and methods

To apply the neutrosophic IADOV technique, experts must rely on a linguistic evaluation system that shows the expert's opinion [25-28]. This system and its neutrosophic and numerical equivalents are shown in Table 2 [25][29].

Linguistic term	SVNN	Scale
Clearly satisfied	(1,0,0)	3
More satisfied than dissatisfied	(1, 0.35, 0.35)	2.3

Undefined	I	1.5
More dissatisfied than satisfied	(0.35, 0.35, 1)	1
Clearly dissatisfied	(0; 0; 1)	0
Contradictory	(1,0,1)	2

Table 2. Evaluation system for experts. Linguistic terms are associated with their neutrosophic assessment and a score value

The term I in neutrosophy is interpreted as a unit of indeterminacy.

Another component of the method is the IADOV Logical Table, which assigns numerical values to three closed questions that are applied to the experts. If necessary, open questions can be applied in the surveys [30].

1st question	Yes			I don't know			Not		
2nd question	Yes	I don't know	Not	Yes	I don't know	Not	Yes	I don't know	Not
3rd question									
It is a consolidated research process	1	2	6	2	2	6	6	6	6
It is a partially consolidated research process	2	3	3	2	3	3	6	3	6
It does not matter to me	3	3	3	3	3	3	3	3	3
It is a less established research process than it claims to be	6	3	6	3	4	4	3	4	4
It is an unconsolidated research process	6	6	6	6	4	4	6	4	5
I do not know what to say	2	3	6	3	3	3	6	3	4

Table 3. Derivation of IADOV's Logical box

To survey the level of satisfaction of the experts, the neutrosophic IADOV technique was used. This technique is based on the use of single value neutrosophic sets (SVNS) associated with linguistic variables or its ability to increase the interpretability in the recommendation models and the use of indeterminacy [31] [32].

The definition of SVNS is:

Let X be a universe of discourse. An SVNS A over X is an object of the form.

$$A = \{[x, u_a(x), r_a(x), v_a(x)]: \in X\}\, dA = \{[x, u_a(x), r_a(x), v_a(x)]: \in X\}d \quad (1)$$

Where:

$$u_a(x): X \to [0, 1], r_a(x): X \to [0, 1]\ y\ v_a(x): X \to [0, 1]$$

With

$$0 \leq u_a(X), r_a(X), v_a(X) \leq 3, \forall x \in X$$

For convenience, a Single Value Neutrosophic Number (SVNS) will be expressed as $A = (a, b, c), where\ a, b, c \in [0,1]\ and\ satisfies\ 0 \leq a + b + c \leq 3$.

Aggregation operators are used for finding a SVNS that describes several sets at the same time. One of these operators is the neutrosophic weighted average (WA), which is defined as follows [30].

Let the Neutrosophic Weighted Average Operator (WA) be calculated:$\{A_{1,}A_2, \dots, A_n\} \in SVNS\ (x), where\ A_j = (a_j, b_j, c_j)(j = 1, 2, \dots, n)$,

$$WA\ (A_{1,}A_2, \dots, A_n) = \sum\nolimits_{i=1}^{n} [w_j\ , A_i] \quad (2)$$

Where:

$$WA\left(w_{1},w_{2},\ldots,w_{n}\right)=\sum_{i=1}^{n}\left[w_{j},A_{i}\right] is\ the\ vector\ A_{j}\ (j=1,2,\ldots,n)\ such\ that\ w_{n} \in [0,1]\ y \sum w_{j}=1$$

De-neutrosophication of this set so that a single value is obtained, a scoring function is generally used [33].

Let A = (a, b, c), the scoring function S of an SVNS, based on the indeterminate degree of membership and the false membership degree, is defined by the following equation:

S (A) = 2 + a-b-c (3)

For the use of an SVNS to measure individual satisfaction, this value must be associated with a linguistic variable [25]. Therefore, the scales shown in table 2 were specified and the corresponding score was calculated using (3)

For cases in which the evaluation corresponds to indeterminacy (not defined) (I), a process was developed.

$$\lambda([a_1,a_2])=\frac{a_1+\ a_2}{2} \qquad (4)$$

To calculate the Global Satisfaction Index of Respondents (GSI), the aggregation operator WA (2) was used, taking into account the scoring values and that all respondents have the same weight, so that $w_i=\frac{1}{n}$

The instrument designed for the application of the survey was a questionnaire with five questions, three of which are closed (1, 3, and 5) and two are open (2 and 4). The three closed questions were related through the "IADOV logical table", which is presented in Table 3 [31] [26].

The algorithm used for the application of the neutrosophic IADOV technique:

1. Once the questionnaire is applied, the corresponding value (from 1 to 6) for the satisfaction classification of the surveyed experts is found in the IADOV logical table of three entries. [26].
2. The linguistic variable, the SVNS, and the score according to table 2 correspond to this value.
3. The score value of each respondent is used to calculate the group satisfaction index (GSI) from the aggregation of all scores using the aggregation operator formula WA (2).
4. The GSI is interpreted from the location of the value in the graph of figure 1.

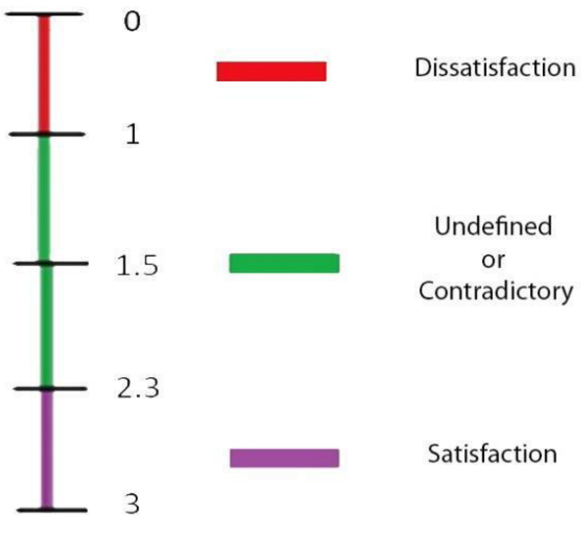

Figure 1. Scale to determine the level of satisfaction according to the scores used

The two open questions allowed to complete the assessment of the level of satisfaction of the students with the applied methodology:

1. Do you think that the integration of software engineering research will improve the proposed results in the software industry? (question 1 of the questionnaire)
2. Do you consider that the scope and guidelines of software engineering investigations should be developed? (question 4 of the questionnaire)

3. What is your judgment about the software engineering research method? (question 5 of the questionnaire)
4. How do you think you could develop this technique? (question 2 of the questionnaire)
5. How about the new science and its applications? (question 3 of the questionnaire)

3 Results

From the application of the survey to the three groups of experts, the results were obtained in terms of the individual satisfaction levels shown in Figure 2.

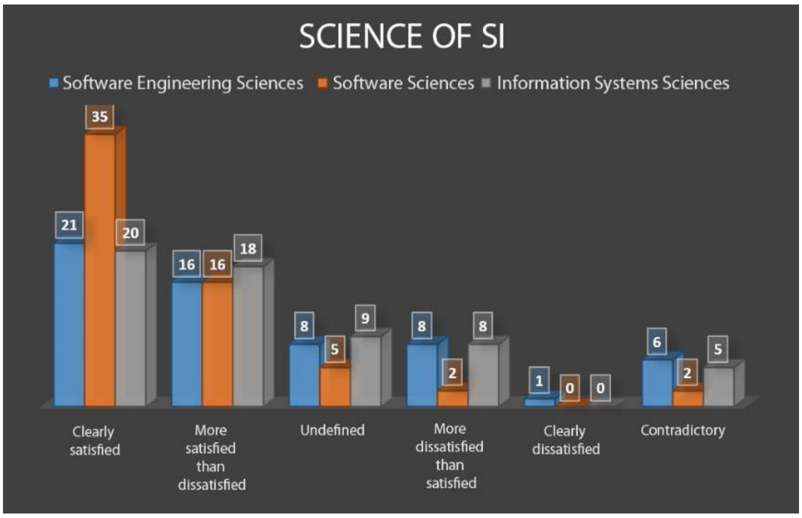

Figure 2: Individual satisfaction levels by group

Positive satisfaction levels can be seen in the sciences of the SI, with a predominance of the Software Sciences in all three groups. However, experts are observed with dissatisfaction especially in the integration of research of Software Sciences and the Information Systems Sciences. Indeterminate and contradictory positions were also found, although scarce.

The calculations of the GSI according to the frequency of observation and the indices of individual satisfaction of the designed categories and their corresponding scores are shown in tables 4, 5, and 6, for each group respectively.

Linguistic term	**SVNU**	**Punctuation** (S)	**Frequency** (F)	**F * S**	**(F * S) / n**
Clearly satisfied	(1,0,0)	3	21	63	1.05
More satisfied than dissatisfied	(1, 0.35, 0.35)	2.3	16	36.8	0.61
Undefined	I	1.5	8	12	0.20
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	8	8	0.13
Clearly dissatisfied	(0; 0; 1)	0	1	0	0.00
Contradictory	(1,0,1)	2	6	12	0.20
Group Satisfaction Index					2.20

Table 4: Calculation of the Group Satisfaction Index (ISG) of the Software Engineering Sciences group

Linguistic term	**SVNU**	**Punctuation (S)**	**Frequency (F)**	**F * S**	**(F * S) / n**
Clearly satisfied	(1,0,0)	3	35	105	1.75

More satisfied than dissatisfied	(1, 0.35, 0.35)	2.5	16	40	0.67
Undefined	I	1.5	5	7.5	0.13
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	2	2	0.03
Clearly dissatisfied	(0; 0; 1)	0	0	0	0.00
Contradictory	(1,0,1)	2	2	4	0.07
Group Satisfaction Index					2.64

Table 5: Calculation of the Group Satisfaction Index (GSI) of the Software Sciences group

Linguistic term	SVNU	Punctuation (S)	Frequency (F)	F * S	(F * S) / n
Clearly satisfied	(1,0,0)	3	20	60	1.00
More satisfied than dissatisfied	(1, 0.35, 0.35)	2.5	18	4.5	0.75
Undefined	I	1.5	9	13.5	0.23
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	8	8	0.13
Clearly dissatisfied	(0; 0; 1)	0	0	0	0.00
Contradictory	(1,0,1)	2	5	10	0.17
Group Satisfaction Index					2.27

Table 6: Calculation of the Group Satisfaction Index (GSI) of the Information Systems Sciences (IS) group

Of the three groups, only the GSI from the Software Sciences group is greater than 2.30, so it is established that the experts agree on the integration of software engineering research as a consolidated investigation process of the SI.

For the Software Engineering Sciences and SI Sciences groups, there is a level of indeterminacy or contradiction among the experts on the interrelation and research of the SI Sciences.

These results obtained from the satisfaction of the experts about the Software Sciences with the IADOV technique were reaffirmed with the answers of the experts to the open questions. Among the most frequent opinions stand out the contradictions of the SI sciences as a consolidated research process, for Software Sciences, but they can help the current researchers' analysis and serve as a guide for the improvement of their research strategies by providing elements of comparison with the research strategies developed in similar studies.

It is noteworthy that there is a long way to go to lay the foundations of this new Science of SI. This requires, in turn, an adapted Philosophy of Science [34], a Philosophy of Software Engineering, to be built through close collaboration between Software Engineers and Philosophers of Science.

Conclusions

Based on the results obtained, we reached the following conclusions:

- In this study, knowledge in SI establishes three scientific domains related to this discipline. These domains are called: SI Sciences when the object of study does not exist except in the mind of the researcher and the research process consists precisely in the creation of the same method. Software Sciences, when the object of study is any object previously created in a research process in the Sciences of the SI [14, 15]; Information Systems Sciences if the object of study focuses on the process of implementation and use of the aforementioned objects. Given the object of study of Software Engineering Sciences, it has been concluded that the research methods that are best adapted to this type of problem are qualitative and creative.

- The application of the neutrosophic IADOV technique allows experts to represent indeterminacy as part of their knowledge and complementary evaluations, based on the linguistic terms presented in the questionnaire. It is an instrument of great value for the study of satisfaction - dissatisfaction of the experts when evaluating the investigations of Software Engineering Sciences. However, a more in-depth study of Software Engineering research would allow integration with its counterparts.

- The results obtained can help the current researchers' analysis and serve as a guide for the improvement of their SI research strategies by providing elements of comparison with the research strategies developed in similar studies.

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University of New Mexico

Assessment of the Relevance of a Breast Cancer Rehabilitation Program based on a Neutrosophic Linguistic Scale

Carlos VinicioChiluisaGuacho[1], Nairovys Gómez Martínez[2], Yaritnza Hernández Coromoto[3] and Riber Donoso Noroña[4] , Julio Cesar Dupotey Hernández[5]

[1]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.carloschiluisa@uniandes.edu.ec

[2]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.nairovysgomez@uniandes.edu.ec

[3]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.yaritnzahernandez@uniandes.edu.ec

[4]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.riberdonoso@uniandes.edu.ec

[5]Empresa Neuro Rehabilitar S.A.S, Bogotá Colombia; E-mail: jcdh2016@gmail.com

Abstract. This investigation aims to assess the degree of efficacy of a breast cancer rehabilitation program in Ecuador. To this purpose, a group of experts evaluated the efficacy of the program using the Delphi method. Once experts were rigorously selected, they used a linguistic scale for assessing the program in different aspects. Every element of the linguistic scale was associated with a neutrosophic number, and finally statistically processed. The advantage to use neutrosophy is the possibility to deal with the imprecision in the assessment and to count on a linguistic scale, which undoubtedly usually is more appropriate to express opinions than a numerical one.

Keywords: rehabilitation, breast cancer, neutrosophic linguistic scale.

1 Introduction

Cancer is a group of diseases defined by the existence of an exaggerated multiplication of malignant cells that can invade tissues, organs and spread at a distance, [1]. That is why there have been several authors who have systematized and defined this disease as a "process of uncontrolled growth and dissemination of cells that can appear practically anywhere in the body." [2,3]. It is also considered to be formed from cells in the breast that have grown abnormally and multiplied to form a lump or tumor.

In various studies by international organizations, they state that since the 18th century, that has been one of the main causes of death in the world, representing the second cause of death in most developed countries and some developing countries, [4].

The World Health Organization (WHO) considers that breast cancer is a major problem in developed countries and increasingly in developing countries, as this disease represents the leading cause of cancer death in the world. It is estimated that 1out of 9 to 12 women with risk factors will develop the disease in her lifetime, [5].

While on the other hand, the Pan American Health Organization (PAHO) states that in the American continent and the Caribbean the trend is similar. Thus, breast cancer represents 29% of all cancer cases and is the second cause of death from malignant tumors, where lung cancer is the first one; but for the year 2030, PAHO estimates more than 596,000 new cases and more than 142,100 deaths in the region, [6,7]. This is a matter that makes this issue a serious health problem both for this area and for the world.

Metastatic breast cancer is considered to present a picture of disease evolution in stages I, II, III, which develops metastasis of cancer in sites and/or organs considered outside the limits of the mammary area. That is one of the reasons this disease is considered dangerous, so it is better to carry out preventive actions when the patient is in the so-called stage 0.

Based on these arguments, Piñeros ([8]) asserts that breast cancer is one of the most important and vulnerable. Because the breast has a sexual meaning, motherhood, beauty, and femininity, the experience of removal or loss of one or both breasts, brings with it an impoverishment of the body image with the perception of feeling mutilated.

There is a variable age for the diagnosis of this disease, but it is without any doubt 50 years old women where there is a greater number of cases, since it reaches levels up to 75% of breast cancers after menopause, [6]. This question makes this population group at risk, so they should systematically practice palpation, self-examination and then continue with others that are carried out in different health institutions.

Malignant disease of the breast begins as a simple, painless nodule of variable size, more frequently in the superior-external quadrant of the breast, which may or may not show signs of superficial fixation or muscle planes, and is accompanied by axillary lymphadenopathy, [1].

It is, therefore, necessary to carry out a systematic self-examination and before the presence of the symptoms that are reflected below, the patient should see a doctor as soon as possible:

- Shooting pain in some part of the breast that persists after menstruation,
- Changes in the color or appearance of the skin of the breast,
- Dimples or sagging of the skin or palpation of lumps that were not previously palpable,
- Fluid discharge from the nipple, noting the appearance (clear, milky, or bloody), [7].

The surgical technique for the treatment of breast cancer varies depending on the type of lesion and its extension. The choice of this will be determined by a previous procedure, called *sentinel lymph node biopsy* (SLNB), in which the sentinel lymph node is identified and made the decision whether to remove and examine it, that is, that lymph node at cancer cells are likely to spread. In this way, unnecessary dissection of unaffected lymph nodes is avoided, thus reducing the risk of lymphedema from 20% to 3.5-11%, [9-12].

The disease can develop due to genetic and hormonal factors (not modifiable) and lifestyle (modifiable), but among those with a greater contributory burden are hormonal and genetic factors, [6]. That is why post-operative rehabilitation is a viable alternative and that in most cases it manages to improve the quality of health of these patients.

That is why physical exercise and massage programs can prevent the presence of lymphedema. Aspects that have been systematized by various authors and have already been approved by the oncological college of several countries as part of the ongoing care of patients operated on for this pathology, [13-15].

Another rehabilitation alternative for breast cancer-operated patients is occupational therapy, [9,16]. This is aimed at enabling them to carry out activities of daily life. Therefore, it is necessary to imbricate both trends of rehabilitation in an inclusive program.

Based on the previous arguments, this research proposes an integrative rehabilitation program for breast cancer patients, which, before being applied in the different hospitals of the Republic of Ecuador, must be evaluated by a group of experts to know and improve it to obtain satisfactory results in its implementation.

Therefore, the objective of the present work is to identify the relevance of the rehabilitation program for patients operated on for breast cancer, using the criterion method of experts and with emphasis on the neutrosophic linguistic scale. Each expert was evaluated for selecting the most qualified, latter Delphi method was applied to evaluation. Delphi method consists of the independent evaluation of experts during many rounds until the final evaluation converges. For evaluation, we provided a linguistic scale associated with neutrosophic numbers. So, this combination of linguistic terms and neutrosophic numbers allows us to deal with imprecision and also with accuracy when experts asses with linguistic terms.

2 Materials and Methods

This section describes the main characteristics and procedures of the Delphi method and the fundamental bases that support the use of the neutrosophic linguistic scale.

2.1 Preliminaries in the Delphi method

Delphi method belongs to the so-called subjective forecasting methods and is based on the use of the intuitive judgment of a group of experts who issue criteria on a certain problem, [17,18]. That is why it is very effective to know the degree of relevance of some scientific projection.

This method offers multiple advantages due to its confidentiality, since it allows the freedom of opinions of the experts, encourages creativity, improves and redesigns the proposals that are subject to evaluation. Decision alternatives are offered without encouraging conflict between the experts.

An important aspect to take into account in this method is to theoretically understand who are considered experts. That is why they are considered a group of people or organizations capable of offering, with a maximum of competence, conclusive assessments on a certain problem, make real forecasts on the effect, applicability, feasibility, and relevance that the proposed solution may have in practice and provide recommendations on what to do for its improvement, [17].

This method is developed in the following stages:

1. Target identification,
2. Selection of experts,
3. Choice and application of the methodology,
4. Information processing.

The five values scale with positive Likert statements was used as an evaluative criterion.

- Very suitable (VS) five points,
- Fairly suitable (FS) four points,
- Suitable (S) three points,
- Poorly suitable (PS) two points,
- Not suitable (NS) one point.

2.2 Neutrosophic evaluative scale

Definition 1:

([19,20]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.
See that according to Definition 1, $T_A(x), I_A(x), F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x), I_A(x), F_A(x)$ can be subintervals of $[0, 1]$.

Definition 2:

([20-23]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \rightarrow [0, 1]$, $I_A: U \rightarrow [0, 1]$, and $F_A: U \rightarrow [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.
The *Single-Valued Neutrosophic number* (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Linguistic term	SVN numbers
Very suitable (VS)	(1,0,0)
Fairly adequate (FS)	(0.70,0.25,0.30)
Suitable (S)	(0.50,0.50,0.50)
Poorly suitable (I)	(0.30,0.75,0.70)
Not suitable (NS)	(0,1,1)

Table 1: Linguistic terms of the scale

Let A = (T, I, F) be a single-valued neutrosophic number, a *scoring function* $s: [0, 1]^3 \rightarrow [0, 1]$ related to a single-valued neutrosophic value, based on the degree of belonging to the truth, the degree of belonging to the indeterminacy, and the degree of belonging to falsehood is defined by ([24]):

$$s(A) = \frac{2+T-F-I}{3} \quad (1)$$

The definition of the *precision index* is given in Equation 2.

$$a(a) = T - F \quad (2)$$

Where $a: [0, 1]^3 \rightarrow [-1,\ 1]$.

2.3 General characteristics of the rehabilitation program

Each rehabilitation session was divided into three stages, namely, initial, main and final. The first one was intended to condition the muscles and joints for subsequent activity, while the main part included the following groups of exercises:

- Low-impact aerobic exercise,
- Muscle-strengthening exercises,
- Joint mobility exercises,
- Fine motor exercises,
- Pulley exercises.

We worked with an intensity of very light (60% of heartbeats per minute) in the first 10 weeks, to light (70% of heartbeats per minute) in the remaining 13 weeks.

The calculation of the percentage of heartbeats per minute necessary to work was carried out according to the formula: $\text{maximum HR} = (220 - \text{age})0.6$ for 60% and $\text{maximum HR} = (220 - \text{age})0.7$ for 70%.

2.4 Statistical analyzes

The statistical analyzes were performed with SPSS v. 20 (SPSS Inc, Chicago, IL, United States). The data relating to the descriptive statistics are presented through the distribution of frequencies, while Kendall's coefficient of agreement and the χ^2 contrast was used to determine the existence or not of significance in the community of interests of the experts, [25].

3 Results

To develop this section, the stages described above for the application of this method are retaken ([17]).

1-Target identification

The objective is identified: to assess the theoretical-methodological coherence and the degree of applicability of a breast cancer rehabilitation program.

2-Selection of experts:

A survey was applied to the possible experts to measure their coefficient of competence (K), through their self-assessment. According to the categories of high (H), medium (M), and low (L), regarding the sources of argument proposed in a standard table established for this purpose and the coefficient of competition was calculated using the formula $K = (Kc + Ka)/2$.

Where,

Kc: It is the coefficient of knowledge or information that the expert has about the problem, which is calculated based on the expert's assessment on a scale from 0 to 10 and multiplied by 0.1, so that:

The value zero (0) indicates a complete ignorance of the problem being evaluated.

The value ten (10) indicates full knowledge of the aforementioned problem. Among these borderline (extreme) evaluations, there are nine (9) intermediate ones.

Ka: It is the coefficient of argumentation or justification of the criteria of the experts, determined as the sum of the points obtained from the standard table to which reference has been made.

K: is the coefficient of competence of the experts and allows them to be classified according to what is agreed in:

- $0.8 \leq K \leq 1 \Rightarrow$ high competition,
- $0.5 \leq K < 0.8 \Rightarrow$ average competition,
- $K < 0.5 \Rightarrow$ low competition.

The survey was sent to 26 possible experts, after calculating the coefficient of competence, 16 were included in the research since they were in the high and medium categories. In other words, all those with a low Ka were excluded. Table 2 shows experts' distribution:

Academic level	N	%
Doctors (Ph.D)	5	31.25
Masters (MSc.)	7	43.75
Rehabilitation Specialist (RS)	4	25

Table2: Expert characterization

3-Choice and application of the methodology

For the work of the experts in the evaluation of the proposed program described in the present investigation, the Delphi methodology is used. Thus, this allows the application of consultation rounds, to identify if there is a coincidence between the experts' criteria when evaluating a set of indicators, previously established and that are listed below:

- Stages of the rehabilitation session,
- Selected exercises,
- Intensity of rehabilitation,
- Possibility of being applied in practice.

4-Information processing

After tabulating the information offered by the experts, the results are shown in Table 3:

Indicators to be evaluated by the experts	VS	FS	S	PS	NS
Stages of the rehab session	14 (87.5%)	1 (6.25%)	1 (6.25%)		
Selected exercises	15 (93.75%)	1 (6.25%)			
Rehabilitation intensity	14 (87.5%)	2 (12.5%)			
Possibility of being applied in practice	15 (93.75%)	1 (6.25%)			

Table 3. Results of the tabulation of the criteria offered by the experts after evaluating the rehabilitation program.

When performing a descriptive analysis of these results, the following is noticed:

Referring to the indicator "stages of the rehabilitation session", most of the experts (14 or 87.5%) agreed that they were very adequate and that they were in correspondence with the majority of rehabilitation programs for both patients operated on breast cancer, like other diseases of the osteomyoarticular system. For its part, one expert, or 6.25%, assessed this indicator as quite adequate, while that same amount valued it as adequate. It is noteworthy that there were no negative criteria or evaluations.

In the selected "exercises indicator", most of the experts also agreed that this was very adequate. This was reflected in that 15 or 93.75% out of the total of the experts indicated this category. Only one (6.25%) considered the exercises contained in the presented rehabilitation program to be quite adequate, it is also worth noting that this indicator did not receive an evaluative category or unfavorable criteria.

In the "indicator intensity of rehabilitation", it is noteworthy that the majority of the experts in consultations consider that these are very adequate since 14 of them (87.5%) gave this evaluative category. While only two (12.5%) of the total classified it as quite adequate. Therefore, no unfavorable evaluative category was received.

The indicator possibility of "being applied in practice", an important group of experts considered that it has a very adequate evaluative category, results that were endorsed by 15 experts or 93.75% of the total. On the other hand, only one (6.25%) considered that it is quite adequate. These results are very favorable and important because they come from a group of professionals with high and medium knowledge of this subject.

After the consultation was completed, some modifications to the program were relocated under the criteria issued by the experts, among which the following stand out:

- Make a description of the exercises to be used in the initial part of the rehabilitation session,
- Include pulley exercises,
- Describe how to perform the intensity calculation.

Finally, to determine the validity of the experts' criteria, the Kendall coefficient of concordance was used to determine the existence or not of significance in the experts' community of interests.

To do this, it begins with the formulation of the statistical hypothesis:

Nullity hypothesis (H_0): there is no community of preference among the experts.

Alternative hypothesis (H_1): there is a community of preferences among the experts.

Prefixing as significance level $\alpha = 0.05$.

Kendall's coefficient of agreement	Alpha value	N-1 GL	S2 / CHI (Boards)	S2 / CHI (Calculated)
0.84	0.05	4	14.067	88.511

Table 4. Inferential statistics results

As observed in the table presented above, Kendall's coefficient of agreement reaches a value of 0.84, so it can be considered the existence of a high agreement between the expert evaluations, this is corroborated with the χ^2 contrast in which 14.067 was less than its calculated value (88.511), so the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted.

From the linguistic assessment, a numerical final result is given as follows:

- Every assessment is converted from a linguistic term into its associated neutrosophic number, according to Table 1.
- Secondly, every neutrosophic number is converted into a crisp value using Equation 1 of the scoring function.
- The arithmetic mean of the results is calculated.
- If the moderator of the Delphi method wants to output a linguistic term, the numerical results obtained above are compared with the scoring function of every neutrosophic number in Table 1, and the linguistic term associated with the closest one to the obtained value is assigned.

Then, applying the precedent procedure, we obtained:

- Stages of the rehabilitation session: 0.95104 or “Approximately Very suitable”.
- Selected exercises: 0.98229 or “Approximately Very suitable”.
- Rehabilitation intensity: 0.96458 or “Approximately Very suitable”.
- Possibility of being applied in practice: 0.98229 or “Approximately Very suitable”.

So, the collected criteria were favorable, they express that the program proposed in this research is correctly designed; which guarantees the adequate practical application to achieve the rehabilitation of breast cancer operated patients. Issue by which it can be stated that it contributes to the enrichment of the proposal to achieve more effective practical application and thus improve the quality of life of the patients.

Conclusion

In this paper, we presented the analysis of the theoretical and methodological references on the assessment of the relevance of a breast cancer rehabilitation program. The use of the neutrosophic linguistic scale shows the existence of different bibliographic sources on the subject, however, programs that integrate various types of treatment for these patients are required. The assessment based on linguistic terms and neutrosophic numbers allows containing the accuracy to evaluate with linguistic values and also the imprecision with neutrosophic numbers.

The interpretation of the results derived from the criteria of the experts consulted makes it evident that there are positive criteria, aspects that were ratified with Kendall's coefficient of agreement, which was less than 0.005, therefore that ratified the existence of an agreement between them.

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Incidences of Exploratory Research in Postgraduate University Studies: A Neutrosophic Statistic Approach

Gustavo Álvarez Gómez[1], Miriam Janneth Pantoja Burbano[2], Miryan Janeth Arévalo Haro[3] , Aurelia María Cleonares Borbor[4] and Rodolfo González Ortega[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: vicerrectorado@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.miriampantoja@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador. Email: up.miryanarevalo@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.aureliacleonares@uniandes.edu.ec
[5]Feevale University, University of Holguín - Vila Nova, Novo Hamburgo Brazil. E-mail: rodolfogonzalez1978@gmail.com

Abstract. Exploratory research corresponds to the first approach of investigative work. This type of research is very useful by allowing researchers to have a first approach or a first idea about the subject to study and will be of great help to become familiar with the method, but without providing conclusive results. It is usually carried out when the problem is in a preliminary phase. It is a process of collecting basic information on a problem that is not clearly defined. It is a very flexible technique, which implies that the researcher is willing to take risks, be patient and receptive. This work aims to define the level of incidence that exploratory research has in university and postgraduate studies and to visualize the level of indeterminacy presented by preliminary research. The use of combined method approaches for precision and baseline for exploratory research is handled.

Keywords: exploratory investigation, neutrosophic statistics

1 Introduction

The exploratory research aims to approach novel phenomena. Its objective is to obtain information that allows understanding them better, although, this is not conclusive. Therefore, exploratory research is essential to carry out a preliminary study before carrying out others that could entail a higher cost [1].

Therefore, what exploratory research does is to take an interest in a topic that has not been studied before or know new aspects of existing knowledge. Thus, when we do not know what we are dealing with, it is best to explore first before carrying out other more expensive analyzes [2]. In addition, exploratory research can be used to formulate which audience to address, what questions to ask, or what response options should be included in the next phase of the inquiry (See Figure 1).

Figure 1. Scope and projection of the exploratory research

This type of research has a series of characteristics that should be known. These allow it to be used in the proper way and when it is necessary (Figure 2).

It is usually carried out when the problem is in a preliminary phase. It is often called a grounded theory or interpretive inquiry approach, as it is used to answer the what, why, and how questions. It is important to mention that exploratory research is responsible for generating hypotheses that promote a deeper study from which results and a conclusion are drawn [3]

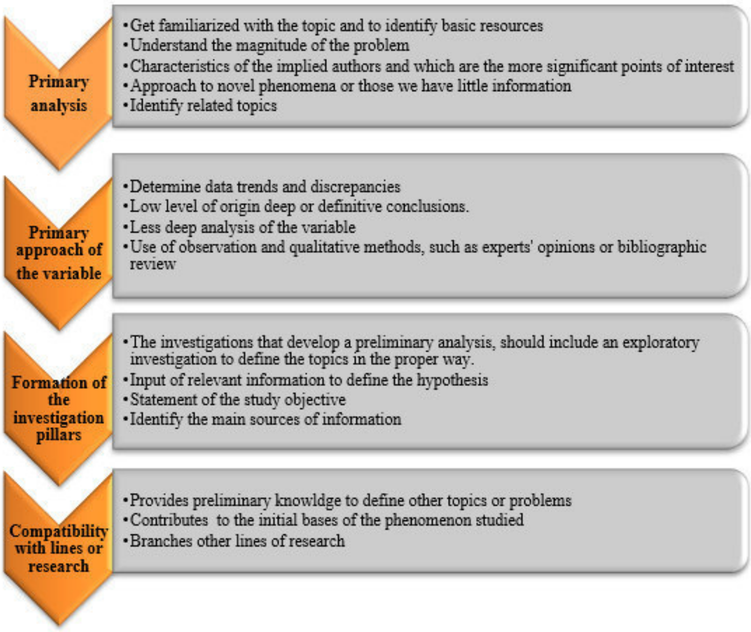

Figure 2. Characteristics of the exploratory research

In short, the main objectives of Exploratory Investigations are three: identification of a specific environment or situation, obtaining an initial hypothesis about it, and serving as a basis for future research with methodology [4-9].

Complementary techniques	Contributions to the study
Document review	• It allows identifying the scientific literature and other secondary sources developed on the subject, to determine the depth with which the subject has been treated.
Interviews	• The interviews in the qualitative studies allow knowing the perceptions, opinions, and direct knowledge of the actors linked to the subject. ▪ Expert interviews: indicates a high level of confidence which are the main issues related to or direct to existing and reliable sources of information around the problem studied. ▪ Interviews with potential users or beneficiaries: these types of interviews are usually semi-structured to identify how the subjects understand the topic or problem studied and what other topics they relate to.
Surveys (In-person or online)	• They allow having a greater scope or breadth than interviews, although with less depth. • With the low level of resources required for exploratory research, it may be relevant to conduct surveys through social networks to direct them to audiences with particular interests and profiles with high value for research.
Field observation	• It allows the researcher to relate directly to the object of study to identify possible relationships or behaviors where the phenomenon or problem occurs. • As it is a primary analysis, not necessarily many field visits will be carried out, but if any are carried out, the observations must be recorded in the corresponding instrument in the most impartial way possible.

Table 1. Complementary techniques in exploratory research [2, 10]

Exploratory research: is a term used to describe research on a topic that has not yet been well defined. It is sometimes loosely used as a synonym for "qualitative research," although this is not strictly true. Research helps determine whether to move forward with a research idea and how to achieve it, is often flexible and dynamic, and can be based on existing data or literature. Research techniques are applied in marketing, drug development, and the social sciences [11].

Market research of an exploratory type can be very useful because it will allow us to have a general knowledge of the subject we want to deal with to launch products or services in the future since they will give us an approximate and prior idea of something about which there are no previous studies, and they serve as general information and as a basis for future market studies [12].

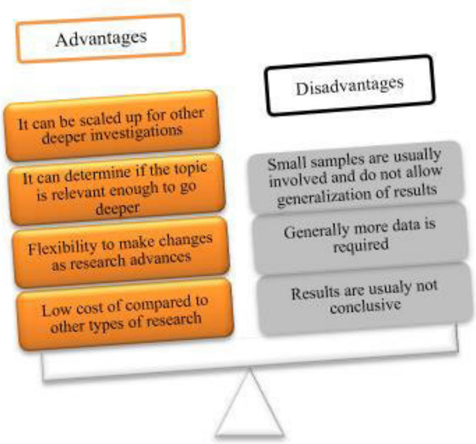

Figure 3. Characteristics of the exploratory research

From the characteristics of the variable and neutrosophic statistical analysis [13-35], this study focuses on:

- The problem situation: low level of precision and coherence when using exploratory research in undergraduate and graduate studies
- Main objective: to define the level of incidence that exploratory research has in university and postgraduate studies.
- Specific objectives:
  - Determine the sciences that most require exploratory research analysis
  - Analyze the effect of exploratory research on research
  - Perform statistical measurement and modeling of the neutrosophic variable

Present potential alternatives to improve the results of exploratory research

Regarding the structure of the study:

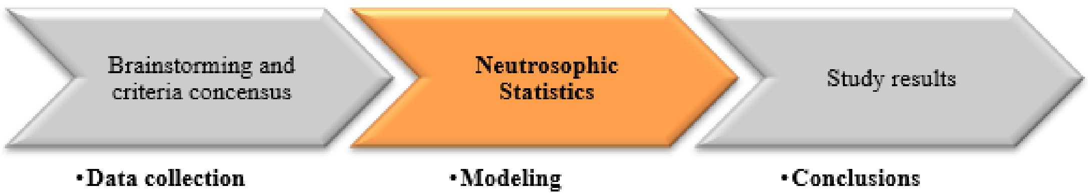

Figure 4. Structure of the exploratory research study

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. For example, the Neutrosophic Probability of an event E is the probability that event E will occur [36, 37], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$NP(x) = (T(x), I(x), F(x)),$

Where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.
Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution[38], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them.

Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns[39].
In short, the Neutrosophic Logic[40] [41], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development. The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data.[42]. Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers[43], while "I" is the indeterminacy part of the neutrosophic number N.

$N = a + bI.$

The study of neutrosophic statistics refers to a neutrosophic random variable where y represents the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval. Following the neutrosophic mean of the variable when formulating:$X_l\, X_u I_N [I_l, I_u](\bar{x}_N)$

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}\ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu}\ n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, the calculation of neutrosophic squares (NNS) can be calculated as follows

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\begin{bmatrix} \min\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \\ \max\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \end{bmatrix}, I \epsilon [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [44].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{x}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U] \tag{5}$$

3 Results

Data collection

In university studies, postgraduate studies, and other research, exploratory research is applied as previous analyzes to recent phenomena in society, commerce, education, culture, while keeping compatibility with methods of greater scope [45] [46]. When analyzing the method, the experts asked themselves, what was the level of integration of this technique in the investigations? To determine this level of integration, a neutrosophic statistical analysis is carried out on a sample of 100 theses of published research (population) in university repositories and some recent studies published on the WEB [10, 45-63].

To identify the possible relationships or integrations, five groups are established from the analyzed investigations, called factors (Figure 5).

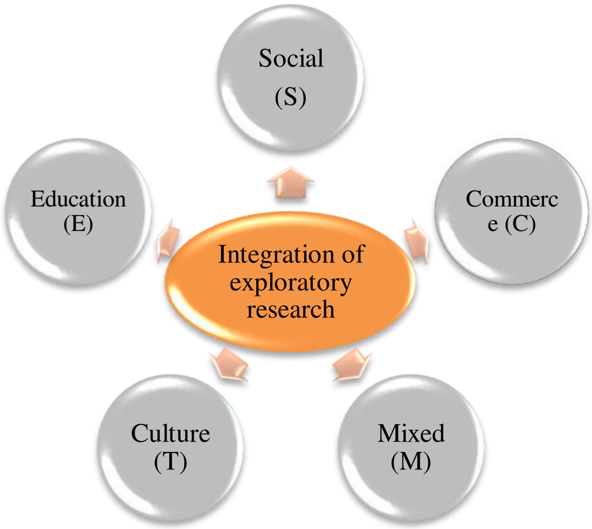

Figure 5. Factors (F_n) interrelated with exploratory research

For the modeling of neutrosophic statistics, it is suggested to code the variable's name and its representation in graphs and tables. The IIE will refer to the integration of exploratory research.

<u>Method development</u>

For the analysis, we proceed to define the variable, code it and determine the scale to start the modeling (Table 2)

Variable	Coding	Sample	Scale
Level of integration of exploratory research in university and postgraduate studies	IIE	100	$[0;\ 1], \forall\ F_n$ IIE = 0 (false) IIE = 1 (True) $0 \leq IIE \geq 1$ (Indeterminacy of the level of IIE)

Table 2. Characteristics of the IIE variable

By modeling the variable using neutrosophic statistics, the relative frequencies are obtained to determine the level of IIE in the factors, = in a sample of 100 research projects analyzed (Table 3). It is observed that for there is a higher incidence of occurrence of 77%, that researchers use exploratory research in conjunction with another method for the development of scientific studies. It should be noted that the experts, given the result obtained, ask themselves, what level of IIE for 23% affects the other factors? Moreover, what frequency of occurrence is present to measure the existing indeterminacy?$F_n\ \{F_s, F_c\ , F_t, F_e, F_m\} F_m \forall\ F_n\ desde\ 0 \leq IIE \geq 1$

Research	**Cumulative absolute neutrosophic frequencies**				
	Social	Commerce	Culture	Education	Mixed
0-100	[0, 10]	[0, 2]	[0, 3]	[0, 8]	[0, 77]

Table 3. Cumulative absolute neutrosophic frequencies.

To obtain the level of IIE in each factor, as the measure of indeterminacy for each investigation on a scale of, it is decided to analyze the variable from the neutrosophic relative frequency $=0 \leq IIE \geq 1 F_n\ \{F_s, F_c\ , F_t, F_e, F_m\}$ (table 4).

Research	Relative neutrosophic frequencies				
	Social	Commerce	Culture	Education	Mixed
1	[0; 0]	[0.02; 0.04]	[0.03; 0.03]	[0.08; 0.16]	[0; 0.77]
2	[0; 0.1]	[0; 0.02]	[0.03; 0.03]	[0.08; 0.16]	[0.77; 0.77]
3	[0; 0]	[0; 0]	[0.03; 0.06]	[0.08; 0.16]	[0; 0.77]
4	[0; 0]	[0.02; 0.02]	[0; 0]	[0.08; 0.08]	[0.77; 0.77]
5	[0; 0]	[0; 0.02]	[0.03; 0.03]	[0.08; 0.08]	[0; 0.77]
6	[0; 0]	[0; 0]	[0.03; 0.03]	[0; 0]	[0.77; 0.77]
7	[0; 0]	[0.02; 0.04]	[0; 0.03]	[0; 0]	[0.77; 1.54]
8	[0; 0.1]	[0; 0]	[0; 0.03]	[0.08; 0.08]	[0; 0]
9	[0.1; 0.2]	[0; 0.02]	[0.03; 0.03]	[0.08; 0.08]	[0.77; 1.54]
10	[0.1; 0.1]	[0; 0.02]	[0; 0.03]	[0; 0]	[0; 0]
11	[0; 0]	[0; 0.02]	[0.03; 0.06]	[0; 0.08]	[0.77; 1.54]
12	[0.1; 0.2]	[0; 0]	[0.03; 0.03]	[0.08; 0.16]	[0; 0.77]
13	[0; 0.1]	[0; 0.02]	[0.03; 0.06]	[0; 0]	[0.77; 1.54]
14	[0; 0]	[0.02; 0.02]	[0.03; 0.06]	[0.08; 0.08]	[0.77; 0.77]
15	[0.1; 0.2]	[0; 0]	[0; 0]	[0; 0.08]	[0.77; 1.54]
16	[0; 0.1]	[0; 0]	[0; 0]	[0; 0]	[0.77; 0.77]
17	[0.1; 0.1]	[0.02; 0.04]	[0; 0.03]	[0.08; 0.08]	[0.77; 1.54]
18	[0; 0]	[0.02; 0.04]	[0.03; 0.06]	[0.08; 0.08]	[0.77; 0.77]
19	[0.1; 0.2]	[0; 0]	[0; 0]	[0; 0.08]	[0; 0]
20	[0; 0]	[0.02; 0.04]	[0; 0.03]	[0; 0]	[0.77; 1.54]
0-100	[4.9; 10]	[0.84; 2]	[1.5; 3]	[3.84; 8]	[36.96; 77]

Table 4. Relative neutrosophic frequency of the level of IIE in university and postgraduate studies

Of the neutrosophic relative frequencies observed for the IIE, it is necessary that for 100 projects analyzed there is a level of total indeterminacy of, with a level of representativeness, on the days that are registered relatively 1.54, with a higher incidence of 52% for the investigations that use exploratory research in integration with other methods and techniques to complete the study.$s = 5.1, c = 1.16, t = 1.5, e = 4.16, m = 40.04[50\% ;\ 58\%]$

In the first stage for the results in the modeling, the level of IIE is observed for the study of new phenomena with low reference information (table 5).

For the analysis of the representative mean based on the values of the neutrosophic means are calculated and for the study of the variations of IIE, they are determined by the values of the neutrosophic standard deviation, to determine in which factor there is greater consistency and precision of IIE in university and graduate studies for each.$\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in\ [S_L; S_U] CV_N \in\ [CV_L\ ;\ CV_U]$

Factors	$\bar{x}_N$	***YN***	***CVN***
Social	0.049 + 0.1 I	0.001 + 0.108 I	0.02 + 1.08 I
Commerce	0.008 + 0.02 I	0 + 0.021 I	0 + 1.05 I
Culture	0.015 + 0.03 I	0 + 0.032 I	0 + 1,067 I
Education	0.038 + 0.08 I	0.001 + 0.078 I	0.026 + 0.975 I
Mixed	0.37 + 0.77 I	0.074 + 0.763 I	0.2 + 0.991 I

Table 5. Neutrosophic statistical analysis of the level of IIE in university and postgraduate studies

Table 5 shows the level of incidence of exploratory research in the study of university and postgraduate theses. It should be borne in mind that the Mixed factor is dominant in the use of combined techniques. However, it is required to know in the neutrosophic set IIE what level of representation and indeterminacy in the condition. This means that for the given condition, the factor is by term The medium is the one that most influences the use of exploratory research for the acquisition and compilation of information (interviews, surveys, and field observation) more than the other factors analyzed. About the value of CV, it can be expressed that for the corresponding factors, $\forall\ F_n,\ [1 -\ F_m]. F_c CV_{Nm}\ y\ CV_{Ne}$, they are lower compared to the rest.

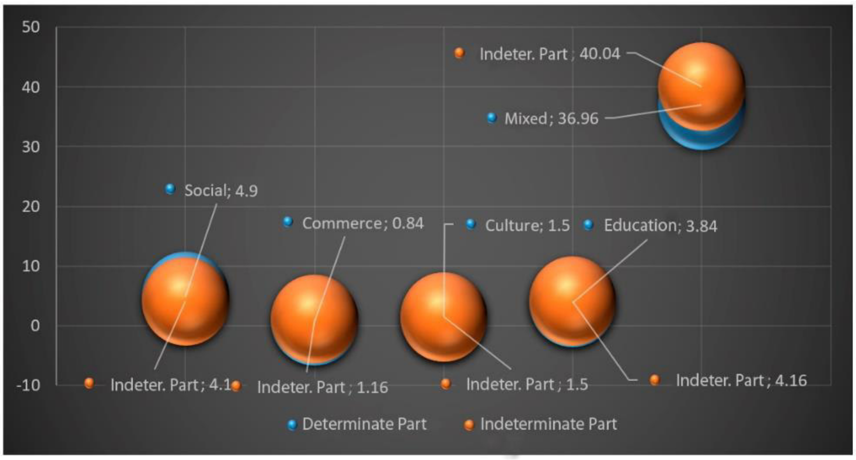

Figure 6. Neutrosophic bubble graph of the IEE level in university and postgraduate studies

Comparative analysis

To determine the associated referent indeterminacy measure for the form of neutrosophic numbers (Table 6). In the results obtained, it is observed that for the values they go from $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U] CV_N \in [CV_L\ ;\ CV_U] CV_N$0 to 0.20 with the indeterminacy measure 79.8%, generated by the Mixed factor and 97.3% in the education factor. Although he needs to use the lowest percentage level of indeterminacy to obtain more precise and more homogeneous results, in this case, it would be for mixed studies or combined with other methods for more robust results.CV_N

However, experts need to know the best option for the indeterminacy in the condition. The analysis focuses on the education factor with 97.3%, where the study projects present better results due to the preparation of this sector in pedagogical issues and method analysis. $\forall\, F_n,\ [1 - F_m]$,

Factors	$\bar{x}_N$	YN	CVN
Social	0.049 + 0.1 I; I $\in$ [0; 0.51]	0.001 + 0.108 I; I $\in$ [0; 0.99]	0.02 + 1.08 I; I $\in$ [0; 0.98]
Commerce	0.008 + 0.02 I; I $\in$ [0; 0.60]	0 + 0.021 I; I $\in$ [0; 0.100]	0 + 1.05 I; I $\in$ [0; 0.100]
Culture	0.015 + 0.03 I; I $\in$ [0; 0.50]	0 + 0.032 I; I $\in$ [0; 0.100]	0 + 1,067 I; I $\in$ [0; 0.100]
Education	0.038 + 0.08 I; I $\in$ [0; 0.52]	0.001 + 0.078 I; I $\in$ [0; 0.98]	0.026 + 0.975 I; I $\in$ [0; 0.97]
Mixed	0.37 + 0.77 I; I $\in$ [0; 0.51]	0.074 + 0.763 I; I $\in$ [0; 0.90]	0.2 + 0.991 I; I $\in$ [0; 0.79]

Table 6. Neutrosophic forms with indeterminacy measure for IIE in investigations

Partial solutions

The analysis of the exploratory research method defines guidelines for studying phenomena that are poorly documented or lacking in information. In addition, the result defines the use of research combining exploratory research and methods related to the results to be achieved; however, for previous studies, it is recognized that the level of relative frequency that a study project has in exploratory research as a single topic is of very low level, due to the high levels of indeterminacy in the information obtained.

As a partial solution for investigations with a low level of depth, it is recommended that the researcher draws on guides, manuals, reference texts that explain the scope, designs, and types of exploratory research as has been obtained in universities when using this method, by making the information more homogeneous and accurate.

Although the experts and the arrival of the processed data selected these factors, the use of this method in other areas to be studied is not considered an error, on the contrary, its application and its use are considered in the neutrosophic probabilities, it only requires a higher level of information acquired so as not to be subject to indeterminacies.

Conclusions

Exploratory research is aimed at studies with implications of a specific problem, in search of the most interesting aspects to be addressed in an investigation. The investigation process begins with an exploratory action;

where the researcher does not know in depth the topic to be developed or needs to visualize the scope. Exploratory research corresponds to that first approach to the correct use of the object of study.

Neutrosophic statistics reveal a more direct approach to the use of exploratory research in undergraduate and graduate studies, considering two starting points. The first that the effectiveness of the study requires a deeper scope, from the combination of different methods with an existing level of indeterminacy and as a second approach for studies that require a partial exploratory analysis, take into account that the levels of indeterminacy, present high levels that are only specified in sectors with a certain level of information and good use of the applied tools, as shown in the education factor, with a lower value of CV for.$\forall F_n,\ [1 - F_m]$

As a tool, it presents a characteristic of homogeneity with other methods, and its results will always require a more in-depth subsequent study to corroborate the first deductions and, in some cases, open new lines of investigation.

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Model for the Diagnosis of Autism Based on Neutrosophic Cognitive Maps

Lester Noel Reyes Salgado[1], Miguel Eduardo Ramos Argilagos[2], Alberto Sánchez Garrido[3] Alex Ramón Valencia Herrera[4] and Salah Hasan Saleh Al-Subhi[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Ambato. Tungurahua. Ecuador Email: ua.lesterreyes@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Ambato. Tungurahua. Ecuador Email: ua.miguelramos@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Ambato. Tungurahua. Ecuador Email: ua.albertosanchez@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Ambato. Tungurahua. Ecuador Email: ua.alexvalencia@uniandes.edu.ec
[5]Universidad de las Ciencias Informáticas-Cuba-Asociación Latinoamericana de Ciencias Neutrosóficas, Yemen. E-mail: salahcuba@hotmail.com

Abstract. Autism spectrum disorders are diverse conditions characterized by some degree of difficulty in social interaction and communication, atypical patterns of activity and behavior, and unusual reactions to sensations. ASDs do not have a single known cause, scientists do not know the exact causes of their development, and it is believed that they are associated with a combination of several factors. The present study was carried out with 42 cases diagnosed with any of the subclasses of autism established by the DSM-V and included patients between 18 months and four years old, from 4 provinces of Ecuador, to determine the main elements to which they were exposed to establish possible common groups of causal factors of the disease. The experts carried out an analysis and determined three predominant casual factors in the group, and some recommendations derived from the analysis are included.

Keywords: Autism; autism spectrum disorder; ASD; neutrosophic cognitive map; NCM.

1 Introduction

Autism spectrum disorders (ASD) are characterized by severe deficits in socialization, communication, and repetitive or unusual behaviors. It affects information processing in the brain by altering how nerve cells and synapses connect and organize; how this happens is not yet well clarified [1].

The term "autism" is used in psychiatry to mean withdrawn and self-absorbed; it comes from the Greek word "autos," which means "in itself", "own". Defining it is not an easy task, because many years have passed since in 1943 Leo Kanner, an Austrian psychiatrist living in the United States, did it for the first time after describing in detail eleven cases of children who presented peculiar characteristics that differentiated them from the rest of minors with psychopathological alterations [2]. Starting in 1994, as a result of important studies, the Pan American Health Organization began to conceptualize it as: "a generalized developmental disorder, defined by the presence of impaired development (...) that manifests itself before three years of age and a characteristic type of functioning (…) in the three areas of psychopathology: reciprocal social interaction, communication and restricted, stereotyped and repetitive behavior [3]. The World Health Organization estimates that one in 270 people worldwide has an ASD. This estimate represents an average figure because, although the observed prevalence varies considerably between different studies, some well-controlled studies have registered notably higher figures [4][5].

According to the England Institute for Health Measurements and Evaluation, in 2015, the worldwide prevalence of ASD in children under five years of age was 0.12%, with an annual percentage change of 0.037%. In children from 5 to 14 years, the prevalence was 1.34%, with an annual percentage change of 0.029%. In Latin America and the Caribbean, in children under five years of age, in the same year, there was a prevalence of 0.27%, with an annual percentage change of 0.0027%, and in the population aged 5 to 14 years, a prevalence of 1.73%, with an annual percentage change of 0.023% [6].

In Ecuador, as in many Latin American countries, there is no accurate data on the prevalence of ASD [7]; however, according to data provided by [6] in the Ecuadorian population under 5 years of age, the prevalence in 2015 was 0.28% (0.18% - 0.41%) with an annual percentage change of 0.0069% and in the population from 5 to 14 years, the prevalence was 1.7% (1.29 - 2.15%), with an annual percentage change of 0.016%. For 2016, according to data provided by the National Directorate of Disabilities of the Ministry of Public Health, based on its technical report, the existence of 1,266 people diagnosed with ASDs is reported. Out of these, 254 have been registered with a diagnosis of atypical autism; 792 with a diagnosis of childhood autism: 205 with Asperger syndrome, and 15 registered within Rett syndrome (As of the Fifth Edition of the Diagnostic Statistical Manual of Mental Disorders (DSM-V) Rett Syndrome is no longer listed among the subtypes of autism) (29) [8] [9].

Numerous investigations have published the "causes of autism," although their results have not been generalized because they contradict the conclusions of other studies [10] [11]. Some reports speak of the occurrence of autism due to anatomical alterations, [12] due to neurobiological disorder, or due to neuronal involvement [13] [14]. Others specify that it is a cognitive and neurobiological disorder [15] or caused by mirror neuron dysfunction [16][17], or by genetics [18] [19]. Other studies point to the environmental component [20], eventual consequence of contamination by heavy metals and toxicity [21] [22], or from exposure to pollutants in pregnancy and/or the first year of life, or due to air pollution [2. 3].

Even though the management of ASD is based on an integral, multi-systemic and inter-professional approach focused on the person with ASD, their family and the community, diagnoses of ASD can be difficult to make because there are no conclusive medical tests to diagnose them; it is specially trained physicians and psychologists who rely on specific behaviors to identify autism [24]. Sometimes ASDs can be detected at 18 months of age or even earlier. At 2 years of age, the diagnosis made by an experienced professional can be considered very reliable [25].

The current study was carried out with a sample of 42 cases diagnosed with any of the subclasses of autism established by the DSM-V. It included boys and girls aged between 18 months and 4 years, of different phenotypes and social strata, natives of the provinces of Guayas, Los Ríos, Manabí, and Santa Elena, to determine the main elements to which the subjects were exposed to establish possible common groups of causal factors of the disease.

The selected team of experts was made up of 9 specialists in Child Psychology, Neuropsychology, and Psychiatry. The study was based on the analysis of the diagnosis through retrospective studies according to the following procedure:

a) Interviews not done with the mother and father separately and then to the parental partner (whenever possible)
b) Very open questions about child development to both parents
c) Elicit anecdotes about the child's development, sometimes triggered by examining photographic materials from the child's early years
d) Review of previous medical records (if any)
e) Tracking over time the symptoms observed in the present

The data obtained were processed by using the Neutrosophic Cognitive Maps (NCM), a very versatile tool in the investigation of causal factors for the treatment of neutralities. Its use enriched the possibilities of analysis, mainly due to the addition of indeterminacy and the possibility of calculating using linguistic terms that are more natural for the selected experts [26].

2 Materials and methods

For a better understanding of data processing with Neutrosophic Cognitive Maps (NCMs), the following is exposed:

Starting from the previous elements, in this particular work, the use of NCM is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [4]. NCMs were introduced by [28] in 2003. MCNs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995 [29]. This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty. [29] Exposes that FCMs constitute a technique that has received increasing attention due to its possibilities for representing causality. The following is a set of definitions necessary for working with NCMs. Firstly, let formally expose the original definition of neutrosophic logic as it is shown in [30].

Definition 1.

[5] Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ be a *neutrosophic set of evaluation*. v: P□N is a mapping of a group of propositional formulas into N, ie, each sentence p is associated to a value in N, as it is exposed in Equation 1, meaning that p is T% true, I% indeterminate, and F% false.

$$v(p) = (T, I, F) \quad (1)$$

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [26] [31].

Definition 2. (See [32] [33]) Let K be the ring of real numbers. The ring generated by K∗I is called a *neutrosophic ring* if it involves the indeterminacy factor in it, where I satisfies I2 = I, I + I = 2I and in general, I +

I + ... + I = nI, if k , then kI = kI, 0I = 0. The neutrosophic ring is denoted by K (I), which is generated by K∗I, ie, K (I) = <K∗I>, where <K∗I> denotes the ring generated by K and I.

Definition 3. *A neutrosophic matrix* is a matrix A = [a_{ij}] ij i = 1, 2,…, m and j = 1, 2,…, n; m, nε1, such that each a_{ij} K (I), where K (I) is a neutrosophic ring, see [3. 4]

Let us observe that an element of the matrix can have the form a + bI, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example,$(-1\ I\ 5I\ I\ 4\ 7\ )(I\ 9I\ 6\ 0\ I\ 0\ \ -4\ 7\ 5\ ) = \ (-21I\ 27I\ \ -6+25I\ \ -28+I\ 49+13I\ 35+6I\ )$

Additionally, a *neutrosophic graph* is a graph that has at least one indeterminate edge or one indeterminate node [30] [35]. The *neutrosophic adjacency matrix* is an extension of the adjacency matrix in classical graph theory. aij = 0 means nodes i and j are not connected, a_{ij} = 1 means that these nodes are connected and aij = I, which means the connection is indeterminate (unknown if it is or if not). Fuzzy set theory does not use such notions.

On the other hand, if the indetermination is introduced in a cognitive map as it is referred to in [36], then this cognitive map is called a neutrosophic cognitive map, which is especially useful in the representation of causal knowledge [26] [37]. It is formally defined in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, events, among others, as nodes and causalities or indeterminacy as edges. It represents the causal relationship between concepts.

The measures described below are used in the proposed model; they are based on the absolute values of the adjacency matrix [36]:

- Outdegree (vi) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of the outgoing relationships (cij) of the variable:

$$od(v_i) = \sum_{i=1}^{n} \quad c_{ij} \tag{2}$$

- Indegree (v_i) is the sum of the column elements. It reflects the strength of relations (cij) outgoing from the variable.

$$id(v_i) = \sum_{i=1}^{n} \quad c_{ji} \tag{3}$$

- Total centrality (total degree td (vi)), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \tag{4}$$

The variables are classified according to the following criteria, see [6]:

a) *Transmitting variables* are those with od (vj)> 0 and id (vi) = 0.

b) *Receiving variables* are those with od (vj) = 0 and id (vi)> 0.

c) *Ordinary variables* satisfy both od (vj) ≠ 0 and id (vi) ≠ 0.

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights [35]. Static analysis in Neutrosophic Cognitive Maps (NCM), see [37], initially contains the neutrosophic number of the form (a + bI), where I = indetermination [38]. Then, it requires a process of de-neutrosophication as proposed in [36], where I ∈ [0, 1] and it is replaced by their values maximum and minimum.

Finally, we work with the average of the extreme values, calculated using Equation 5, which is useful to obtain a single value as it is referred to in [39]. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{5}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{6}$$

3 Results

By the interviews carried out with the parents of the children diagnosed and the clinical review of each case, the experts consulted used brainstorming to propose a universe of possible causal factors in the study sample. After the use of expert methods and taking into account the statistical results of the sample, a smaller set was selected, which, in their opinion, are the most relevant for the fulfillment of the study objectives:

1. Premature birth: studies have found that preterm and low birth weight newborns are more likely to suffer from neurological diseases than other babies [40] [41]. In this group, patients born between 30 and 37 weeks of gestation are considered.
2. Cesarean birth/traumatic delivery: Despite the lack of conclusive evidence, numerous correlations have been found between cesarean birth and ASD. Recent studies suggest that children undergoing cesarean are more likely to develop the disease than other children [42].
3. Use of children's medications during the first 3 years of life: Children exposed to medication for the treatment of chronic diseases or non-chronic diseases that required treatment and specialized medication are considered.
4. Exposure to electronic devices with blue light: The accelerated development of technology has made cell phones, TV screens, monitors, among others, totally diffused objects. This group refers to patients who had an exposure greater than the 2 hours a day recommended by the American Academy of Pediatrics.
5. Social interaction of family members with the child refers to the level of personal interrelation between any close member of the family and the patient under study. It is known that among the cases studied, 7% come from dysfunctional families or from families that have antisocial members.
6. Advanced age of the parents: Children who have been the result of geriatric pregnancies and/or in which the paternal age is greater than 45 years are considered. Of the sample under study, 7.1% are in this category. One of the cases studied includes the advanced age of both the mother and the father.
7. Family history of autism: Several studies have identified a series of genetic changes or mutations associated with autism, confirming that genetics is one of the most important risk factors for ASD. Patients with relatives up to the fourth generation who have presented autism are considered.
8. Family history of mental illness: Children are considered to be related to some extent with close relatives or undiagnosed with some kind of mental illness [43]. In the selected sample, about 5% are within this category.
9. Family history of neurological diseases: Children are considered related to some extent with close relatives diagnosed with some neurological disease.
10. Family history of chronic diseases: This subgroup includes a family history of chronic non-neuronal diseases. In the study group, about 30% are linked in some way to relatives associated with rheumatic, cardiovascular, endocrine, and oncological diseases.
11. Use of medications during pregnancy/lactation: the cases are considered in which the mother was exposed during pregnancy or breastfeeding to the intake of anxiolytic, antidepressant, an opioid analgesic, barbiturate, antispasmodic or anticonvulsant medications. In this case, about 20% of pregnant or lactating mothers fall into this category.
12. Use/abuse of drugs, alcohol and/or cigarettes of one of the parents during the period of fertilization, pregnancy, and lactation (in the case of the mother): About 26% of the cases studied were exposed before birth and during the first years of life for the purposes included in this category.

Once the causal factors that, in the opinion of the experts, have the greatest incidence in the study group have been screened, the data is processed using the NCM. See adjacency matrix below:

$$A(x)=\begin{vmatrix}
1 & 0.7 & 0 & 1 & 1 & 1 & 0.2 & 1 & 0.5 & 1 & 0.4 & 1 \\
1 & 0 & 0 & 0 & 0.4 & 0.5 & 1 & 1 & I & 0 & 0 & 1 \\
0.5 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0.2 & 0 & 1 \\
0 & 0.2 & 0.5 & 1 & 0.2 & 1 & 1 & 1 & 0.8 & 0.5 & I & 0 \\
1 & 1 & 0 & 0 & 0 & 0.5 & I & 0.6 & 0.4 & 0 & 0 & 1 \\
1 & 0.8 & 0 & 1 & 1 & 0 & 1 & 0.5 & 0.4 & 1 & 1 & 0 \\
1 & 0.1 & 1 & 0.5 & 1 & 1 & 1 & 0.1 & 0.5 & 1 & 0 & 0 \\
0 & 0 & 0.5 & 0.3 & 0.6 & 0 & 1 & 0 & 0.5 & 0.5 & 0.4 & 0.5 \\
0.5 & 0 & 0.5 & 1 & 0.4 & 0.6 & I & 1 & 0 & 1 & 0 & 0.2 \\
0.2 & 0.2 & 0.2 & 0.2 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\
0.5 & 0 & 0 & 0 & 0.2 & 0.2 & 0.2 & 0 & 0 & 0.5 & 0 & 1 \\
1 & 1 & 0 & 1 & 1 & 0.5 & 0 & 1 & 0.2 & 0.5 & 0 & 1
\end{vmatrix}$$

Figure 1: Neutrosophic adjacency matrix.

The causal analysis resulting from the data processing indicates that within the group studied, the factors with the greatest influence are the premature birth of the patients and the family history of autism. Other factors such as cesarean birth and traumatic deliveries, and prolonged exposure to electronic blue light devices are considered lesser.

Factors	id	od	td
Premature birth	0.88	1.00	**1.88**
Family history of autism	0.95	0.82	**1.77**
Cesarean birth/traumatic delivery	0.76	0.82	**1.58**
Exposure to electronic devices in blue light	0.80	0.76	**1.56**
Parents' advanced age	0.60	0.88	**1.48**
Social interaction of family members with the child	0.77	0.57	**1.34**
Family history of mental illness	0.70	0.49	**1.19**
Family history of neurological diseases	0.55	0.65	**1.19**
Use/abuse of drugs/alcohol/cigarettes by either parent during the period of fertilization, gestation, and lactation (in the case of the mother)	0.45	0.61	**1.07**
Family history of chronic diseases	0.70	0.32	**1.02**
Use of children's medications during the first 3 years of life	0.31	0.53	**0.84**
Medication use during pregnancy/lactation	0.26	0.30	**0.56**

Table 1: Static analysis of the adjacency matrix by perspectives according to the order of influence

The experts found consensus on the three main causal factors detected for this sample. In the first place, the relationship between exposure to adverse prenatal situations and the prevalence of ASD symptoms is known. In recent years, the international community has increased screening studies investigating possible risk factors for ASD in preterm newborns. Out of the study sample, almost 20% had a birth between 30 and 37 weeks of pregnancy. From the debate with the experts, it was known that babies born prematurely or with low weight are more likely to develop the disease than babies born on term and with adequate weight. At this point, the experts agree with the existing opinion and this factor is validated as a possible causal factor of ASD in the group under study.

On the other hand, although it is very difficult to determine exactly to what extent genes determine the prevalence of ASD, researchers agree that autism has an important hereditary component since the disorder tends to run in families, which is why several studies have validated that genetic inheritance plays an important role in the development of the disease. In the sample studied, 14.7% of the children have a genetic relationship to a greater or lesser degree with a case previously diagnosed with autism, so the experts agree that the genetic relationship is a significant causal factor that is prevalent in the group of study.

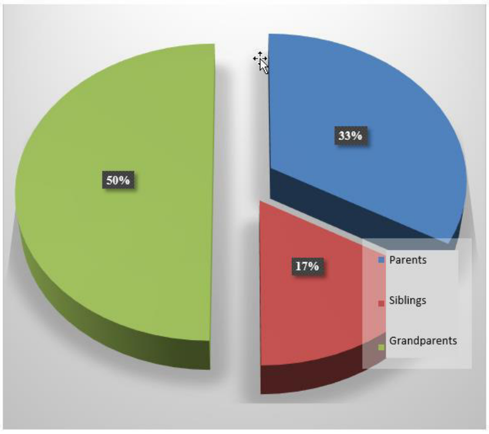

Figure 2: Family history diagnosed with ASD of the study subjects.

Although to a lesser degree than the first two, cesarean birth has also been associated as a possible causal factor for ASD. It is well known that the time of delivery is one of the most biologically complex in mammals. Many neurological disorders have their origin in incorrect brain development, and recent studies reveal that children born by cesarean section or problematic deliveries are more likely to be diagnosed with autism, so experts agree with the inclusion of this factor as a causal factor in the sample studied. Out of the total sample, about 12% were delivered by cesarean method, while 7% of the total were born due to deliveries that had some kind of neonatal complication and suffered some obstetric injury.

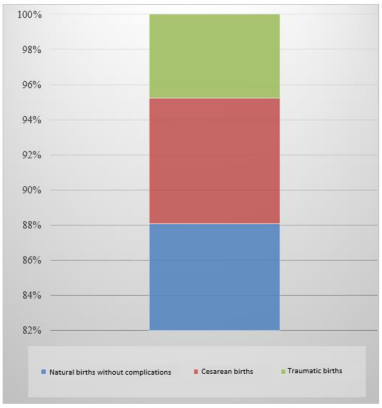

Figure 3: Percentage ratio of natural deliveries, cesarean deliveries, and traumatic deliveries of the total sample.

It is important to note that, although it is not among one of the top three causative agents of the disease in the group, experts position exposure to blue light electronic devices above others approved by the international scientific community. Currently, there is no doubt that exposure to these devices is increasing. Mothers and fathers turn to them as an infallible means of entertainment for children, many times without considering that their needs for human interaction at an early age are vital for the proper development of psychosocial functions.

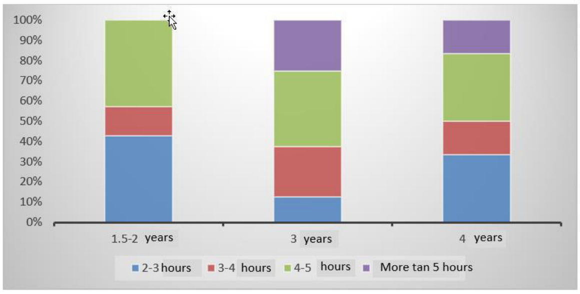

Figure 4: Summary of the time of exposure to blue light devices according to age groups.

In the sample analyzed, almost half of the children were exposed to blue light devices for a longer time than recommended by the American Academy of Pediatrics. Children from 18 months to 2 years have a large representation of exposure for times more significant than 4 hours; 3-year-old children are prevalent in 4 to 5-hour exposure, as are 4-year-old patients. It should also be noted that the most affected group of those studied is the 3-year-old since they have the largest number of children exposed to this factor for more than 5 hours. In this sense, it would be pertinent for this same group to develop other studies that could analyze in-depth the real impact of blue light devices and patients' medium and long-term behavior when eliminating this exposure.

Conclusions

The number of cases diagnosed with some kind of autism has been increasing over the years. The causes of ASD are still unknown to science; however, experts on the subject have concluded that there are factors of various kinds that lead to the appearance of the disease with greater probability in some individuals than in others. The sample studied determined that the most important causal factors were premature birth and a family history of autism. To a lesser extent, other factors such as cesarean delivery and traumatic deliveries and prolonged exposure to electronic blue light devices are considered. It is recommended to study the behavior of the symptoms and signs of the disease before the elimination of the exposure to blue light devices.

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University of New Mexico

Statistical Methods and Management of Indeterminacy in Medical Sciences. Surgical Site Infection Study after Vascular Surgery Procedures

Carlos Acosta Mayorga[1], Piedad Elizabeth Acurio Padilla[2], Guillermo Bastidas Tello[3] and Abdel Bermúdez del Sol[4]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.carlosacosta@uniandes.edu.ec
[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.piedadacurio@uniandes.edu.ec
[3] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.guillermobastidas@uniandes.edu.ec
[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.abdelbermudez@uniandes.edu.ec

Abstract. Surgical site infections (SSIs) are one of the main infection control problems in modern hospitals, significantly prolonging the stay at the hospital and increasing the cost of treating patients with infections. They are the leading cause of failure for both patients and staff, including the need for repeated surgeries. The objective of this study is the epidemiological and microbiological analysis, through neutrosophic statistical tools, of surgical site infections after vascular surgery in a highly specialized vascular surgery center in the city of Guayaquil, in which 327 vascular operations were performed, during the year 2019 and the follow-up of patients was taken into account as required, until 2020. The neutrosophic hypothesis tests applied allowed us to identify possible problems in the vascular surgery room from their comparison with multicenter studies described in the literature, specifically, from the National and State HAI Progress Report of the USA, as well as to rule out the classification of the state of the patient as a possible predictor of SSI diagnoses at this hospital.

Keywords: neutrosophic statistics, neutrosophic hypothesis test, surgical site infection, vascular surgery.

1 Introduction

Nosocomial infections (from the Latin nosocomium «hospital») are infections acquired during a hospital stay that were not present or during the incubation period nor at the time of patient admission [1]. Today, this concept extends to the hospital and the entire non-strictly hospital healthcare environment (day hospital, ambulatory surgery centers, ambulatory hemodialysis centers, chronic disease centers, etc.), so the term extends to healthcare-related infections [2]. They constitute a problem with repercussions on mortality and hospital stay, assuming a high cost due to the use of antimicrobials, the need for isolation, and the performance of diagnostic and therapeutic tests [6].

According to the World Health Organization (WHO), more than 1.4 million people worldwide contract infections in hospitals. Between 5 and 10% of patients admitted to hospitals in the developed world will contract one or more infections, with the risk of infection in developing countries being 2 to 20 times higher than in developed countries. In the United States, one in every 136 hospital patients becomes seriously ill from an infection acquired in a hospital, equivalent to 2 million cases and approximately 80,000 deaths per year, at the cost of about $ 4.5 trillion US [2].

Of the types of nosocomial infection due to medical care, surgical site infection (SSI) is one of the most common and affects tissues manipulated or adjacent to the surgical site. Surgical site infections (SSI) are a type of infection that occurs after a surgical intervention, in an area of the body where the operation was carried out, involving the skin, tissues, and organs or implanted material, revealing itself as a combination of signs and symptoms that show infection [3].

At present, all health centers have a mandatory goal for the safety of their patients to reduce nosocomial infections. A patient with a surgical site infection has a five times higher risk of dying than a patient with the same uninfected condition [9]. At the same time, each infection at the surgical site causes the patient to spend in the hospital one more week than expected, which leads to additional expenses and, in addition, the loss of health expectations placed on the surgical procedure itself [10].

Different studies have identified risk factors that can influence the appearance of SSI. Among others, the following are worth noting as intrinsic factors: malnutrition and protein depletion, advanced age, diabetes, cancer, chronic vascular disease and obesity, alteration of immune function due to disease or therapeutic regimens, smoking, chronic organ failure, recurrent infection in a remote location and decreased tissue perfusion. Extrinsic factors include hand-washing for surgery, prolonged preoperative (more than 24 hours), prolonged hospitalization, re-operation, shaving, surgical clothing, duration of surgery, air conditioning, instruments, surgical technique, antisepsis of skin, prophylactic antibiotics, sterilization [3].

Despite the improvement in surgical techniques, the better knowledge of the pathomechanisms of the infection, and the greater knowledge of their control, the problems associated with SSI continue to be the most common and serious complications after surgery, also in the field of vascular surgery, where the incidence ranges between 2.1% and 4.1%. (1, 2, 3) and a mortality of 10 to 48% [4].

The objective of this study is the epidemiological and microbiological analysis of surgical site infections after vascular surgery in a highly specialized vascular surgery center in the city of Guayaquil, using neutrosophic statistics tools.

2 Materials and methods

The study was carried out in a specialized vascular surgery hospital room in the city of Guayaquil, in which 327 vascular surgical procedures were performed, during 2019. Among the main procedures performed are those involving the incision of vessels: arteries of the lower extremities, abdominal aortic aneurysm, aortic-iliac prosthesis, intra-abdominal vascular anastomoses, femoral implants, and the placement of aortic-duodenal prostheses.

The registration of SSI cases was carried out in collaboration with the center's Department of Microbiology. For each patient submitted to the analyzed procedures, general demographic data (age, sex, reason for hospital admission, date of admission, discharge or death), risk factors, diagnostic and therapeutic procedures, and information on the patient's condition described using the scale of the American Society of Anesthesiology (ASA) [5] were collected and are shown in table 1.

ASA Class	Definition	Definition
I	Normally healthy patient	Healthy, nonsmoking, no or minimal alcohol use
II	Patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 <BMI <40), well-controlled DM / HTN, mild lung disease
III	Patient with severe systemic disease	Substantive functional limitations; 1 or more moderate-to-severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥ 40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA <60 weeks, history (> 3 months) of MI, CVA, TIA, or CAD/stents
IV	Patient with an incapacitating systemic disease that is a constant threat to life	Old traumatic wounds with retained devitalized tissue and those wounds including (but not limited to): recent (<3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD, or ESRD not undergoing regularly scheduled dialysis involve existing clinical infection or perforated viscera. This definition suggests that organisms causing a postoperative infection are present in the operative field before the operation
V	Moribund patient who is not expected to survive for 24 h with or without operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology, or multiple organs/system dysfunction

Table 1. ASA Physical Status Classification (PSC)

The criteria for the diagnosis of infections were based on the recommendations of the National Health Care Network (2021) [7] regarding:

1) Division into clinical forms of infection: superficial, deep, organ-related

2) Qualification standards for superficial infections of the MCA up to 30 days after surgery, and in the case of surgery with the use of an implant (deep and organ infections), up to 1 year.

The local infection control team performed scoring of infections in the room during hospitalization. If the infection developed after hospital discharge, the review and grading were carried out in collaboration with the hospital's outpatient staff. The basis for the post-discharge registry was a screening form, filled out in the outpatient clinic and delivered to the team.

Based on the results of the microbiological examination and the medical record, the team decided on the qualification of the case. The microbiological tests of the materials of the patients with symptoms of infection were carried out in the microbiological diagnostic laboratories of the hospital itself. In nine cases, mixed flora was grown. The species affiliation of the grown strains was determined using routine diagnostic methods, and their susceptibility to drugs was tested using the disk diffusion method.

The analysis used the standardized SSI risk index analysis method. The Surgical Site Infection Risk Index is a tool to study morbidity in patient populations (small and well described), based on an integrated analysis of three categories of variables (which are real indicators of STM risk). According to [7], the Standardized Infection Ratio (SIR) is the primary summary measure used by the National Healthcare Safety Network (NHSN) to track healthcare-associated infections (HAI).

In this study, the same risk factors were adopted for their use in the analysis, of the degree of microbial contamination of the surgical area. Wounds that occur during surgery in the dirty or contaminated field were classified as an increased risk of HAIs. The classification was carried out by the surgeon during or immediately after the procedure. Procedures performed in the presence of trophic-inflammatory changes were classified as contaminated.

To carry out the statistical comparison between the SIR values standardized by the NHSN, with the proportions observed in the hospital studied, a neutrosophic hypothesis test of comparison of proportions was used since these allow applying levels of significance with a certain level of indeterminacy.

According to [1], "The neutrosophic statistics (NS) is the alternative of classic statistics to be applied under the uncertain environment. NS is based on neutrosophic numbers. NS logic is the extension of the fuzzy logic and deals with the measure of indeterminacy" (p. 1).

Smarandache [8] defines the neutrosophic hypothesis as a statement about the neutrosophic values of one or more population characteristics. Therefore, we start from the Z statistic of the classical statistic comparison test of proportions [11]:

$$\text{Statistic } Z = \frac{\widehat{P_1} - \widehat{P_2}}{\sqrt{pq\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (1)$$

And a neutrosophic critical region is applied for $z > min[z_{\alpha 1}, z_{\alpha 2}]$

To determine the relationship between the patient's status (as a measure of risk factors), regarding the suffering of SSI, a neutrosophic Chi-square test was performed, due to the vagueness regarding the information collected on 18 of the patients, which prevented assigning a unique ASA Physical Status Classification. This test was performed to determine the feasibility of using the patient's status category as a predictor of SSI.

4 Results

In the studied center, 16 cases of surgical site infections were diagnosed. The mean/average age of the sample was 58.8 years, and the mean age of the patients diagnosed with SSI was slightly higher (59.3). The influence of the duration of the surgery on the onset of the infection was analyzed and a statistically significant difference was observed: patients who underwent a longer surgery were more likely to develop an infection (T = 2.0087, p = 0, 0485) for a 95% confidence level.

The microbiological cleaning of the field did not affect morbidity, nor did it affect the patient's condition during qualification for surgery expressed by the ASA score and age.

Furthermore, hospitalization in this hospital before the procedure lasted longer, especially in the population diagnosed with PD, although the mean length of stay is, in general, shorter (Table 1).

Variable	Total	SSI
Number of treatments	327	16
Procedures in the clean field/clean-contaminated field [%]	98.0	100.0
Status of the patients according to the ASA scale: 3/4/5 [%].	76.8	82.5
Hospitalization before procedure [days]	4	3
Average length of stay in total [days].	16	2. 3

Mean age of patients [years].	67	66
Proportion of women among operated patients [%].	19.8	25.0
Average duration of the procedure [min]	116	
Duration of the procedure above the norm [min]	145	

Table 2. Patient characteristics and procedures performed

Hospital specialists applied an effective method of post-discharge surveillance, grading SSI cases both during the ward stay and in cooperation with the hospital outpatient clinic (Table 3). The mean time to onset of the first symptoms of infection was 34 days. Among all diagnosed cases, more than half of the infections are in the "deep" category, so almost half of the patients required treatment.

Observed Variables	Diagnosed cases	
MND Standard	**Frequency**	**[%]**
Superficial	5	33.33%
Deep	8	53.33%
Organ related	2	13.33%
SSI cases - time of detection	**Frequency**	**[%]**
Before discharge	2	13.33%
After discharge	9	60.00%
Rehospitalization	4	26.67%
Time since operation	**Frequency**	**[%]**
<21 days	7	46.67%
21-50 days	5	33.33%
> 51 days	3	20.00%

Table 3. Characteristics of diagnosed cases

In the hospital setting (re-hospitalization), all cases of SSI occurred in the form of superficial infections. Analysis of the risk index was only possible in approximately 95% of the data, the remaining part of the records contained deficiencies, mainly in terms of the description of the patients' conditions (ASA scale).

More than half of the operated patients were diagnosed with one of the risk factors analyzed; the rest of the patients had no risk (22%) or had a higher risk (2 or 3 risk factors). As a result, morbidity reached values of 5.6%.

To compare the incidence of SSI in patients with a different load of selected risk factors, with the US NHSN infection control program [10], the neutrosophic hypothesis test of comparison of proportions for a neutrosophic alpha $\alpha = [0.01, 0.05]$ was proposed.

H0: p1 = p2.

H1: p1> p2.

$\alpha = [0.01, 0.05]$

Neutrosophic critical region: $z > min[1.645, 2,32]$

The frequency and proportion data for both the NHSN data and the selected sample are shown in Table 4.

Source	Total interventions	SSI Cases	Proportion
NHSN	31,339	128	0.004
Show	327	15	0.047

Table 4. Proportion of SSI cases

Applying (1) we obtain:

$$\text{Statistic } Z = \frac{0.047 - 0.004}{\sqrt{0.0045 * 0.9955(\frac{1}{317} + 1/31339)}} = 11.359$$

The equality hypothesis is rejected since the value of the Z statistic belongs to the neutrosophic rejection region, so it can be stated that the proportion of SSI cases observed in the sample studied is higher than the results published by the NHSN.

ASA classification of each patient is shown in table 5, in which P represents the patient; SSI, whether he suffered an infection or not, and PSC stands for Physical State Classification. Please note that the interval was

[3,4] for seven patients, while for eleven patients, it was [4,5].

P	SSI	PSC	P	SSI	PSC	P	SSI	PSC	P	SSI	PSC	P	SSI	PSC	P	SSI	PSC	P	SSI	PSC
1	NO	2	51	NO	3	101	NO	2	151	NO	1	201	NO	2	251	NO	2	301	NO	1
2	NO	5	52	NO	2	102	NO	2	152	NO	2	202	NO	2	252	NO	2	302	NO	2
3	YES	4	53	NO	3	103	NO	2	153	NO	4	203	NO	1	253	NO	1	303	NO	3
4	NO	[3,4]	54	YES	3	104	NO	5	154	NO	2	204	NO	1	254	NO	2	304	NO	3
5	NO	2	55	NO	[4,5]	105	NO	[3,4]	155	NO	4	205	NO	4	255	NO	1	305	NO	4
6	NO	1	56	NO	3	106	NO	1	156	NO	2	206	NO	3	256	NO	4	306	NO	1
7	NO	2	57	NO	3	107	NO	1	157	NO	4	207	NO	3	257	NO	1	307	NO	3
8	NO	3	58	NO	2	108	YES	1	158	NO	1	208	NO	5	258	NO	[4,5]	308	NO	1
9	NO	2	59	NO	1	109	NO	4	159	NO	4	209	NO	3	259	NO	1	309	NO	2
10	NO	3	60	NO	3	110	NO	[3,4]	160	NO	3	210	NO	2	260	NO	3	310	NO	3
11	NO	2	61	NO	3	111	NO	5	161	NO	1	211	NO	3	261	NO	3	311	NO	2
12	YES	4	62	NO	3	112	NO	1	162	NO	2	212	NO	1	262	NO	1	312	NO	5
13	NO	3	63	NO	3	113	YES	3	163	NO	3	213	NO	1	263	NO	2	313	NO	1
14	NO	4	64	NO	1	114	NO	5	164	NO	4	214	NO	[4,5]	264	NO	2	314	NO	3
15	NO	4	65	NO	1	115	NO	1	165	NO	4	215	NO	3	265	NO	3	315	NO	[4,5]
16	NO	[3,4]	66	NO	1	116	NO	2	166	NO	2	216	NO	5	266	NO	1	316	NO	2
17	YES	1	67	NO	3	117	NO	2	167	NO	4	217	NO	3	267	NO	3	317	NO	5
18	NO	4	68	NO	2	118	NO	3	168	NO	5	218	NO	[4,5]	268	NO	1	318	NO	1
19	NO	1	69	NO	5	119	NO	4	169	NO	1	219	NO	1	269	NO	2	319	NO	3
20	NO	2	70	NO	4	120	NO	4	170	NO	[4,5]	220	NO	2	270	NO	1	320	NO	3
21	NO	2	71	NO	5	121	NO	3	171	YES	5	221	NO	2	271	NO	1	321	NO	3
22	NO	3	72	NO	4	122	NO	1	172	NO	1	222	NO	4	272	NO	2	322	NO	3
23	NO	1	73	NO	1	123	YES	3	173	NO	2	223	NO	3	273	NO	3	323	NO	2
24	NO	2	74	NO	2	124	NO	2	174	YES	3	224	NO	2	274	NO	1	324	NO	2
25	NO	5	75	YES	2	125	NO	1	175	NO	1	225	NO	1	275	NO	1	325	NO	5
26	NO	5	76	NO	2	126	NO	1	176	NO	3	226	NO	3	276	NO	[4,5]	326	NO	1
27	NO	2	77	NO	5	127	NO	2	177	NO	3	227	NO	1	277	NO	3	327	NO	3
28	NO	4	78	NO	1	128	NO	3	178	NO	2	228	YES	2	278	NO	5			
29	NO	3	79	NO	3	129	NO	2	179	NO	1	229	NO	5	279	NO	1			
30	NO	3	80	NO	1	130	NO	1	180	NO	3	230	NO	1	280	NO	1			
31	NO	2	81	NO	3	131	NO	3	181	NO	3	231	NO	[3,4]	281	NO	[4,5]			
32	NO	2	82	NO	1	132	NO	1	182	NO	2	232	NO	2	282	NO	1			
33	NO	5	83	NO	3	133	YES	4	183	NO	1	233	NO	2	283	NO	2			
34	NO	3	84	NO	3	134	NO	4	184	NO	3	234	NO	4	284	NO	2			
35	NO	5	85	NO	2	135	NO	4	185	NO	3	235	NO	1	285	NO	3			
36	NO	[4,5]	86	YES	4	136	NO	4	186	NO	2	236	NO	3	286	NO	3			
37	YES	1	87	NO	2	137	NO	1	187	NO	3	237	NO	1	287	NO	2			
38	NO	1	88	NO	[3,4]	138	NO	2	188	NO	5	238	NO	3	288	NO	2			
39	NO	3	89	NO	3	139	NO	4	189	NO	2	239	NO	2	289	NO	3			
40	NO	2	90	NO	2	140	NO	3	190	NO	1	240	NO	1	290	NO	1			
41	NO	3	91	NO	4	141	NO	2	191	NO	2	241	NO	4	291	NO	3			
42	NO	5	92	NO	4	142	NO	[4,5]	192	NO	1	242	NO	[3,4]	292	NO	3			
43	NO	3	93	NO	2	143	NO	1	193	NO	4	243	NO	2	293	NO	2			
44	NO	1	94	NO	1	144	YES	4	194	NO	3	244	NO	3	294	NO	2			
45	NO	1	95	NO	1	145	NO	2	195	NO	1	245	NO	1	295	NO	2			
46	NO	1	96	NO	3	146	NO	3	196	NO	3	246	NO	2	296	NO	1			
47	YES	5	97	NO	1	147	NO	3	197	NO	3	247	NO	1	297	NO	2			
48	NO	3	98	NO	3	148	NO	3	198	NO	2	248	NO	1	298	NO	2			
49	NO	1	99	NO	2	149	NO	4	199	NO	3	249	NO	4	299	NO	1			
50	NO	2	100	NO	3	150	NO	3	200	NO	[4,5]	250	NO	3	300	NO	2			

Table 5 SSI-PSC ratio per patient

A deneutrosophication process, using the midpoint of the intervals [3,4] and [4,5] (3.5 and 4.5 mean points respectively), allows generating two new intermediate categories to be able to apply the classic statistics Chi-square test for contingency tables. From which we obtained table 6, after processing the data with IBM SPSS software.

			PSC							
			1,00	2,00	3,00	3,50	4,00	4,50	5,00	Total
SSI	YES	Score	3	2	4	0	5	0	2	16
		% in PSC	3,7%	2,4%	4,6%	0,0%	13,9%	0,0%	8,7%	4,9%
	NO	Score	78	80	83	6	31	11	21	311
		% in PSC	96,3%	97,6%	95,4%	100,0%	86,1%	100,0%	91,3%	95,1%
Total		Score	81	82	87	6	36	11	23	327
		% in PSC	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 6. Contingency table SSI-PSC

Table 6 shows the new categories obtained through the de-neutrosophication process, which have zero frequency in the first row. This means that no patient with a certain level of indeterminacy in his information about his risk factors was diagnosed with SSI. In general, the diagnosed cases represent 4.9% of the total of surgeries performed. It indicates that morbidity is not related to risk factors of patients regarding ASA classification.

The statistical analysis confirms the differences in morbidity between the population from the United States and the sample of the studied hospital, which indicates the need for a permanent and detailed review of the epidemiological risk factors and the practice and the prevention measures to improve the current situation. On the other hand, a statistically significant relationship between the physical state (risk factors) of the patients and their SSI diagnosis could not be established.

Conclusions

At the analyzed institution, the follow-up of the hospital infections is being carried out for several years now, using active infection monitoring tools and databases. From the very first years of the current century, specific monitoring of certain surgical procedures was introduced. One of the most important elements was the attempt to implement the supervision of infections that appeared after the patients were discharged.

This study confirms the need and feasibility of the follow-up after the patient is discharged, especially in a unit that uses implants, where exceptional reliability in monitoring infections one year after the surgery is required. The data registered by the Ecuadorian health centers, on many occasions, do not register information after the patient is discharged, so its sensibility was lesser.

The neutrosophic hypothesis tests applied, allowed identifying possible problems of the vascular surgery room of an Ecuadorian hospital based on its comparison with multicenter studies described in the literature, specifically, of the National and State HAI Progress Report from the USA, developed by specialist of the CDC, along with the National Healthcare Safety Network (NHSN); as well as ruling out the classification of the patient's state as a possible predictor of SSI diagnosis in this hospital.

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Handling of the Indeterminacy in the Market Segmentation of the Tourist Destination Patrimonial City of Cuenca - Ecuador

Sharon Dinarza Álvarez Gómez[1], Aida Margarita Izquierdo Morán[2], Lourdes Viviana Moreira Rosales[3] and Oscar Rodrigo Aldaz Bombón[4]

[1] Directora Financiera. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: dirfinanciera@uniandes.edu.ec

[2] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador. Email: uq.aidaizquierdo@uniandes.edu.ec

[3] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.lourdesmoreira@uniandes.edu.ec

[4] Docente de la carrera de Contabilidad y Auditoría. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.oscaraldaz@uniandes.edu.ec

Abstract. This paper aims to identify the profiles of the different segments of tourists who visit the destination of Cuenca, declared a World Heritage Site by UNESCO in 1999. Methodologically, a quantitative approach with a descriptive scope was used through surveys with systematic random sampling. Several questions were analyzed divided into four groups: demographic characteristics, travel characteristics, aspects related to the service or product, and the evaluation of the satisfaction of the tourist offer. In order to evaluate the factors that motivated the visit, the preferred activities, and the level of general satisfaction and attributes of the destination, linguistic terms associated with sets of neutrosophic values were used, with which subjectivity and the indeterminacy of the answers could be managed.

Keywords: Single Value Neutrosophic Sets, linguistic terms, market segmentation, tourist destination.

1 Introduction

In its definition and practice, tourism is closely related to the movement of people to places other than their habitual residence, who, according to the length of stay, can be visiting hikers, residents, or non-residents. This mobility responds to the human need to move in search of freedom to know the world and interact face to face with other cultures [4],[3] that is satisfied through tourist activity, with which individuals enjoy a wide offer to discover so many places that diversify consumer experiences and that set guidelines in demand [1, 2].

Despite the economic crises that many countries have experienced, tourism in the last decade has maintained a growing development that places it as one of the most important and solid sectors of the world economy, even higher than oil exports. Such is its development that, according to the World Tourism Organization (2017), it contributes 10% of the world's Gross Domestic Product (GDP), generates exports of more than 1.5 trillion US dollars, and constitutes 7% of international trade [18].

In this context, tourism is certainly a social and cultural phenomenon that affects the economy of the visited places; its impact is measured through tourist indicators and statistical data, such as the count of lodging units [3]. Therefore, statistical information on tourism is important for the sustainable management of the destination and is a solid tool for the analysis of current and future trends in tourism, as well as essential for decision-making by local governments [1, 2],[1, 2], [3].

According to [10], the growing development of cultural tourism in recent years is fundamentally due to the growing appreciation of cultural and historical heritage by society, and this growth has been more notable in cities or historical complexes declared Heritage of the Humanity. Therefore, heritage destinations have to rigorously and systematically face those aspects related to the balanced insertion of tourist activity, a consideration that leads to the need to interpret more adequate solutions to problems or needs that interfere with local development [1, 2] [15].

The current scenarios create the need to adopt strategies that allow us to respond to the challenges and demands of dynamic, changing, and complex environments; and orient its action towards the objectives set out in the local development plans [14]; where the enhancement of the natural, cultural, social, architectural and gastronomic heritage of the town is preponderant [16].

The importance of knowing the profile of the users of a destination lies in the possibility of better understanding the reasons for visiting and the use that visitors make of the place [1, 2]. According to [13], it also allows directing the strategic management of tourism marketing and promotion. The determining factors or that condition the decision to travel are grouped according to their nature into economic, relative to the demanding units, marketing system, and customer satisfaction [1, 2] [1, 2].

The purpose of market segmentation is to find similarities between groups about the product that is being offered to them and to find basic consumer traits so that they will respond in a similar way to the implemented marketing strategies [5][1, 2]. In this way, the offer can better respond to the needs and expectations to achieve greater satisfaction from the different groups [1, 2].

Consumer segmentation is based on the assumption that markets are inherently heterogeneous, and that consumer preferences vary according to their values, needs, desires, restrictions, beliefs, and incentives [6]. Precisely to obtain these profiles or segments, marketing experts use the so-called segmentation criteria [5] that can be very diverse (demographic, socioeconomic, motivational, and psychographic, among others). At the same time, products (including tourist destinations) compete with each other to satisfy the needs and desires of consumers.

In the case of Ecuador, the results of the investigation carried out by [1, 2] for the estimation of demand in the countries of the Andean Community of Nations, reflect that Ecuador is the country with the highest incoming tourist flow and an estimate of international demand. Ecuador has achieved constant growth in the volume of international arrivals, exceeding one and a half million visitors, with an average occupancy rate of over 50% and with revenues amounting to 1,075.5 million USD as of 2016 [18].

All of the above consequently favors the tourism of the city of Cuenca, if we considered that it is the third most important city in Ecuador, which has also seen its income from tourism increased since its declaration as Cultural Heritage of Humanity by UNESCO in 1999. This merit is based on its heritage assets such as churches, historical monuments, squares, parks, and traditional houses. It is one of the most touristic cities in the Azuay province. The "Athens of Ecuador" enjoys a privileged climate for being located within an extensive valley in the middle of the Andean column with a variable temperature between 7 to 15 ° C in winter and 12 to 25 ° C in summer[1, 2].

There are many activities in Cuenca to have fun and keep busy. Nature lovers can walk the peaceful river paths through the diverse and colorful parks or perhaps take a trip to El Cajas National Park, which is just an hour outside the city. It is also easy to make a weekend getaway to a beautiful beach town thanks to its strategic location.

For those looking for activities in the city, Cuenca is generally considered the cultural capital of Ecuador, with many museums, various live music venues, modern art, film festivals, traditional celebrations, exhibitions of artisan products, international cuisine festivals, jazz club, archaeological ruins, and countless arts and crafts fairs that also have specialty groceries and organic products.

The objective set out in this research was to identify the profiles of the different segments of tourists who visit the city of Cuenca tourist destination, through market segmentation. For this, we proposed to use Neutrosophy to treat the elements to be evaluated with a high content of subjectivity.

2 Materials and methods

In this section, the fundamental theoretical supports of neutrosophy are exposed, as well as the description of the research technique and instrument.

2.1 Some basic concepts of Neutrosophy

Neutrosophy is a mathematical theory developed by Florentin Smarandache to deal with indetermination [4-6] [1, 2]. It has been the base for the development of new methods to handle indeterminate and inconsistent information as the neutrosophic sets and the neutrosophic logic and, especially, in decision-making problems [7-9].

Let $N = \{(T, I, F): T, I, F \subseteq [0,1]\}n$, be a neutrosophic evaluation of a mapping of a group of formulas propositional to N, and for each sentence p you have:

$$v(p) = (T, I, F) \tag{1}$$

To facilitate the practical application to decision-making problems, the use of single-value neutrosophic sets (SVNS) [10, 11] was proposed, through which it is possible to use linguistic terms, to obtain greater interpretability of the results.

Let X be a universe of discourse, an SVNS A over X has the following form:

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\} \tag{2}$$

Where

$u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ v_a(x): X \to [0,1]$

With $0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \forall\, x \in X$

The intervals $u_a(x), r_a(x)$ and $v_a(x)$ denote the memberships to true, indeterminate, and false from x in A, respectively. For convenience a Single Value Neutrosophic Number (SVNN) will be expressed as A = (a, b, c), where a, b, c ∈ [0.1] and satisfies 0 ≤ a + b + c ≤ 3[12].

Let $\{A_1, A_2, \dots, A_n\} \in$ SVNS (x), where $A_j = (a_j, b_j, c_j)$ (j = 1, 2, …, n), then, the Single Valued Neutrosophic Weighted Average Operator is defined by [13]:

$$P_w(A_1, A_2, \dots, A_n) = \langle 1 - \prod_{j=1}^{n}\left(1 - T_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(I_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(F_{A_j}(x)\right)^{w_j} \rangle \quad (3)$$

Where: $w = (w_1, w_2, \dots, w_n)$ is vector of $A_j (j = 1,2, \dots, n)$ such that $w_n \in [0,1]$ y $\sum w_j = 1$.

Let A = (a, b, c) be a single neutrosophic number, a score function S of a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and falsity membership degree is defined by[14, 15]:

$$S(A_i) = 2 + a - b - c \quad (4)$$

Where $S(A) \in [-1,1]$

When there is a tie between the scores, the precision function is defined as:

$$T(A_j) = T_j - F_j \quad (5)$$

And then:

If $S(A_j) < S(A_i)$, then $A_j < A_i$

If $S(A_j) = S(A_i)$ and $T(A_j) < T(A_i)$ then $A_j < A_i$

If $S(A_j) = S(A_i)$ and $T(A_j) = T(A_i)$ then $A_j = A_i$

2.2 Technique and instrument applied

The research is quantitative, with a descriptive-correlational approach. The survey technique was applied through systematic random sampling (the first individual is chosen randomly and the rest are conditioned by a fixed number, in this case, every 2 individuals). The methodology proposed by [1, 2] assumes an infinite population to determine the sample size. The variability of the population is estimated at 50% (p = q = 0.5) [16]. A total of 338 valid surveys were collected, representing a sampling error of 4.56% for a confidence level of 95.5%.

A 13-item questionnaire structures the fieldwork and the application of the survey based on previous studies [1, 2] [1, 2] [1, 2] [1, 2] [1, 2], where it is asked about the factors that determine the demand, the client's profile, satisfaction and valuation of the tourist products and services of the territory.

The structure of the questionnaire is made up of four blocks: (I) the demographic characteristics, (II) the characteristics of the trip, (III) related to the service or product, and (IV) the evaluation of the satisfaction of the tourist offer.

Within the demographic characteristics, sex, age, country of residence, and occupation are analyzed. Regarding the characteristics of the trip, it is of interest if it is the main destination, how many people are in the group, through what means of information did they learn about the destination and what factors motivated their visit. In this last aspect, the respondent was asked to classify between totally true and false, the following possibilities, which are not mutually exclusive:

a) Curiosity to know this city
b) Interest in culture and history
c) Interest in architectural heritage
d) Because of the weather
e) Natural attractions, landscapes
f) Prices
g) Recommendation of friends
h) Other causes

For the processing of the results of this question, the scale of linguistic terms associated with SVNS shown in table 1 was used. The general results of each alternative were determined by means of the aggregation function (3) and ordered using the scoring function. (4).

Expression		SVN Number
Totally True	TT	(1, 0, 0)
Mostly true	MT	(0.85, 0.25, 0.25)
Cannot be determined	I	(0,1,0)
Mostly false	MF	(0.25, 0.25, 0.85)
Totally false	TF	(0,1,1)

Table 1: Scale of linguistic terms associated with SVNS applied to determine the factors that motivated a visit to the tourist destination city of Cuenca.

Regarding what is related to the product or service, you want to know the type of accommodation, the duration of the trip, the total of previous visits, and what activities you prefer to do. To answer about the activities that the respondent prefers to carry out, they were asked to classify the following activities between very satisfactory and very unsatisfactory:

a) Visit museums and historical sites
b) Visit nearby tourist sites
c) Attend cultural activities and events
d) Go on excursions, hiking
e) City tours
f) Other activities

The scale of linguistic terms associated with SVNS used for this question is shown in table 2. The general evaluation of each activity was determined through the aggregation function of equation (3) and to rank the activities according to the preference of the respondents, the scoring function of equation (4) was used.

Expression		SVN Number
Clearly pleased	CP	(0., 0, 0)
More pleased than unpleased	MP	(0.85, 0.25, 0.25)
Not defined	ND	(0,1,0)
More unpleased than pleased	MU	(0.25, 0.25, 0.85)
Clearly unpleased	CU	(0,1,1)
Contradictory	C	(1,0,1)

Table 2: Scale of linguistic terms associated with SVNS used to determine respondents' preferred activities

Finally, to evaluate the satisfaction of the tourist offer, the respondent is asked to evaluate the attributes of the destination: a) accommodation, b) restaurants, c) culture, d) nature, e) prices, and f) service; according to the scale of linguistic terms associated with SVNS shown in table 3.

Expression		SVN Number
Excellent	E	(1,0,0)
Very very good	VVG	(0.9, 0.1, 0.1)
Very good	VG	(0.8, 0.15, 0.20)
Good	G	(0.70,0.25,0.30)
Regular tending to Good	RG	(0.60, 0.35, 0.40)
Regular	R	(0.50, 0.50, 0.50)
Regular tending to Bad	RB	(0.40, 0.65, 0.60)
Bad	B	(0.30,0.75,0.70)
Very bad	VB	(0.20, 0.85, 0.80)
Very very bad	VVB	(0.10,0.90,0.90)
Extremely Bad	EB	(0; 1; 1)

Table 3: Scale of linguistic terms associated with SVNS applied to determine the level of satisfaction of respondents by tourism attributes.

The evaluation of the level of satisfaction of the respondent with the general offer is obtained through the aggregation of the evaluations of all the previous attributes using equation (3) for each respondent.

4 Results

The results on the main demographic characteristics of the tourists surveyed in the city of Cuenca show a slight majority of adults between 21 and 50 years of age, of both sexes, workers in private companies and from the United States, Canada, Italy, and France, and from Ecuador itself. Table 4 shows a summary of the demographic characteristics of the respondents.

Age range		Sex		Country of residence		Occupation	
0-20	9%	F	49%	Ecuador	31%	Private enterprise	44%
21-35	32%	M	51%	USA	29%	Public sector	27%
36-50	33%			Canada	9%	Student	9%
51-65	16%			Italy	8%	Other	20%
65 or more	10%			France	6%		
				Other	17%		

Table 4. Demographic characteristics of the respondents

Regarding the characteristics of the trip, we obtained that 48% of tourists arrived in Cuenca as their main destination, mostly as a couple and they learned about the destination mainly by having visited it previously, through friends and acquaintances, or the World website Travel Awards. Most of the foreign tourists surveyed declared that they visited Cuenca in passing, complementing the visit to other cities in Ecuador.

To analyze what factors motivate the visit to the city, the proposed alternatives were scored through the aggregation function (equation 3) and were ordered based on their neutrosophication using the scoring function (equation 4). In this case, the precision function (equation 5) was used to sort the alternatives with the same score. The results are shown in Table 5.

Order	Reasons for visit	Agregate SVNS $P_w(A_1, A_2, \dots, A_{338})$	Scoring $S(P_{w_i})$	Precision $T(P_{w_i})$
1	Interest in culture and history	(0.81; 0.23; 0.02)	2,561	0.790
2	Natural attractions, landscapes	(0.8; 0.25; 0.02)	2,532	0.784
3	For the climate	(0.79; 0.26; 0.02)	2,513	0.770
4	Recommendation of friends	(0.79; 0.26; 0.02)	2,513	0.776
5	Interest in the architectural heritage	(0.73; 0.3; 0.03)	2,400	0.700
6	Curiosity to know this city	(0.68; 0.46; 0.02)	2,210	0.667
7	Other reasons	(0.61; 0.39; 0.03)	2,192	0.581
8	Religion	(0.6; 0.43; 0.04)	2,135	0.564

Table 5. Order of factors motivating the visit

It was evidenced that the factors that most motivated choosing the city of Cuenca as a tourist destination were the interest in knowing the cultural and historical heritage, natural attractions, the weather, and the recommendation of friends.

The results of the analysis of what is related to the product or service, allowed us to determine that mostly tourists between 36 and 50 years old prefer to stay in hotels, while a significant percentage of those between 21 and 35 years old stay in hostels and finally the group ranging in age from 50 to 65 prefer boutique hotels. The days of stay oscillate in a range between 2 and 14 days, being more frequent than the trips of 3 and 4 days. 49% of those surveyed had already visited the city at least once and 67% visited it for the third time.

When analyzing which activities they prefer to carry out, it was found that those tourists were usually pleased with all the proposed activities, the best evaluated being visits to museums and historical sites, the tours for the city, and the cultural activities and events. Table 6 shows the activities ordered by preference according to the aggregation and score of the respondents' answers.

Order	Activities	Aggregate SVNS $P_w(A_1, A_2, \dots, A_{338})$	Scoring $S(P_{w_i})$	Precision $T(P_{w_i})$	Evaluation
1	Visiting museums and historical sites	(0.95; 0.05; 0.01)	2,899	0.949	CP
2	City tours	(0.57; 0.31; 0.06)	2,191	0.503	MP
3	Attend cultural activities and events	(0.54; 0.34; 0.05)	2,145	0.487	MP
4	Go on excursions, hiking	(0.49; 0.38; 0.04)	2,065	0.450	MP
5	Other activities	(0.34; 0.32; 0.08)	1,938	0.256	MP
6	Visit nearby tourist sites	(0.39; 0.41; 0.06)	1,926	0.337	MP

Table 6. Order of activities preferred by tourists in Cuenca city destination

The results of the evaluation of the respondents' satisfaction about the particular attributes of the tourist destination are shown in table 7.

Order	Tourist destination attributes	Aggregate SVNS $P_w(A_1, A_2, \dots, A_{338})$	Scoring $S(P_{w_i})$	Precision $T(P_{w_i})$	Evaluation
1	Nature	(0.78; 0.18; 0.22)	2,370	0.554	VG
2	Restaurants	(0.73; 0.23; 0.27)	2,231	0.464	VG
3	Culture	(0.73; 0.24; 0.27)	2,216	0.451	VG
4	Lodging	(0.64; 0.33; 0.36)	1,949	0.281	G
5	Service	(0.54; 0.43; 0.46)	1,654	0.086	RG
6	Prices	(0.43; 0.59; 0.57)	1,267	-0.143	RB

Table 7. Order and evaluation of satisfaction with the attributes of the tourist destination of the city of Cuenca

According to the satisfaction evaluations provided by the respondents, the most valued attributes of the destination are nature, restaurants, and culture, while the worst evaluation is the prices. The results of the evaluation of tourist satisfaction with the destination, in general, are shown in Figure 1.

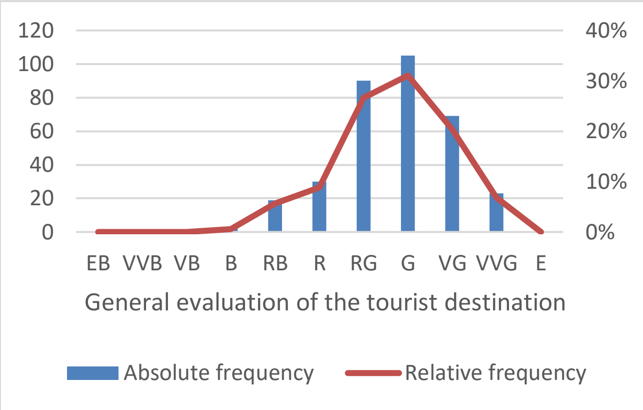

Figure 1. Absolute and relative frequencies of the general evaluation of the city of Cuenca as a tourist destination.

According to these results, 57% of those surveyed expressed a high level of satisfaction with the tourist destination, offering a general evaluation of good, very good, or very very good. Less than 5% evaluated it from fair tending to bad, this being the lowest rating.

Conclusions

The segmentation of the tourist market in a Heritage city such as Cuenca is important because strategic projections are needed to improve the offers and the country's tourism system. It is worth mentioning that the city has weak tourist statistics.

Through the study carried out, it was defined that the city receives visitors mainly from nationals and the United States, Canada, Italy, and France. The predominant age range is between 35 and 50 years old and hotels and hostels are preferred as a form of accommodation. Generally, the reason for the visit is interest in the cultural and historical heritage and the activities of visits to museums and historical sites are preferred. The level of satisfaction with the destination, in general, is high, with the attributes of nature, restaurants, and culture being the most valued.

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Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless

Alex Javier Peñafiel Palacios [1], Jesús Estupiñán Ricardo[2], Iyo Alexis Cruz Piza[3] and Marcia Esther España Herrería[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Jorge Villegas. Babahoyo. Los Ríos. Ecuador Email: ub.c.derecho@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Jorge Villegas. Babahoyo. Los Ríos. Ecuador Email: ub.c.investigacion@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Jorge Villegas. Babahoyo. Los Ríos. Ecuador Email: ub.iyocruz@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Jorge Villegas. Babahoyo. Los Ríos. Ecuador Email: ub.marciaespania@uniandes.edu.ec

Abstract. The homeless are a social group that does not have a profession, job, basic rights, or a house to live in, and have been excluded by society. In Quito, Ecuador, especially in the center, it is common to see people living on the street without a roof or a dwelling to live in. They are referred to by society as the excluded population, marginalized, homeless, among other terms. Living on the street does not imply having to be a victim of aggression, but there are more demonstrations of this type of behavior every day. There are several organizations designed to help or improve the lifestyle of these people to mitigate this situation. Then, to contribute to the strengthening of the work of these institutions, the research objective of this research is to develop a cause-and-effect analysis of the crimes committed against the homeless, improving their services with knowledge, standards, and methods to be able to manage the problem, along with activities to guide the Homeless to contribute to the Good Living Plan. For the research development, a hermeneutical approach was applied and a cause-effect tree based on the neutrosophic cognitive maps was built.

Keywords: hermeneutic, neutrosophic cognitive maps, homeless, crime.

1. Previous knowledge

The homeless are a social group that does not have a profession, job, basic rights, or a house to live in, and have been excluded by society. In Quito, Ecuador, especially in the center, it is common to see people living on the street without a roof or a dwelling to live in. They are referred to by society as the excluded population, marginalized, homeless, among other terms. They are people without rights or basic services and above all, without interest on the part of society towards them. For this reason, this socially excluded group becomes ignored in political, economic, and social eyes [1-5].

On [1-14], it is considered that the most common causes of homelessness can be organized around the following groups:

- Materials (group economic variables including poverty)
- Affective (they group the variables related to the loss of social support and the breakdown of social networks)
- Personal (physical and mental illnesses, addictions, and loneliness are included in this category)
- Institutional (include the relationship of the person with all types of institutions)

This current situation has a critical panorama since the COVID-19 health emergency began, the number of people living on the streets increased. Due to the pandemic, there has been an increase in people living on the streets in Quito. They spend the night in places where they can take refuge. There is no exact number, however, the President of the Ecuadorian Red Cross exposes in [9] that in recent weeks 150 food kits have been delivered and of that number, 75% are 'new' inhabitants. He refers that it has been increased by 30 per day [9].

The increase in homelessness is not favorable. These are supposed to lead to an economic decrease since their contribution to society is null. This is endorsed because not having a stable job, a home, or basic rights such as food, health, water, etc., they are not constituted as citizens. So that is to say, they do not have economic rights towards a State and for the same reason, they are free from tax payment, a monthly retirement, or social security payment. In the eyes of the leaders, they do not contribute monetarily to the development of a country [1].

In addition, it can be said that it also indirectly affects the tourist or visual representation of (Quito). Because an image about the beggars as a presence that disturbs and offends the image of a "clean Quito" or a "21st Century Guayaquil ", as shown in the main campaigns of the cities created by their respective mayors or municipalities. For a tourist, the vagabond as they are contemptuously known is an unwanted being of society or of the place they occupy [1].

This negative view influences the complex situation for the management of these people since prejudices turn citizens into criminals daily. Given mainly by the fact of committing actions against the physical and mental integrity of the homeless, motivated mainly by the wishes of discrimination. Currently agoraphobia, that is, hatred towards impoverished and vulnerable people is considered a hate crime [6, 8] and it takes place among the citizens of Ecuador. The intention of those who commit hate crimes is not only to direct a message of intolerance towards the immediate person on whom it acts but above all the group that person belongs to [6].

Living on the street does not imply having to be a victim of aggression, but there are more demonstrations of this type of behavior every day. Sadly, in most cases, victims do not report for various reasons: because they believe that it will not help, they are afraid of possible reprisals or, in the case of foreigners, who are in an irregular or illegal situation, for fear of being expelled [2-4, 8, 11]. According to the literature consulted, it has been observed worldwide that young people mostly tend to carry out such violent acts, especially on men over 45 years of age and young women who live on the street [6].

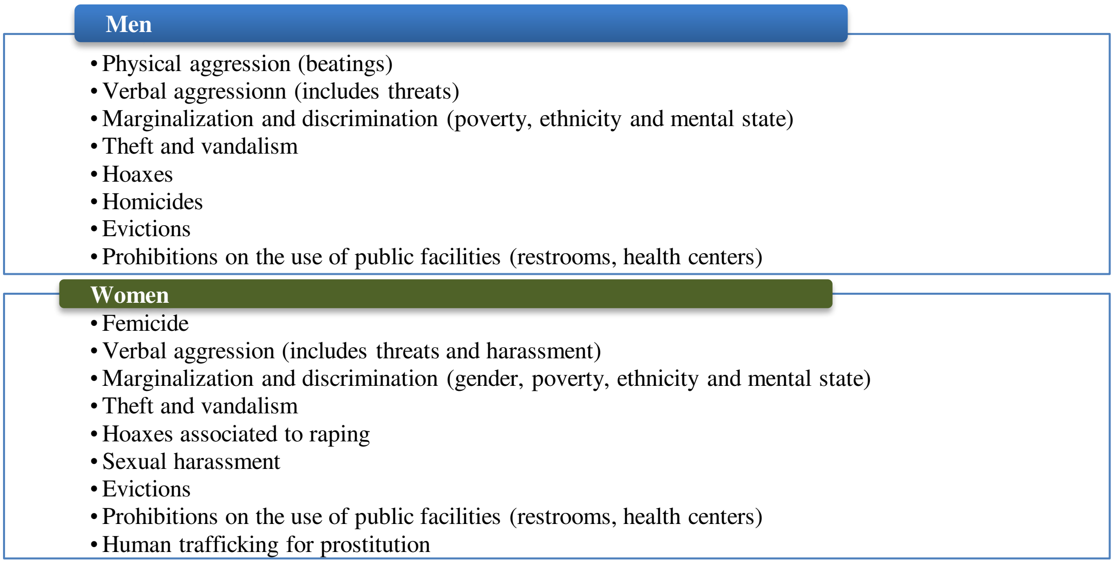

Figure 1: Main crimes committed against homeless people. Source [1-19].

There are several organizations designed to help or improve the lifestyle of these people to mitigate this situation [1]. Therefore, it is necessary to contribute to the strengthening of the work of these institutions, government and NGOs. Therefore, the *objective of the investigation* is to elaborate a cause-effect analysis of the crimes committed against the homeless, improving their services with knowledge, norms, and methods to be able to manage the problem, together with activities to guide the Homeless to contribute to Good Living Plan.

The analysis of the subject will be treated through a phenomenological hermeneutical approach since it is necessary to analyze different points of view. The results will be processed with the help of the neutrosophic cognitive maps (NCM), coming from the theory of Neutrosophy proposed by Florentin Smarandache for the treatment of neutralities, which has been proven by the possibility of enriching the analysis and converting linguistic terms into quantitative variables [15, 20-35]. The NCM according to [13] is a way of representing knowledge by means of a graph, the strength between the relationship can be measured, so it is used in social studies [15, 28, 36-42].

For the development of the research, the following *specific objectives* must be executed:

1. Analyze the problem using a hermeneutical process approach
2. Build the cause-effect tree to trace the phenomenon
3. Strategies from various perspectives
4. Partial conclusions

2. Methods

The phenomenological hermeneutical method is characterized by a high level of subjectivity and therefore it can be said that there is uncertainty. In other words, hermeneutics tends to qualitative interpretation, which leads to subjectivity in knowledge, and although the scientific method owes its roots to hermeneutics, it seems a contrasting form of knowledge in which hermeneutics no longer has a place. That is why its fusion with Neutrosophy and the MCN is convenient. For a better understanding of data processing with MCNs, the following is exposed:

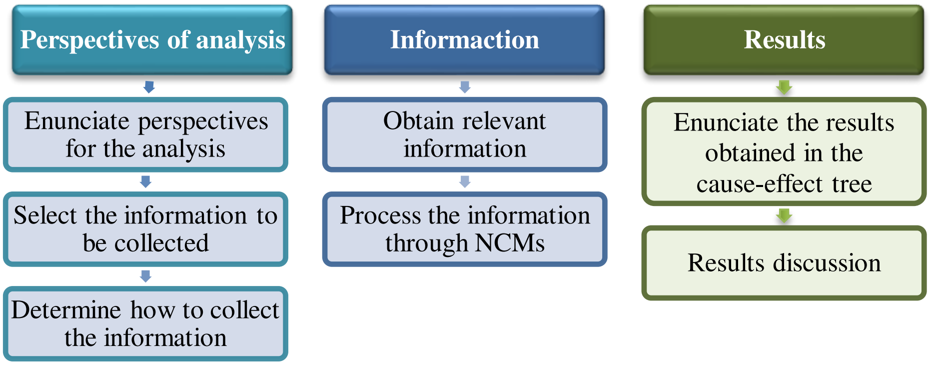

Figure 2: Process approach diagram for the analysis of the problem posed.

Questionnaires: questionnaires were used depending on the group of people to be interviewed. A dynamic environment was presented for the interviews, that is, topics for the questions were elaborated a priori, but as progress was made, the plan could be modified, but never leaving the topic. Below is exposed:

a) Socio-demographic information: sex, date of birth, nationality, education, family, children.
b) Information on elements related to the state of physical, mental, and psychological health both from the perspective of the homeless person himself and from that of the interviewer.
c) Information related to life as a homeless person: time, causes, main factors that affect life, crimes committed against him or her (type, when, where, witnesses, frequency, sex, and estimated age of the aggressor), consequences.
d) Information on the attitude after the assault (sought help, reported the events, hospital report)

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [34]. NCMs were introduced by [43] in 2003. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995 [20]. This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty. [20] Exposes that FCMs constitute a technique that has received increasing attention due to its possibilities for representing causality. The following is a set of definitions necessary to work with NCMs. First, let formally expose the original definition of neutrosophic logic as it is shown in[30].

Definition 1. [27] Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ be a *neutrosophic set of evaluation*. v: P→N is a mapping of a group of propositional formulas into N, ie, each sentence p∈ is associated to a value in N, as it is exposed in Equation 1, meaning that p is T% true, I% indeterminate, and F% false.

$$v(p) = (T, I, F) \tag{1}$$

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [29, 33].

Definition 2. (See[27, 28]) Let K be the ring of real numbers. The ring generated by K∪I is called a *neutrosophic ring* if it involves the indeterminacy factor in it, where I satisfies I2 = I, I + I = 2I and in general, I + I + ... + I = nI, if k∈, then kI = kI, 0I = 0. The neutrosophic ring is denoted by K (I), which is generated by K∪I, ie, K (I) = <K∪I>, where <K∪I> denotes the ring generated by K and I.

Definition 3. A *neutrosophic matrix* is a matrix A = [aij] ij i = 1, 2,…, m and j = 1, 2,…, n; m, n≥1, such that each aij∈K (I), where K (I) is a neutrosophic ring, see [15].

Let us observe that an element of the matrix may have the form a + bI, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example, $\begin{pmatrix} -1 & \mathrm{I} & 5\mathrm{I} \\ \mathrm{I} & 4 & 7 \end{pmatrix}\begin{pmatrix} \mathrm{I} & 9\mathrm{I} & 6 \\ 0 & \mathrm{I} & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21\mathrm{I} & 27\mathrm{I} & -6+25\mathrm{I} \\ -28+\mathrm{I} & 49+13\mathrm{I} & 35+6\mathrm{I} \end{pmatrix}$

Additionally, a neutrosophic graph is a graph that has at least one indeterminate edge or one indeterminate node [25, 30]. The neutrosophic adjacency matrix is an extension of the adjacency matrix in classical graph theory. $a_{ij} = 0$ means nodes i and j are not connected, $a_{ij} = 1$ means that these nodes are connected and $a_{ij} = I$, which means the connection is indeterminate (unknown whether it is or not). Fuzzy set theory does not use such notions.

On the other hand, if the indetermination is introduced in a cognitive map as it is referred to in [24], then this cognitive map is called a neutrosophic cognitive map, which is especially useful in the representation of causal knowledge [23, 33]. It is formally described in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, events, among others, as nodes and causalities or indeterminacies as edges. It represents the causal relationship between concepts.

The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [24]:

- Outdegree (vi) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of the outgoing relationships (cij) of the variable:

$$od(v_i) = \sum_{i=1}^{n} c_{ij} \tag{2}$$

- Indegree (v_i) is the sum of the column elements. It reflects the strength of relations (c_{ij}) outgoing from the variable.

$$id(v_i) = \sum_{i=1}^{n} c_{ji} \tag{3}$$

- Total centrality (total degree td (vi)), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \tag{4}$$

The variables are classified according to the following criteria, see [44]:

a) The transmitting variables are those with od (vj)> 0 and id (vi) = 0.
b) The receiving variables are those with od (vj) = 0 and id (vi)> 0.
c) Ordinary variables satisfy both od (vj) ≠ 0 and id (vi) ≠ 0.

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights [25]. Static analysis in Neutrosophic Cognitive Maps (NCM), see [23], initially contains the neutrosophic number of the form (a + bI), where I = indetermination[22]. It requires a process of de-neutrosophication as proposed in [24], where I ∈ [0, 1] and it is replaced by their values maximum and minimum.

Finally, we work with the average of the extreme values, which is calculated using Equation 5, which is useful to obtain a single value as it is referred to in [21]. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{5}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{6}$$

3. Results

3.1 Analysis perspectives

We worked with four perspectives based on the identification of the stakeholders of the social phenomenon to be analyzed below:

Legend:

HP: homeless people

Brigades: support brigades working on the streets to help the homeless

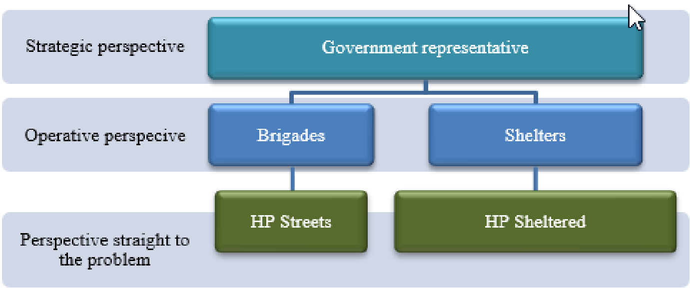

Figure 3: Analysis perspectives.

3.2 Information

It was decided to work with a 95% confidence (2σ) and p = q, the error for the whole sample being ± 5.95%. The following criteria conditioned the sampling of the population:

1. Be or have been homeless for at least four months
2. Equal the number of men and women to interview and that 50% of them were immigrants

From the population to be interviewed, a sample of 150 people in a shelter was chosen, from them, in addition to the criteria already established, it was possible to determine that:

- 23% had a disability
- Average age 47 years
- Average time without a home: 8 months
- 60% had only primary studies, 35% secondary and 5% graduated from a technician in their country of origin (in the latter case they were all immigrants)
- 28% had established children of legal age with whom they have no relationship
- 31% presented alcoholism and drug addiction problems.
- 100% of the immigrants came from Venezuela from a low social class.
- Most frequently detected effects of violence:
  - I. Femicides / Homicides
  - II. Verbal assault (includes threats and harassment)
  - III. Marginalization and discrimination (gender, poverty, ethnicity, and mental state)
  - IV. Theft and vandalism
  - V. Hoaxes linked to rapes
  - VI. sexual harassment
  - VII. Evictions
  - VIII. Prohibitions on the use of public facilities (restrooms, health center)
  - IX. Trafficking in persons for prostitution
- Regarding the causes of your condition:
  - ➢ Poverty
  - ➢ State of crisis due to the pandemic (living in a lower class but with minimal sustenance due to services)
  - ➢ Drug and alcohol use
  - ➢ Break-up of important relationships (family, friends, interpersonal) and not having financial aid from the government
  - ➢ Lack of education
  - ➢ Having been subjected to domestic violence
  - ➢ Immigration

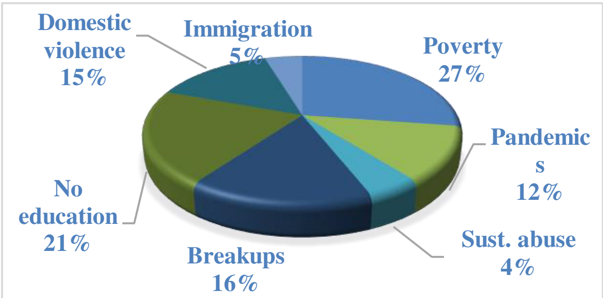

Figure 4: Main causes of the condition of Homeless Persons detected in the interviews.

Analysis of the causal interrelation of the strategic perspective:

	Poverty	Crisis	Cons	Relat.	No ed	Viol	Immig.	id	od	td	Order
Poverty	0	0.5 + I	1	0.6 + I	1	I	0.5	1	0.75833	1,75833	1
Crisis	1	0	1	1	1	I	0	0.7917	0.75	1.54167	5
Cons	1	1	0	1	1	1	0	0.8333	0.83333	1.66667	2
Relat	1	0	1	0	1	1	0.7	0.8	0.78333	1.58333	4
No ed	1	1	0	1	0	1	0	0.8333	0.66667	1.5	6
Viol	1	1	1	0	1	0	1	0.8333	0.83333	1.66667	3
Immig	1	1	1	1	0	1	0	0.3667	0.83333	1.2	7

Table 1: Adjacency matrix and "Government representatives" processing

Analysis of the causal interrelation of the operational perspective:

	Poverty	Crisis	Cons	Relat.	No ed	Viol	Immig.	id	od	td	Order
Poverty	0	1	1	1	1	1	1	0.7894	1.0526	1.8421	2
Crisis	1	0	1	1	1	1	0	0.7192	0.8772	1.5965	5
Cons	0	0.7	0	0.8	1	1	0	1,1053	0.7368	1.8421	3
Relat	1	0	1	0	1	1	I	0.8421	0.8772	1,7193	4
No ed	0.6	0.4	0.7	1	0	1	I	0.9649	0.7368	1.7017	5
Viol	0.9	1	1	0	1	0	1	1	0.8596	1.8596	1
Immig	1	1	0.9	I	I	0.7	0	0.5263	0.8071	1.3333	7

Table 2: Adjacency matrix and "Brigades" processing

	Poverty	Crisis	Cons	Relat.	No ed	Viol	Immig.	id	od	td	Order
Poverty	0	1	1	1	1	1	1	0.65458	1	1.6543	4
Crisis	1	0	1	1	1	1	0	0.6282	0.8333	1.4615	6
Cons	0	0.5648	0	0.6994	1	1	0	1.0959	0.6816	1.7775	2
Relat	1	0	0.9238	0	1	1	0.7 + I	0.7813	0.879	1.6603	3
No ed	0.3592	0.2045	0.8257	0.9886	0	1	0	0.9167	0.563	1.4797	5
Viol	0.8683	1	1	0	1	0	1	1	0.8114	1.8114	1
Immig	0.7	1	1	I	I	1	0	0.475	0.7833	1.2583	7

Table 3: Adjacency matrix and "Shelter" processing

Analysis of the causal interrelation from the direct perspective to the problem:

	Poverty	Crisis	Cons	Relat.	No ed	Viol	Immig.	id	od	td	Order
Poverty	0	1	1	1	1	1	1	1	1	2	3
Crisis	1	0	1	1	1	1	1	1,1667	1,1667	2.3333	1
Cons	1	1	0	1	1	1	0	1,1667	1	2.1667	2
Relat	1	1	1	0	1	1	0	0.6667	0.8333	1.5	6
No ed	1	1	1	1	0	1	1	0.8333	1	1.8333	4
Viol	1	1	1	0	1	0	1	0.9167	0.8333	1.75	5
Immig	1	1	1	0	0	I	0	0.6667	0.5833	1.25	7

Table 4: Adjacency matrix and "HP Street" processing

	Poverty	Crisis	Cons	Relat.	No ed	Viol	Immig.	id	od	td	Order
Poverty	0	1	1	1	1	1	1	1	1	2	3
Crisis	1	0	1	1	1	1	1	1,1667	1,1667	2.3333	1
Cons	1	1	0	1	1	1	0	1,1667	1	2.1667	2
Relat	1	1	1	0	1	1	0	1	0.8333	1.8333	4
No ed	1	1	1	1	0	1	1	0.8333	1	1.8333	5
Viol	1	1	1	1	1	0	1	0.8333	1	1.8333	6
Immig	1	1	1	1	0	0	0	0.6667	0.6667	1.3333	7

Table 5: Adjacency matrix and "HP Sheltered" processing

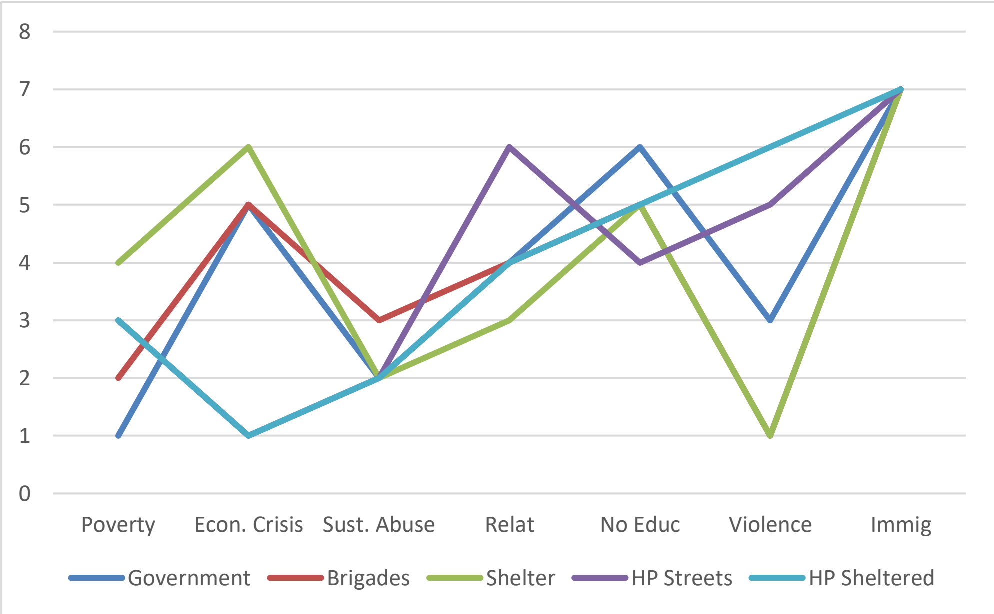

Figure 5: Summary of *td* scores.

3.3 Results

The results obtained are stated in the causes-effect tree and brainstorming will be submitted to obtain different perspectives in the search for solutions and possible strategies.

Strategic and Operative solutions	1. Action campaigns in the community and education centers to create awareness about the abuse of drugs and alcohol, domestic violence, and the need to take care of an elderly. 2. Insert social workers and consultants to prevent students from deserting. 3. Increase the amount of workers, material and financial resources in the shelters and support brigades in zones with bigger concentration of Homeless people.. 4. Use the government resources to protect small business.
Effects of being Homeless	1. Femicides/homicides 2. Verbal aggression (includes threats and) 3. Marginalization and discrimination (gender, poverty, ethnicity mental estate) 4. Theft and vandalism 5. Hoaxes linked to rapes 6. Prohibitions on the use of public facilities (restrooms, health center) 7. Trafficking people for prostitution

Causes for the existence of Homeless	1. Abuse of drugs and alcohol 2. Poverty 3. Have been a victim of domestic violence 4. In crisis due to the pandemic (to live in a low class but with minimal supplies due to services) 5. Breaking up important relationships (relatives, friends, interpersonal) not having economic help from the government 6. Lack of education 7. Immigration

Figure 6: Causes-effect Tree.

Conclusions

- Even though homeless people are part of the public space of a city, they suffer from aggressions caused by other citizens. According to the data, all the homeless people interviewed have suffered aggression, humiliation, and intimidation motivated by the intolerance and prejudice of their aggressors towards their situation of extreme social exclusion. Sleeping and living on the street have a component of structural violence, which is further aggravated by the direct violence to which these people are subjected.
- From the bibliographic point of view, we found that it is an international problem, increased by the negative impact of the economic crisis caused by COVID-19.
- Homeless people are mostly exposed to abuse, violence, and social rejection. They are repressed mainly by young people. In addition, it was evidenced that women are an easy target for human trafficking and sexual abuse. It is currently a crime within the Penal Code, but a complaint is required, a situation that generally does not occur since most victims are ignored due to their "indigent" status.
- Not all homeless have this condition due to poverty and substance abuse, it was determined that domestic violence and break-up relationships with the elderly are also considered important causes. As well as it was determined that the small businesses affected by the economic crisis were forced to become homeless mainly due to their condition as low-income Venezuelan immigrants. Due to the inability to meet the expenses, they experienced rejection and had no choice other than to go to the streets.
- The strategic level made up of the city government has a very different vision of the phenomenon with respect to the rest of the levels. Perhaps this is the cause of the creation of ineffective strategies. It is recommended that these personnel be part of the help so that they know the facts reliably.
- It is considered at a strategic and operational level that campaigns should be implemented to mitigate these issues with the full involvement of the centers to help the homeless and the educational ones. All with the aim of prevention and reactivity to the problem at the same time. The involvement of all social layers is needed as well as the help of the government and Non-Governmental Organizations.

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Design of a Model for the Evaluation of Social Projects Using Neutrosophic AHP and TOPSIS

Bayron Pinda Guanolema[1], Luis German Castro Morales[2], Dailin Peña Suárez[3] and Mario Javier Cabezas Arellano[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: dir.contabilidad@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.luiscastro@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador. Email: up.dailinpena@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.mariocabezas@uniandes.edu.ec

Abstract. Projects are responses to identified problems. So a thorough analysis to detect the problem is extremely important in project management. There are countless types of projects depending on their purpose, content among other issues. Among these, those related to content and social development stand out due to the current context. In the development of this research, the characteristics of a project in a general sense are detailed and it is specified in those related to social programs, taking into account the current situation in the world, mainly influenced by the economic crisis and the Covid 19 pandemic. The foundations for the design and development of a procedure for the evaluation of social projects will be established. A series of principles and premises related to these will be analyzed using the AHP and TOPSIS multicriteria methods in their neutrosophic version. The result is a decision support tool for all the people involved in the process.

Keywords: projects, procedure, principles, premises, Neutrosophy

1. Introduction

The vast majority of human decisions (if not all) can be classified as projects. However, of the thousands or millions of decisions that are adopted and carried out daily, many are relatively simple. In contrast, others require a careful analysis of their probable outcome and, therefore, it is advisable to take a certain time to ensure, as far as possible, that given the prevailing circumstances, the results obtained are the most convenient.

A project is an organized set of actions, carried out in an orderly manner during a determined period, that respond to a demand or problem to offer a solution [1]. In this sense, it is good to point out that the project becomes a tool that has an established deadline, it will be carried out in the future, generating specific products or solutions. There is an infinity of types, depending on their purpose, content, financing, projects can be of one type or another.

Depending on financing:

- Private
- Public
- Mixed or subsidized.

Depending on its content:

- Building
- Business
- Production of goods or services
- Computer scientist.

Depending on the complexity:

- Simple
- Complex

Depending on its purpose:

- Production
- Educational
- Community
- Research or academics
- Social.

The most critical phases of the projects are formulation and evaluation. The formulation is the stage focused on designing the different options of the project, which means systematizing a set of technically feasible possibilities, to achieve the objectives and solve the problem that motivated its initiation. Through the formulation of projects, producing and regulating the most appropriate information is guided, which allows efficient progress in its execution. Furthermore, it implies adapting to a presentation or format that is required for this purpose, containing all the necessary information for its subsequent management or execution.

Evaluation is a process of estimation, assessment and detailed review of the achievements based on the proposed objectives. It allows organizing activities systematically, consolidating the participation of those involved, and reflecting on the need to make changes, to make decisions that lead to its improvement and subsequent implementation. Thus, formulation and evaluation are two interdependent processes, in which one serves as a frame of reference for the other.

There are two types of evaluation depending on when it is carried out and the objectives set:

- The ex-ante evaluation, which is carried out before the operation. Its objective is to estimate costs, impact, scope of objectives, viability and feasibility of the project, ultimately to diagnose the context.
- The ex-post evaluation is carried out in the execution and completion stage of the project. Its objective is to decide whether to continue with the process, establish similar formulations, guide the process, adapt and change conditions, reprogram.

Monitoring is a type of administrative management, which is carried out periodically and at different levels, to monitor and know the inputs, activities, processes, products related to time, quantity, quality, and costs. It allows verifying the development of scheduled activities, measuring management results and optimizing processes.

Just as the ex-post evaluation is carried out during the operation, they differ in that the monitoring is concerned with the analysis of the different components of internal management, in terms of effectiveness, efficiency, and focalization, while the ex-ante evaluation, focuses on the relationship between the products and the achievement of the objectives, that is, externally, (effects, impact, objectives).

From the foregoing, it can be concluded that the evaluation makes it possible to establish a feedback process, which seeks to improve the processes based on future actions and promote the well-being of the participants.[2]. In summary, a project can be defined as "a proposal for action that involves the use of a specific set of resources to achieve expected results." Projects are responses to identified problems, and the analysis to identify the problem is extremely important in project management. Finally, the evaluation process (of identifying, quantifying and evaluating costs and benefits) constitutes a very powerful tool to help define society's priorities.

Social is an adjective related to society (the community formed by individuals who share a culture and who interact with each other). A social project, therefore, has the objective of modifying the living conditions of the people. The intention is that the project improves the daily life of society as a whole or, at least, of the most disadvantaged social groups. Typically, a social project aims to satisfy a basic need of people. Most of these projects, in this way, seek to promote improvements in the fields of education, housing, health, or employment. The social project concept seeks to maintain the balance between three fundamental points that give meaning to its existence: the fragility of the individual, which can lead to a lack, which must be resolved through the responsibility of the social worker. As one of its extremes increases, the other decreases.

At a time marked by the rapid advance of scientific and technological progress, especially visible in the industrialization processes and the concomitant changes in our cultures and societies. Experience teaches that the success of any development attempt depends on the goodness of the knowledge of the economic, sociological, and cultural factors specific to each country or region. From an understanding of these objective conditions and the available means of action, the coherence, relevance, and effectiveness of the development of adopted strategies.

The evaluation of benefits and costs corresponding to investment projects has advanced extraordinarily in the course of the last three decades until it has become a discipline widely used by financing organizations, although it still arouses controversies related not so much to its basic methodological content, but mainly with differences of emphasis with respect to the objectives pursued, the parameters of economic policy, the instruments of action and the interpretation of the elements and relationships of the economic structure of the countries. The same does not happen in the field of social programs. Decisions in this area are usually made with the best intentions to meet the needs of a certain population [3-8].

For this, it is important that in the social field too, the establishment of techniques for evaluating policies, programs and projects is sought. The ex-post evaluation will make it possible to learn from experience and, based on it, to design new projects more appropriately.

The ex-ante evaluation, in turn, will ensure that various ways to achieve the objectives are taken into account and, likewise, that the one that represents the most efficient solution in the use of these resources has been chosen.

The Autonomous University of the Andes has the subject of social development in the Faculty of Mercantile Systems in the Systems Engineering degree where it sets out in its objective to design technological projects oriented to the social sphere and structured under the so-called logical framework scheme. The reason for the present contribution to that institution responds to an attempt to clarify in a general way, the elaboration of intervention projects in social problems to contribute to the development of such processes. Therefore, based on the antecedents above, it is derived as a scientific problem to be solved: how to develop a procedure for the evaluation of social projects for UNIANDES?

The research object is to analyze the basis of a procedure for the evaluation of social projects. Therefore, its field of action is part of the development of UNIANDES social projects. To comply with it, the following specific objectives are proposed:

1. Develop a theoretical framework of reference
2. Establish the basis to design a procedure for the evaluation of social projects at UNIANDES.

The research hypothesis states that, if a procedure is developed for the evaluation of social projects, it will contribute to improving the procurement of preventive and correct information for precise decision-making and selection of projects to guarantee the adequate registration of the activities derived from it.

2. Case Study

The current situation of Latin American social development is far from promising. The economic crisis in the region has affected the living conditions of important segments of the population. In addition to this, the appearance of the Covid-19 shows a not very encouraging picture and requires social assistance of all kinds. Faced with this situation, technicians and professionals from all branches have the responsibility of facilitating political decisions by proposing alternatives that go beyond the merely declarative and pessimistic diagnoses, outlining theoretically based solutions that are supported by the analysis of successes and failures of the past.

In this line, it is especially important to focus on developing adequate methodologies and procedures for the formulation and evaluation of social projects since, in a situation where there is a shortage of resources and the needs have increased, the task of comparing, choosing, and discard alternative projects, while seeking to increase the rationality of the options adopted, would be even more pressing.

The evaluation of social projects plays a central role in this rationalization process and is a basic element of planning. These cannot be effective and efficient if the results of their application are not evaluated. For this reason, having ex-post evaluations of projects in progress or already carried out is essential to improve their design. Likewise, the ex-ante evaluation allows you to choose the best option of the programs and projects in which the political actions are specified.

The existing experience in the field of evaluating social projects has large gaps. On the one hand, there is the tradition of social evaluation linked to the ex-ante stage of those projects that comply with all the "states" of the conventional cycle: pre-investment, investment, and operation, which means that social projects imply the design and execution of physical work (investment) so that they can operate. But there are various types of social projects that do not require any physical work, or where it has a marginal magnitude, for which these projects would remain without the possibility of being evaluated.

On the other hand, there is no doubt that cost-benefit analysis is a useful tool for evaluating social projects. It is also equally undeniable that there are strong restrictions derived from the methodology used to analyze projects whose products are not translatable into benefits expressed in monetary units.

Due to the above, the need to develop a procedure for the evaluation of social projects is considered. To achieve this procedure, certain fundamentals must be followed to guarantee coherence and correct implementation. At the beginning of this first stage, a bibliographic review was carried out that allowed defining some principles and premises related to these procedures for their correct design.

Principles:

1. Practicality or Utility: This principle must be understood in a double aspect. The evaluation must be practical, in the sense that an evaluation with very sophisticated instruments is of little use when what is intended can be achieved by simpler procedures. The "practicality" of an evaluation is given by the adequacy of the design used with the intended purpose of the conclusions and recommendations. And it is called *useful* because the evaluation should serve to improve the program, project, activities, or service that is being evaluated; its results must be applicable and usable in decision-making by those who have administration and management responsibility; They must respond clearly and concisely to the interests of the multiple hierarchical levels (funder, politicians, executing units, counterparts or beneficiaries)
2. Credibility: depends on the specialization, independence, and transparency of the process. Transparency must be a characteristic throughout the evaluation process, from selecting, executing, and disseminating reports at different levels.

3. Impartiality: contributes to the credibility of the evaluation and the elimination of prejudices in the results, analysis, and conclusions
4. Objectivity. The programs will be oriented to eradicate the structural causes of poverty, extreme poverty, marginality, and prevention and reduction of vulnerability in all its manifestations.
5. Timeliness: a key point that influences the ability to use the results promptly; it must be carried out at a time when it is possible to introduce corrections or modifications in the process of management and/or implementation of a program or project or to introduce them quickly enough when dealing with very dynamic processes; that it is done with the full acceptance of the political, technical and administrative officials who have the power to make decisions and introduce corrections
6. Independence: provides legitimacy to the evaluation and reduces the potential conflict of interest that could arise if policymakers and managers are solely responsible for evaluating their activities
7. Validity: It is understood that the evaluation meets this requirement when it is capable of revealing, in a demonstrable and controllable way, that the evaluations and judgments that have been made are valid. The principle of validity involves the possibility of rigorously estimating what is to be verified, excluding all kinds of systematic distortions, and that the data collected can be used for evaluation.
8. Reliability: an evaluation is reliable or safe when, applied repeatedly and in the same situation to the same individual or group, or at the same time by different researchers, it provides the same or similar results

These principles [9] were subjected to multicriteria analysis, using neutrosophic AHP for the versatility in decision-making to determine the relevance related to the evaluation of social projects. To ensure that the principles are met during the development of the procedure, a group of UNIANDES experts brainstormed a series of premises related to them.

Premises:

1. There are conditions and an appropriate environment for the assessment task to be possible
2. The evaluation must be useful, feasible, ethical, and accurate
3. The political and administrative leaders of the project are fully convinced that the evaluation is necessary; they must agree on its purposes, thus they are fully committed to the decision to include the evaluation as part of their program.
4. There are the resources required to carry out an evaluation
5. Who will be responsible for conducting the evaluation is defined and responsibilities are distributed
6. The personnel participating in the evaluation have the appropriate knowledge about the techniques and tools for its realization
7. The effective participation and the willingness to cooperate of the users or beneficiaries who will take part in the evaluation are ensured, for which they are defined with which criteria are selected
8. The information that is expected to be obtained, as well as the objectives of the evaluation, must be clarified and defined.
9. The evaluation must generate sufficient information to arrive at valid, systematic, and reliable results, on time, in such a way that its conclusions can be applied within a reasonable space of time and in the life cycle of the project or planning.
10. It must be clearly known how the processes associated with the implementation of the project are organized and how the flows and interrelationships between the different components of the system are manifested, to identify the sources of value creation.

Taking into consideration the amount of premises obtained, to select the best ones that allow determining a path to follow, the technique called TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was used. This technique is characterized by its effectiveness and the simplicity of its principle in solving multicriteria decision problems.

3. Methods

After studying the case, it is convenient to define the methods used for this research.

- Analysis and synthesis: for the development of the theoretical framework and bibliographic analysis, the determination of the common thread of the evaluation model of social projects and the elaboration of the conclusions.
- Hypothetical - Deductive: for the formulation of hypotheses, it was also used in all stages of the research in the analysis of the research problem, which allowed the extraction of the necessary information to support both the theory and also reach the conclusions.

- Logical history for the background analysis of the process both in the state of the art and in practice in the country.
- Surveys: they are developed and applied to the experts who will intervene in decision-making.

Experts' selection:

The competencies of potential experts are checked. For this, a competency validation survey was applied, tested by [10] where it is carried out through self-assessments, on a scale from 1 to 10 the degree of knowledge that said potential expert possesses about the subject and the degree of influence that each of the sources of argumentation has. The processing of the form was based on the calculation of the rating factor of the experts through the following mathematical expression:

$$K = ((FA + GC)) /= [((SI + EP + IR + FB)) / 4 + GC]/2 \quad (1)$$

Where:

YI = your intuition

EP = practical experience	IR = Investigations carried out by you	FB = Consultation of bibliographic sources	CG: degree of knowledge (1-10)

K-value	Classification
8-10	High
5-7	Half
1-4	Under

Neutrosophic AHP:

Analytic Hierarchy Process (AHP): it was proposed by Thomas Saaty in 1980 [11]. It is one of the most widespread methods for solving multicriteria decision-making problems. This technique models the problem that leads to the formation of a representative hierarchy of the associated decision-making scheme. This hierarchy presents in the upper level the objective that is pursued in the solution of the problem and in the lower level the different alternatives are included from which a decision must be made. The intermediate levels detail the set of criteria and attributes considered [12-25]. For the description of the method it is necessary to present the following definitions:

Definition 1: ([26, 27]) The Neutrosophic set N is characterized by three membership functions, which are the truth-membership function TA, indeterminacy-membership function IA, and falsehood-membership function FA, where U is the Universe of Discourse and $\forall x \in U$, TA (x), IA (x), FA (x) $\subseteq$] -0, 1+ [, and -0≤inf TA (x) + inf IA (x) + inf FA (x) ≤sup TA (x) + sup IA (x) + sup FA (x)≤3+. Notice that, according to the definition, TA (x), IA (x) and FA (x) are real standard or non-standard subsets of] -0, 1+ [and hence, TA (x), IA (x) and FA (x) can be subintervals of [0, 1].

Definition 2: ([26, 27]) The Single-Valued Neutrosophic Set (SVNS) N over U is A = {<x; TA (x), IA (x), FA (x)>: x∈U}, where TA: U→[0, 1], IA: U→[0, 1], and FA: U→[0, 1], 0 ≤TA (x) + IA (x) + FA (x)≤ 3. The Single-Valued Neutrosophic Number (SVNN) is represented by N = (t, I, f), such that 0 ≤t, I, f ≤ 1 and 0 ≤t + I + f≤ 3.

Definition 3: ([26-29]) the single-valued trapezoidal neutrosophic number $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & a_2 \le x \le a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \le x \le a_4 \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{4}$$

Where, and. $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R} a_1 \le a_2 \le a_3 \le a_4$

Definition 4: ([26-29]) given and two single-valued trapezoidal neutrosophic numbers and $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle \tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ λany non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Subtraction: (4)$\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Investment: where.$\tilde{a}^{-1} = \langle (a_4{}^{-1}, a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle a_1, a_2, a_3, a_4 \neq 0$

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases} \tag{5}$$

Definitions 3 and 4 refer to single-valued triangular neutrosophic number when the condition a2 = a3, [30-32]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in[33]. The analytic hierarchy process was proposed by Thomas Saaty in 1980 [11]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [12, 13]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [34], [35, 36]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level, the decision options are understood [37]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6) [38].

$$S = \left\{ \frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9 \right\} \tag{6}$$

We can find in [33]the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP or NAHP for short. Equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{7}$$

The matrix must satisfy the condition, based on the inversion operator of Definition 4. $\tilde{A}$ $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [33]. They are the so-called score and accuracy indexes, respectively, see Equations 8 and 9:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{8}$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \tag{9}$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$ $\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$ $\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$ $\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1. Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions[39]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 6.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, ie, aik = aijajk for all i, j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 9 and 10. To get the score and the accuracy degree of the following equations are used:$\tilde{a}_{ji}$

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \quad (10)$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \quad (11)$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (12)$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Note that Step 3 refers to consider the use of the calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ [40]}, \quad (13)$$

where n is the order of the matrix, in addition, the Consistency Ratio (CR) is defined by the equation:

$$CR = \frac{CI}{RI} \quad (14)$$

RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2. RI associated with every order.

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent, we can use NAHP. We apply this procedure to matrix "A" in Equation 12.

TOPSIS

In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and, in turn, moves further away to the worst solution. It was developed by Hwang and Yoon in 1981 and is based on the concept that a given alternative should be located at the shortest distance from an ideal alternative that represents the best (positive ideal or simply ideal), and at the greatest distance from an ideal alternative that represents the worst (negative ideal or anti-ideal) [41, 42]. This method had its evolution towards Neutrosophy. In this paper, linguistic terms will be associated with Single-Valued Neutrosophic Numbers (S), so that experts can carry out their assessments in linguistic terms, which is more natural [16, 22, 43-49]. Therefore, the scales shown in Table 3 will be taken into account.

Linguistic term	NNVU
Highly related (AR)	(0.9, 0.1, 0.1)
Related (R)	(0.75,0.25,0.20)
Medically related (MR)	(0.50,0.50,0.50)
Little related (PR)	(0.35,0.75,0.80)
Very little related (MPR)	(0.10,0.90,0.90)

Table 3. Linguistic terms that represent the evaluation of the criteria in the alternatives.

The TOPSIS method for SVNN consists of the following, assuming it is a set of alternatives and it is a set of criteria, where the following steps will be carried out: $A = \{\rho_1, \rho_2, \dots, \rho_m\} G = \{\beta_1, \beta_2, \dots, \beta_n\}$

Step 1: Establish a performance matrix

In this step, we proceed to the construction of the neutrosophic decision matrix of aggregated single values. Which is used to aggregate all individual evaluations. Each dij is calculated as the aggregation of the evaluations given by each expert using the weights of the AHP of each criterion with the help of equations 7 and 8 and tables 1 and 2. In this way, a matrix D = (dij) ij is obtained, where each dij is a SVNN (i = 1,2, .., m; j = 1,2,…, n).$(u_{ij}^t, r_{ij}^t, v_{ij}^t)$

Step 2: Normalize the decision matrix

Suppose that the weight of each criterion is given by W = (w1, w2,…, wn), where wj denotes the relative importance of the criterion wj. If it is the evaluation of criterion wj by the t-th expert. Then Equation 13 is used to add those with the weights. The construction of the normalized matrix will be as follows:$w_j^t = (a_j^t, b_j^t, c_j^t) w_j^t$

$$w_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \tag{15}$$

Where: w_{ij} is the normalized value for the qualification of alternative i against criterion j and fij is the indicator of each alternative i against each indicator j.

Step 3: Calculate the weight normalized decision matrix

We proceed to constructing the neutrosophic decision matrix of the weighted average of single values with respect to the criteria.

$$D^* = D^*W, \text{ where } d_{ij}^* = w_j * d_{ij} = (a_{ij}, b_{ij}, c_{ij}) \tag{16}$$

Step 4: Determine the positive ideal and negative ideal solutions

$$s^{+} = (x_1^{+}, x_2^{+}, \dots x_{j+l}^{+}) \text{ namely, } s_i^{+} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{+}\right)^2 + \left(b_{ij} - b_j^{+}\right)^2 + \left(c_{ij} - c_j^{+}\right)^2\right\}\right)^{\frac{1}{2}} \tag{17}$$

$$s^{-} = (x_1^{-}, x_2^{-}, \dots x_{j+l}^{-}) \text{ namely, } s_i^{-} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{-}\right)^2 + \left(b_{ij} - b_j^{-}\right)^2 + \left(c_{ij} - c_j^{-}\right)^2\right\}\right)^{\frac{1}{2}} \tag{18}$$

Step 5: *Calculation of the distances to the ideal positive and negative SVNN solutions.* With the help of Equation 6, the following Equations are calculated:

$$\rho(A^k, A^+) = \|w * (TA^k - TA^+)\| \tag{19}$$

$$\rho(A^k, A^-) = \|w * (TA^k - TA^-)\| \tag{20}$$

Step 6: Calculate the relative closeness to the ideal solution

To calculate the Relative Proximity Index (Ri), it is done as follows. The proximity coefficient of each alternative is calculated with respect to the positive and negative ideal solutions.

$$Ri(A^k, A^i) = \frac{\rho(A^k, A^+)}{\rho(A^k, A^+) + \rho(A^k, A^-)} \tag{21}$$

Step 7: Rank the preference order
The alternatives are ordered from highest to lowest, under the condition that Ri1 is the optimal solution.→

4. Results and discussion

Once the different previous approaches have been analyzed, the techniques described above will be applied: with the Neutrosophic AHP method, the weights of the principles on which the procedure for evaluating social projects will be based are based on the following determined.

Principles	P1	P2	P3	P4	P5	P6	P7	P8
P1	1	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(7,8,9);0.85,0.10,0.15⟩	⟨(5,6,7);0.70,0.25,0.30⟩	⟨(5,6,7);0.70,0.25,0.30⟩	⟨(5,6,7);0.70,0.25,0.30⟩
P2	⟨(6,7,8);0.90,0.10,0.10⟩	1	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(3,4,5);0.60,0.35,0.40⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩
P3	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(2,3,4);0.30,0.75,0.70⟩	1	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩
P4	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(2,3,4);0.30,0.75,0.70⟩	1	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩
P5	⟨(7,8,9);0.85,0.10,0.15⟩	⟨(3,4,5);0.60,0.35,0.40⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(1,1,1);0.50,0.50,0.50⟩	1	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩
P6	⟨(5,6,7);0.70,0.25,0.30⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(1,1,1);0.50,0.50,0.50⟩	1	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩
P7	⟨(5,6,7);0.70,0.25,0.30⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩	1	⟨(1,1,1);0.50,0.50,0.50⟩
P8	⟨(5,6,7);0.70,0.25,0.30⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩	1
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 1. Paired Matrix AHP Neutrosophic

Principles	P1	P2	P3	P4	P5	P6	P7	P8	Weight
P1	0.52	0.77	0.58	0.40	0.38	0.23	0.27	0.27	0.43
P2	0.07	0.11	0.25	0.28	0.27	0.23	0.19	0.19	0.20
P3	0.07	0.04	0.08	0.17	0.16	0.23	0.19	0.19	0.14
P4	0.07	0.02	0.03	0.06	0.05	0.14	0.12	0.12	0.08
P5	0.07	0.02	0.03	0.06	0.05	0.05	0.12	0.12	0.06
P6	0.10	0.02	0.02	0.02	0.05	0.05	0.04	0.04	0.04
P7	0.07	0.02	0.02	0.02	0.02	0.05	0.04	0.05	0.03
P8	0.07	0.02	0.02	0.02	0.02	0.05	0.04	0.04	0.03

Table 2. Determination of criteria weights applying the Neutrosophic AHP method

Criteria	A x Weight	Approximate eigenvalues
1	4.48	10.52939754
2	1.94	9.7130298
3	1.24	8.743880449
4	0.62	8.253215035
5	0.54	8.399642628

6	0.35	8.371912999
7	0.29	8.212070304
8	0.29	8.42304258
	8.830773916 Eigenvalue	

Table 2. Analysis of the consistency of the paired matrix

The analysis of the consistency of the method showed that its eigenvalue is 8.83, IC = 0.12, and RC = 0.08, so it is confirmed that the exercise was correct.

Neutrosophic TOPSIS

To identify in a simpler way the elements to be analyzed, the principles will be identified with P and the premises (Pr):

Principles/ Premises	P1	P2	P3	P4	P5	P6	P7	P8
Pr1	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)
Pr2	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)
Pr3	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.10,0.90,0.90)	(0.10,0.90,0.90)	(0.10,0.90,0.90)	(0.35,0.75,0.80)	(0.10,0.90,0.90)
Pr4	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)
Pr5	(0.50,0.50,0.50)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)
Pr6	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.75,0.25,0.20)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
Pr7	(0.35,0.75,0.80)	(0.50,0.50,0.50)	(0.35,0.75,0.80)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.35,0.75,0.80)	(0.50,0.50,0.50)
Pr8	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.75,0.25,0.20)	(0.35,0.75,0.80)	(0.75,0.25,0.20)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)

Table 3. Performance Matrix

Principles/ Premises	P1	P2	P3	P4	P5	P6	P7	P8	D+	D-	Ri	Hierarchy Order
Pr1	0.21943346	0.10050378	0.06527534	0.039036	0.02797514	0.01873172	0.01477994	0.01404879	0.21943346	0.08777338	1	1
Pr2	0.21943346	0.08040303	0.06527534	0.039036	0.02238012	0.01873172	0.01182395	0.01404879	0.10050378	0.04020151	0.87258786	2
Pr3	0.08777338	0.04020151	0.02611013	0.0078072	0.00559503	0.00374634	0.00591198	0.00280976	0.06527534	0.02611013	0	7
Pr4	0.17554676	0.08040303	0.05222027	0.0312288	0.02238012	0.01873172	0.01477994	0.01404879	0.039036	0.0078072	0.66666667	3
Pr5	0.13166007	0.08040303	0.05222027	0.0312288	0.02238012	0.01498537	0.01182395	0.01123903	0.02797514	0.00559503	0.39793807	4
Pr6	0.13166007	0.06030227	0.0391652	0.0234216	0.02238012	0.01123903	0.00886796	0.00842927	0.01873172	0.00374634	0.33333333	5
Pr7	0.08777338	0.06030227	0.02611013	0.0234216	0.01678509	0.01123903	0.00591198	0.00842927	0.01477994	0.00591198	0.12741214	6
Pr8	0.08777338	0.04020151	0.05222027	0.0156144	0.02238012	0.00749269	0.00591198	0.00561951	0.01404879	0.00280976	0	8

Table 4. Weighted normalized matrix, Proximity calculation relative to the ideal solution, and hierarchical order

In the first stage of the study, a consensus is achieved among the experts by identifying 7 fundamental principles that the evaluation procedure must comply with and the weighting of weights allows determining the level of relevance of each one. The need to find the best alternative to facilitate decision-making made it possible to determine that the greatest weight in the assessment corresponds to the principle related to credibility.

This decision is supported by the analysis carried out on the consistency of the paired matrix, according to which, when determining the ratio between the consistency index and the random index, a value of $0.08 \leq 0.10$ is obtained, which leads to conclude that the analysis carried out is consistent.

Once the weights have been calculated, it is decided to apply the TOPSIS technique for the evaluation of the premises, on the aforementioned principles, using the weights resulting from the AHP. Moreover, all the resulting results can be summarized in a table like the following one that relates the principles that best fit a procedure for the evaluation of social projects with the premises that must be met for their establishment.

Principle	Related premise
Practicality or utility	2; 3; 10
Credibility	6; 8; 9
Impartiality	1; 5; 6
Objectivity	2; 4; 6; 8
Timeliness	3; 7; 9
Independence	1; 5
Validity	1; 4; 5; 9
Reliability	9

Table 5. Relationship of principles and premises

The procedure for the evaluation of social projects must then comply with the following principles.

Figure 1. Procedure design.

Conclusion

After conducting the investigation, we have reached the following conclusions:

a. Projects require a careful analysis of their likely outcome and, therefore, it is advisable to take some time for their formulation and evaluation.
b. The evaluation of investment projects has progressed extraordinarily. This is not the case in the field of social programs.
c. The existing experience in the field of evaluating social projects has large gaps. On one hand, there is the tradition of social evaluation linked to the ex-ante stage. On the other hand, there is no doubt that cost-benefit analysis can and often is a useful tool
d. The need to develop a procedure for the evaluation of social projects is considered. To achieve this procedure, certain fundamentals must be followed to guarantee coherence and correct implementation.
e. The development of a procedure for evaluating social projects will contribute to obtaining preventive and correct information for precise decision-making and selection of projects.
f. The development of the research allowed defining some principles and premises that the procedure must comply with for its correct design and it will become a tool that can unify criteria and allow decisions to be made in a short period.

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Neutrosophic Statistical Analysis of E-commerce

Lysbeth Kruscthalia Álvarez Gómez[1], Mireya Silvana Cuarán Guerrero[2], Jimena Elizabeth Montes de Oca Sánchez[3], Mónica Elizabeth Benalcázar Paladines[4] and Asnioby Hernandez Lopez[5]

[1] Directora. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.lysbethalvarez@uniandes.edu.ec
[2] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.mireyacuaran@uniandes.edu.ec
[3] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.jimenamontesdeoca@uniandes.edu.ec
[4] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.monicabenalcazar@uniandes.edu.ec
[5]Mercado Libre, Montevideo, Uruguay. Email: asnioby.hernandez@mercadolibre.com

Abstract. E-commerce consists of the purchase, sale, distribution, marketing, and supply of information about products or services through the internet so that any client can access the products or services from anywhere and at any time. It constitutes a negotiation model that acquires more and more followers, generating great economic benefits for those who use it. To make e-commerce successful, it is necessary to be present in large marketplaces, by increasing visibility. A marketplace has a very large flow of users who already trust the brand. Therefore every detail of the consumer's shopping experience must be taken care of, the customer service system perfected, and business promoted with the practice of marketing. In this paper, the main effects that influence the pillars and the success of e-commerce were determined and it is identified that customer service constitutes the factor with the greatest incidence in the growth of e-commerce, based on the analysis of the neutrosophic statistics.

Keywords: E-commerce, business, neutrosophic statistics.

1 Introduction

Electronic commerce or e-commerce is the economic activity that allows the trade of products and services from digital media [1-3], and it is a trend that moves a large part of the world economy. It is present in governments and large companies. The globalized world, its dizzying competitiveness and the speed to do business have driven the development of electronic commerce by modifying the way of selling and buying products or services on the internet in a local, national and international market [4], either through web pages, mobile applications, or social networks.

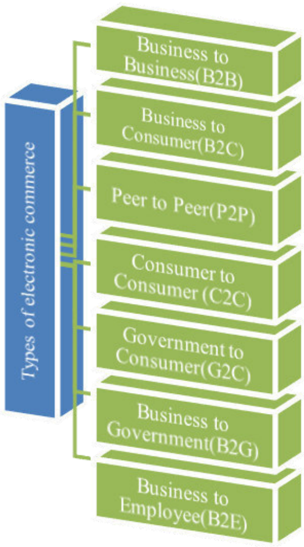

Figure 1. Types of e-commerce

Nowadays, various types of e-commerce can be done: (see Figure 1) [5]. These allow anyone to start an online business. Among the most used are B2B and B2C (see Figure 2). In 2015, B2B accounted for 89% of global e-commerce. The rest (11%) to B2C [6], the latter grew annually by 31% on average between 2014 and 2017, leading the United States with sales of $ 7.1 trillion, corresponding to 28% of global e-commerce [7]. Thus, the amount of global e-commerce would increase in total from 1.3 to 4.9 trillion dollars.

The use of e-commerce generates millionaire profits; during 2015 the global e-commerce market exceeded 25 trillion dollars [8] and contributed in 2016 to the increase of 2.92% of GDP worldwide, verifying that the use of online stores by companies increases their exports and productivity, with a growth in the use of broadband in the countries, thus increasing the trading relationship [9].

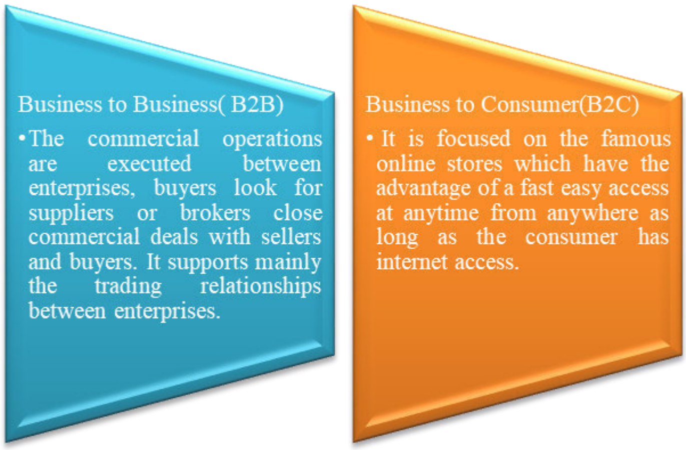

Figure 2. Types of electronic commerce that are most used in the world.

For the proliferation of e-commerce, technologies play an essential role in the exchange, promotion and sales of products and services today and their use is increasing. Among the most important electronic commerce sites in 2019 are Amazon, JD.com, Alibaba, eBay, Rakuten, Zalando, and Otto [10-13].

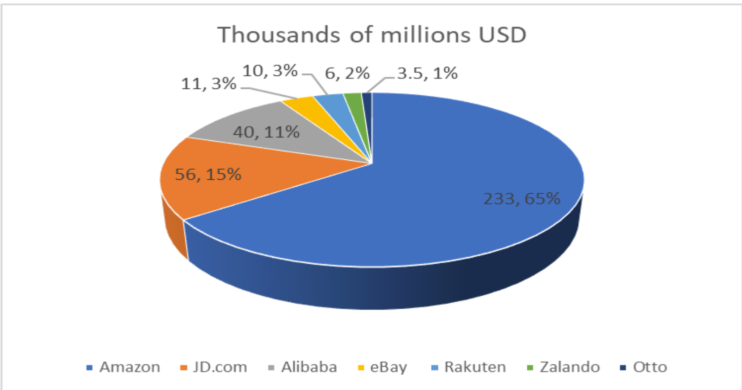

Figure 3. Incomings of the main e-commerce companies in 2019.

This new form of business undoubtedly represents a driving force for the economic development of the business sector, as well as for developed and developing nations [14]. As organizations grow in size, e-commerce becomes more complex and challenging and to maintain customer attention, it is necessary to create a strong relationship with the customer and offer services that attract them to visit the website frequently, buy products and services and carry out successful digital marketing activities [15], which are essential to the success of an e-commerce business today [1-3].

All the effort invested in creating and marketing a product will be wasted if the logistics involved in delivery are not robust. In addition, a negative experience will leave a bad impression on the customer, reducing the probability that they will return to the online store [16]. Another important impact is to guarantee security in financial transactions between customers and suppliers, combat fraud and unwanted emails [17], and prioritize authentication and controls over access to data.

For the analysis of the factors that affect electronic commerce, it is defined:

- Problem situation: effects on the development of e-commerce
- Main objective: define the main effects that influence the success of e-commerce
- Specific objectives:
  - Determine the factors that affect the variable analyzed
  - Carry out the measurement and modeling of the variable
  - Define the potential alternatives to mitigate the effects that influence the success of the e-commerce

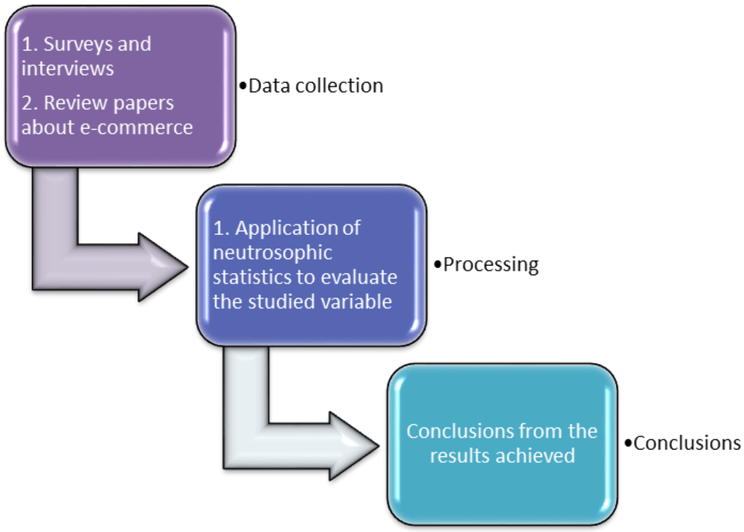

Figure 4. Development of the study

2 Materials and methods

[18-40] Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. For example, the Neutrosophic Probability of an event E is the probability that event E will occur [41], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup ≤1, while in neutrosophic probability nsup ≤3+. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)),$$

Where T(x) represents the probability that the value x occurs, F(x) represents the probability that the value x does not occur, and I(x) represents the indeterminate or unknown probability of the value x. Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [42], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them.

Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [43].

In short, the Neutrosophic Logic [44, 45], Neutrosophic Sets and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development.

The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [46].

Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [47], while "I" is the indeterminacy part of the neutrosophic number N.

$$N = a + bI.$$

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable $(\bar{x}_N)$when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N} \sum_{i=1}^{n_N}, X_{il}\ \bar{x}_b = \frac{1}{n_N} \sum_{i=1}^{n_N}, X_{iu}\ n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS), it can be calculated as follows.

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N} \begin{bmatrix} \min\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \\ \max\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \end{bmatrix}, I \epsilon [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated through

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is than the other factors. NCV can be calculated as follows [48].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U] \tag{5}$$

3 Results

Data collection

After analyzing the different approaches in the introduction of this paper, the techniques described above are applied as follows: for the growth of e-commerce and due to the complexity and indeterminacy of the data, we decided to apply the neutrosophic statistics for modeling the analyzed variable.

From the information processing and the consensus of the experts, the factors that most affect e-commerce and the variable to be modeled were determined (Table 1).

Variable analyzed: e-commerce growth, for a sample of n = 120 for each factor (f)

Resources needed to create or maintain e-commerce	Initials	Factors that affect business success (e-commerce)	Scale	Occurrence of the incident
Security in financial transactions	V	Digital security breaches	[0; 3]	From 0 to 3 people per day, report a violation of their data
Market	M	Marketing does not guarantee trust in the website	[0; 3]	0 to 3 people do not recommend the website due to the low level of publicity and promotion
Positioning of the business in web search engines	D	Difficulty accessing the platform	[0; 3]	From 0 to 3 people per day comment that they had some difficulty accessing the website
Customer Support	B	Low interaction with customers	[0; 3]	0-3 people per day complain about customer service delays

Logistics	A	Delays in delivery times	[0; 3]	0 to 3 people have problems with the delivery of the purchased product

Table 1. Incidence range for each factor.

To model the neutrosophic statistics, it was decided to code the factors to make the results viable (Table 2).

Code	Initials	Factors that affect business success
A	V	Digital security breaches
B	M	Marketing does not guarantee trust in the website
C	D	Difficulty accessing the platform
D	B	Low interaction with customers
E	A	Delays in delivery times

Table 2. Determinant factors for the business success.

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the success of an electronic commerce business are analyzed. For each factor, an incidence is analyzed in an interval of days for each factor, which makes up the set of affectations for e-commerce to become a sales success.

Days	Neutrosophic frequencies				
	V	M	D	B	A
1	[1 ; 2]	[1 ; 4]	[2 ; 5]	[0; 1]	[0; 1]
2	[0; 1]	[3 ; 5]	[2 ; 4]	[2 ; 4]	[3 ; 6]
3	[0; 0]	[0; 1]	[0; 3]	[0; 3]	[3 ; 6]
4	[1 ; 2]	[0; 1]	[0; 1]	[3 ; 6]	[1 ; 4]
5	[0; 0]	[3 ; 6]	[1 ; 2]	[0; 2]	[0; 1]
6	[1 ; 2]	[3 ; 6]	[1 ; 3]	[0; 3]	[1 ; 4]
7	[1 ; 1]	[2 ; 5]	[1 ; 1]	[0; 2]	[0; 3]
8	[1 ; 1]	[1 ; 1]	[3 ; 3]	[0; 3]	[0; 1]
9	[0; 1]	[1 ; 3]	[0; 0]	[0; 0]	[1 ; 1]
10	[1 ; 1]	[0; 0]	[0; 0]	[2 ; 2]	[2 ; 2]
11	[0; 1]	[3 ; 4]	[3 ; 3]	[3 ; 5]	[1 ; 2]
12	[0; 1]	[2 ; 4]	[3 ; 6]	[2 ; 5]	[0; 0]
13	[0; 1]	[1 ; 1]	[1 ; 1]	[1 ; 4]	[2 ; 5]
14	[1 ; 1]	[2 ; 2]	[0; 3]	[3 ; 3]	[1 ; 3]
15	[0; 1]	[0; 0]	[0; 2]	[0; 1]	[3 ; 6]
16	[0; 0]	[2 ; 5]	[1 ; 1]	[1 ; 1]	[3 ; 3]
17	[1 ; 1]	[3 ; 6]	[1 ; 2]	[2 ; 2]	[1 ; 4]
18	[0; 0]	[0; 0]	[1 ; 3]	[1 ; 3]	[1 ; 1]
19	[1 ; 1]	[2 ; 5]	[1 ; 3]	[1 ; 1]	[2 ; 3]
20	[1 ; 1]	[1 ; 3]	[2 ; 3]	[3 ; 6]	[3 ; 4]
0-120	[60; 125]	[186; 359]	[175; 353]	[177; 358]	[173; 353]

Table 3. Neutrosophic frequencies of factors

Table 3 analyzed the neutrosophic frequency of occurrence of the determining factors in the development of e-commerce, for 120 days, with an occurrence level of [0; 6] for each factor per day with a total indeterminacy level of a = 65, b = 173, c = 178, d = 181, e = 180, and a level of representativeness of [48.19%; 52.00%], on the days that 6 impacts per factor were recorded, with an incidence of 52% in terms of digital security violations.

<u>Neutrosophic statistical analysis</u>

From the data on the effects that affect the business (table 4), it will be possible to understand which factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated and for the study of the variations in the effects, the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$. To determine which impact requires a greater impact on business growth, the $CV_N \in [CV_L ; CV_U]$values are calculated.

Factors	$\overline{x}_N$	YN	CVN
Digital security breaches	[0.5; 1,042]	[0.112; 0.934]	[0.224; 0.896]
Marketing does not guarantee trust in the website	[1.55; 2,992]	[0.707; 2.39]	[0.456; 0.799]
Difficulty accessing the platform	[1,458; 2,942]	[0.695; 2.24]	[0.477; 0.761]
Low interaction with customers	[1,475; 2,983]	[0.721; 2,106]	[0.489; 0.706]
Delays in delivery times	[1,442; 2,942]	[0.681; 2,237]	[0.472; 0.76]

Table 4. Neutrosophic statistical analysis of incidents in online business

In table 4, we determined that the factors. *Marketing does not guarantee trust in the website* and *low interaction with customers* have higher mean values that affect the other factors. This means that the M and B factors are, on average, the ones that most affect an online commerce business to be successful and evolve, while the value of CV_{Nb} in the low interaction with customers is lower than the rest. This means that the result of factor B has a more consistent, coherent, and precise impact when evaluating indeterminacy than the other factors in e-commerce (Figure 5).

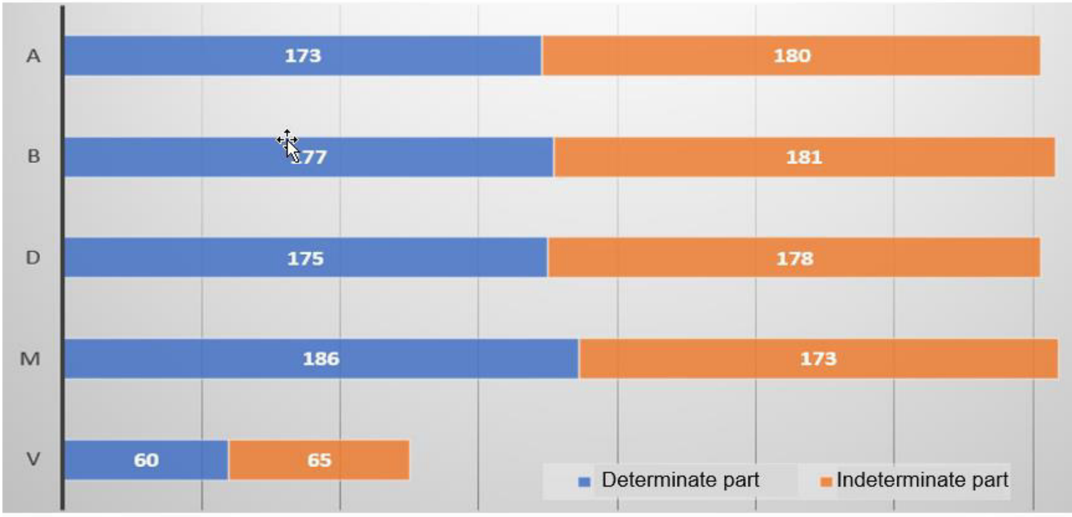

Figure 5: Neutrosophic bar chart of incidents for the development of the online business

<u>Comparative analysis</u>

To calculate the associated referent indeterminacy measure $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ for the form of neutrosophic numbers (Table 5), in the results, we observe that the values range from 0.489 to 0.706 with indeterminacy measure 30.7 generating a negative impact on poor communication with customers.

Factors	$\overline{x}_N$	YN	CVN
V	0.5 + 1.042 I;I $\in$ $[0; 0.52]$	0.112 + 0.934 I;I $\in$ $[0; 0.88]$	0.224 + 0.896 I;I $\in$ $[0; 0.75]$
M	1.55 + 2,992 I;I $\in$ $[0; 0.48]$	0.707 + 2.39 I;I $\in$ $[0; 0.70]$	0.456 + 0.799 I;I $\in$ $[0; 0.42]$
D	1,458 + 2,942 I;I $\in$ $[0; 0.50]$	0.695 + 2.24 I;I $\in$ $[0; 0.69]$	0.477 + 0.761 I;I $\in$ $[0; 0.37]$
B	1,475 + 2,983 I;I $\in$ $[0; 0.50]$	0.721 + 2.106 I;I $\in$ $[0; 0.65]$	0.489 + 0.706 I;I $\in$ $[0; 0.30]$
A	1,442 + 2,942 I;I $\in$ $[0; 0.51]$	0.681 + 2.237 I;I $\in$ $[0; 0.69]$	0.472 + 0.76 I;I $\in$ $[0; 0.37]$

<u>**Table 5.** Neutrosophic statistical analysis</u>

Alternatives to mitigate negative effects on e-commerce

With this study, it was determined that one of the main priorities of electronic commerce is to enhance the Customer Service System. Online chats are a very easy-to-use tool that will improve customer service in two fundamental aspects, quality and speed. It is a strategy that manages to reach the recipients more quickly. Several reasons lead the client to contact your company: defects, doubts, claims, suggestions, delivery time, among others, and the use of various communication channels to offer solutions at all times and raise the prestige of the company's online store is the point of reference for anyone who wants to start an online business. So, it is necessary to train professionals, they must have the ability to serve clients with patience, cordiality, efficiency, and clarify all doubts. There is no better customer service than offering you quick answers to your client's problems.

Figure 6. Alternatives to enhance communication channels

Conclusions

E-commerce needs to overcome various obstacles and public policy challenges. For example, limited and deficient connectivity and inadequate technological infrastructure, postal services with unsatisfactory performance, legal and regulatory frameworks that restrict the degree to which people trust and carry out online transactions, in addition to creating promotions and enhancing the communication channel with the consumer, are some of the main reasons for the growth and success of electronic commerce.

The analysis of the neutrosophic statistics found that the e-commerce growth variable is affected by the low interaction with customers with an indeterminacy level of 30.7% by influencing inversely proportional with respect to the other factors, so that, if the factor B, increases the other factors and the instability of the business.

The neutrosophic statistical analysis shows a lower CV value for low interaction with customers as a determining factor to start an online business. Based on this result, it was concluded that with the use of several communication channels, quick responses could be offered to the consumer and guarantee satisfactory buying experiences.

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Electronic Payments in Decentralized Autonomous Municipal Governments of Ecuador. Decision Making through Plithogenic Logic

Llerena Ocaña Luis Antonio[1], Viscaino Naranjo Fausto Alberto[2], Culque Toapanta, Walter Vinicio[3], Baño Naranjo and Freddy Patricio[4]

[1] ua.luisllerena@uniandes.edu.ec, Software, UNIANDES, Ambato, Ecuador
[2] ua.faustoviscaino@uniandes.edu.ec, Software, UNIANDES, Ambato, Ecuador
[3] ua.walterculque@uniandes.edu.ec, Software, UNIANDES, Ambato, Ecuador
[4] ua.freddybn@uniandes.edu.ec, Software, UNIANDES, Ambato, Ecuador

Abstract. With the constant technological changes and their exponential growth due to the use of numerous applications, you can see the expansion of the electronically paid quotas which added to the organizations that experience a considerably greater misrepresentation, as well as the expansion of the quotas made with the Visa that was added to this development. Extortion can be characterized as a criminal behavior executed to obtain advantages related to money without reflecting on the results of this demonstration. Therefore, the development of an age adjustment was proposed to limit the problem using individual and regulated calculations that depend on AI strategies. The arrangement also considered excavation methods for handling information. The research used information from a public organization that relied on information from outside organizations to conduct banking transactions. For the complete system development, PHP was used as the programming language and PayPal as a transactional method or payment gateway due to the security it offers between transactions. For the development of the topic, we used mathematical modeling for decision making through Neutrosophic Logic and Plithogenic Logic.

Keywords: PHP, PayPal, Software Development, Neutrosophic Logic, Plithogenic Logic

1 Introduction

In the study presented by [1], the author has tried to analyze the cash transaction process, the importance of the cash transaction. He examines how information technology plays a vital role in the cashless economy and explains the impact of cashless transactions on the business process and the educational process. In [2], the personal experiences of customers and the use and level of awareness of customers towards electronic payment have been examined. Determine the variety of facilities that are available for online payment. On [3], it is determined that the electronic payment system improves people's quality of life and most commercial companies that accept electronic payments for their business transactions. In [4], they studied the prospect of digital payments and the opportunities and challenges of electronic payments in India and summarizes the initiatives taken by the government and India to promote electronic payment or digital payment.

The growth of information and communication technologies is persuading people and supporting the achievements of human society as a whole, and these are reinforced by the vast amount of available information and awareness about the use of various types of technologies [5]. Digitization has broken the traditional boundaries of society and provided creative and dynamic wings for business growth [6]. The digital revolution enables people to live life with ease and conduct convenient financial transactions. Banks enthusiastically adopted the electronic payment system as a method of financial transactions and created a convenient money transaction tool. Electronic payment is one of the prominent pillars of e-commerce and has become an integral part of the electronic commerce system. The efficient implementation of monetary policies and transactions in the money market depends on the electronic payment system. The electronic payment system influences the country's financial and economic system. Electronic payment became a monetary instrument for people to carry out their economic activities. Electronic payment is part of the economic infrastructure and plays a vital role in liquid transactions. The electronic payment system allowed the settlement infrastructure to be transferred from one person to another in a short period. Building an electronic payment infrastructure can be an excellent platform for future growth [7, 8].

As mentioned on the website of the Central Bank of Ecuador, "The Online Payment System has as its main characteristic that of incorporating a gross settlement scheme in real-time, being able to demand relatively high amounts of liquidity during the day, since the participants need sufficient liquidity to cover their payments. Under this consideration, the normal flow of payments will depend on whether the level of liquidity available to the ordering institution is adequate, concerning the value and distribution of pending payments, in such a way that delays to individual payments are avoided and at the same time risks related to uncertainty regarding the level of short-term liquidity are minimized" [9].

In recent years, e-commerce in Ecuador has grown rapidly and the perception of consumers towards electronic payment is also changing, but the lack of awareness about electronic payment is not an easy task. Most people cannot buy smartphones or laptops which play a very important role in electronic payment. People still fear the security of electronic payment and fear restricting themselves to adopt electronic payment.

Electronic payment is a method of payment through an electronic network. Digital payments are payments directly to the payee from the payer's bank account using security features. Electronic payments are financial transactions between the buyer and the seller over the Internet. Electronic payments are based on digital financial instruments and backed by banks.

According to the Organic Monetary and Financial Code (2014), "electronic funds transfer" is any transfer of funds initiated by a person through instruction, authorization, or order to a bank to debit or credit an account maintained in that bank through electronic means, and includes transfers at the point of sale; ATM transactions, direct deposit or withdrawal of funds, transfers initiated by phone, Internet, and card payment.

Electronic payment systems are essential mechanisms used by individuals and organizations as a safe and convenient way to make payments over the Internet and, at the same time, a gateway to technological advancement in the world economy. In addition, it has also become the main part of e-commerce through which the success of e-business was based. The electronic payment system has also brought efficiency, reduced fraud, and innovation to the global payment system. However, despite the merits of electronic payment, it is essential to measure consumer satisfaction to make further corrections.

Payment methods are not only available for online purchases. Public entities have chosen to integrate this method for the collection of taxes, fees, and basic services to avoid crowds in public establishments. It can be clearly defined that some state institutions offer these types of services, but not all of them [10].

Given the case of the Municipal Decentralized Autonomous Government (DAG) of San Pedro de Pelileo, a relatively small state entity, which begins to have problems due to the number of taxpayers who request to cancel the values on property payments, these can be urban or rural and each of them you have estimate values established by each administration according to appraisals, patent payments and payments for drinking water consumption [10, 11].

For the development of the study, mathematical modeling for decision making was applied using Neutrosophic Logic and Plithogenic Logic. Neutrosophic sets are part of Neutrosophy, which studies the origin, nature, and scope of neutralities and their interactions with different ideational spectra. Neutrosophic sets are relatively new extensions of fuzzy intuitionist sets, while Plithogeny advocates the connections and unification of theories and ideas in varied fields of science, as it is an extension of the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set [12-24].

2 Methods

A qualitative-quantitative method was used since interviews were established for the director of the systems department and a public collection official. In addition, the information is described through a survey directed to the taxpayers of the Municipal DAG of San Pedro de Pelileo. We work with a sample of 279 people from a population of 6450 taxpayers. It should be noted that these are registered in one of the databases of the Municipal DAG of San Pedro de Pelileo.

The inductive method determined the characteristics, parameters, and relationships that would exist between the mobile software and the final taxpayers who are the citizens of the Pelileo canton. For the development of the research, we used the deductive method that can be evidenced in the analysis of the management processes of inquiries and payments that the Municipal DAG of San Pedro de Pelileo currently provides to taxpayers in general, and through this, we obtained the information necessary to make a diagnosis about the deficiencies that can be found in this process.

A survey was applied to the taxpayers of the canton of Pelileo to obtain information, which contributed significantly to the solution of the defined problem. An interview was applied to the director of the systems department and a public official who manages the consultations and payments of the Municipal DAG of San Pedro de Pelileo, in order to collect relevant information, which contributed significantly to the proposal of an adequate solution to the research problem.

2.2 Mathematical modeling through Neutrosophic Logic to Plithogenic Logic

Neutrosophic sets were introduced in the literature by F. Smarandache since fuzzy intuitionistic sets could only handle incomplete information, but not the indeterminate and inconsistent information, which commonly exists in fuzzy systems. Neutrosophy means knowledge of neutral thought, and this neutrality represents the main distinction between fuzzy logic and fuzzy intuitionist [12, 16, 25-28].

In neutrosophic sets, the indeterminacy is explicitly quantified through a new parameter I. True membership (t), indeterminate membership (I), and false membership (F) are independent of each other and the sum among them satisfies the inequalities $0 \leq T + I + F \leq 3$. In fuzzy intuitionistic sets, the uncertainty depends on the degree of membership and the degree of non-membership [29]. In neutrosophic sets, the indeterminacy factor (I) is independent of the true and false values. There are no restrictions between the degree of truth, the degree of indeterminacy, and the degree of falsehood [12, 16, 25].

If U is a universe of discourse, a Neutrosophic Set (NS) is characterized by three membership functions, $uA(x), rA(x), vA(x) : X \rightarrow \,]0-, 1+[$, which satisfy the condition $0 \leq -\inf uA(x) + \inf rA(x) + \inf vA(x) \leq \sup uA(x) + \sup rA(x) + \sup vA(x) \leq 3+$ for all $x \in X$. $uA(x), rA(x)$ and $vA(x)$ are the membership functions of the veracity, the indeterminacy, and the falsehood of x in A, respectively and their images are standard or non-standard subsets of $]0-, 1+[$.

When approaching the perspective of indeterminacy and contradiction, as is the case with Gödel's incompleteness theorem, it states that any proposition in a mathematical axiom system will present a degree of truth (T), falsehood (F), and indeterminacy (I). Neutrosophy, therefore, establishes a unique solution for the existence of paradoxes in philosophy [15].

Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and mergers of multiple contradictory and/or neutral and/or non-contradictory previous entities. Plithogeny advocates the connections and unification of theories and ideas in varied fields of science. We can take "knowledge" as "entities", in various fields, such as social sciences, technical sciences, theories of arts, and so on [16].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a type of opposites: <A> and <antiA>), Neutrosophy (dynamics of a type of opposites and their neutrals: <A> and <antiA> and <neutA>), since Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites (<A> and <antiA> and <neutA>, <B> and <antiB> and <neutB>, etc.), and many do not opposites (<C>, <D>, etc.) all together. As an application and particular case derived from Plithogeny, the plithogenic set is an extension of the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set, and has multiple scientific applications [25].

So, (P,a,V,d,c) is called a plithogenic set

1. Where "P" is a set, "a" is an attribute (multidimensional in general), "V" is the range of attribute values, "d" is the degree of membership of the attribute value of each element x to the set P for some given criteria (), and "d" means "" or "" or "", when it is a fuzzy degree of membership, an intuitionistic fuzzy membership or a neutrosophic degree of membership, respectively, of an element x to the plithogenic set P; x ∈ Pd_F d_IF d_N
2. "c" means "" or "" or "", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value degree of contradiction function, respectively. c_F c_IF c_N

The functions are defined according to the applications that the experts need to solve. $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ then, the following notation is used: $x(d(x, V))$, where . $d(x, V) = (d(x, v)$, for every $v \in V), \forall x \in P$

The attribute value contradiction degree function is calculated between each attribute value with respect to the dominant attribute value (denoted by v_D) in particular, and also for other attribute values.

The attribute value contradiction degree function c, evaluated between the values of two attributes is used in the definition of Plithogenic aggregation operators (intersection (Y), union (OR), implication (⟹), equivalence (⟺), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of attribute values based on a t-norm and a t-conorm

Most plithogenic aggregation operators are linear combinations of a fuzzy t-norm (indicated by) with a fuzzy t-conorm (indicated by), but nonlinear combinations can also be constructed. ∧_F ∨_F [30]

If the t-norm is applied on the value of the dominant attribute denoted by, and the contradiction between and is, then it is applied on the value of the attribute as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2) \tag{1}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2) \tag{2}$$

Similarly, if the t-conorm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2) \tag{3}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2) \tag{4}$$

The *Plithogenic Neutrosophic Intersection* is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right) \quad (5)$$

The *Plithogenic Neutrosophic Union* is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right) \quad (6)$$

In other words, if something applies to membership, the opposite applies to non-membership, while in indeterminacy the average between them is what applies.

The *Plithogenic Neutrosophic Inclusion* is defined as follows:

Since the degrees of contradiction are $c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5$, applies: $a_2 \geq [1 - c(a_1, a_2)]b_2$ or $a_2 \geq (1 - 0.5)b_2$ or $a_2 \geq 0.5b_2$ while $c(a_1, a_3) = c(b_1, b_3) = 1$.

Having $a_1 \leq b_1$ the opposite is done for $a_3 \geq b_3$, hence $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only if $a_1 \leq b_1$, $a_2 \geq 0.5b_2$, and $a_3 \geq b_3$.

Next, an algorithm for the resolution of this research is presented where Plithogeny will be merged with the algorithm of Neutrosophy.

From this moment on, expressions 2 to 8 must be applied to execute the operations of the classical algorithm with plithogenic numbers.

For the elaboration of a single decision matrix, the median of the plithogenic numbers is calculated for each combination, for all specialists. The median is calculated using the following formula:

$$\text{median}_{i=1}^{m}\{PN_i\} = (\text{median}_{i=1}^{m}\{T(PN_i)\}, \text{median}_{i=1}^{m}\{I(PN_i)\}, \text{median}_{i=1}^{m}\{F(PN_i)\}) \quad (7)$$

Where PN_i, are plithogenic numbers, $T(PN\_i)$ true components, $I(PN\_i)$ indeterminate components and $F(PN_i)f$ false components. In other words, Equation 8 means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components:

To compare the relationships between the quadrants, the following formula is used to blur a neutrosophic number [28]:

$$\mathcal{S}([T, I, F]) = \frac{2+T-I-F}{3} \quad (8)$$

- Determine for each line of the pairwise comparison matrix, a weighted sum based on the sum of the product of each cell by the priority of each alternative or corresponding criterion.
- For each line, divide its weighted sum by the priority of its corresponding alternative or criterion
- Determine the $ƛmax$ mean of the result of the previous stage.
- Calculate the consistency index (CI) for each alternative or criterion

$$CI = \frac{ƛ_{max} - m}{m-1} \quad (9)$$

Where m is the number of alternatives

- Determine the Random Index (RI) from table 2
- Determine the consistency ratio index (the ratio between the consistency index and the random index)

3 Results

Regarding taxpayers using mobile applications and smartphones, it was found that the majority of citizens are eligible to use the application.

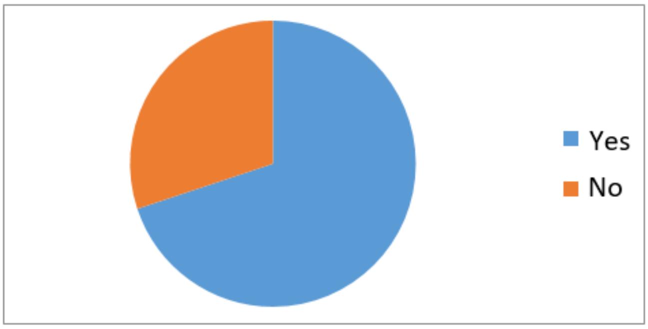

Figure 1. Statistical data. Source:[10]

In a sample before the implementation of the mobile web application, the following results were obtained:

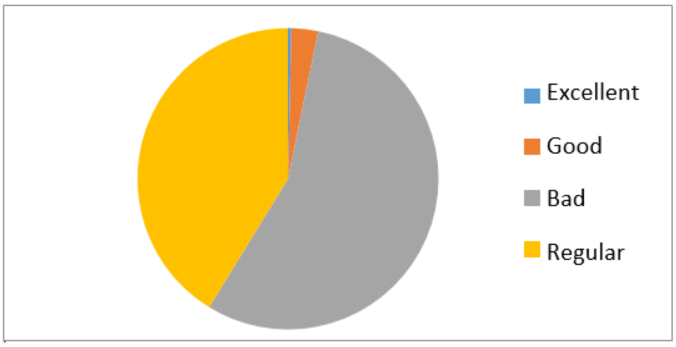

Figure 2. Customer service regarding payments. Source:[10]

Alternatives	Frequency	Percentage %
Excellent	1	0.3%
Good	8	2.7%
Bad	155	56%
Regular	115	41%
Total	279	100%

Table 1. Customer service regarding payments. Source: [10]

By the time the mobile web application was implemented, they were in confinement due to the pandemic resulting from COVID-19, for this reason, the authors think that the effectiveness rate for the use of the web and mobile payment methods developed and implemented in the DAG Municipality of San Pedro de Pelileo were accepted and recognized as a good practice in terms of management by the DAG systems personnel.

Alternatives	Frequency	Percentage %
Excellent	248	88.89%
Well	31	11.11%
Bad	0	0%
Regular	0	0%
Total	279	100%

Table 2. Implementation results. Source: [10]

4 Discussion

Authorization is the option established by the seller so that the protocol is sufficient to complete the payment; otherwise, the protocol does not achieve the payment authorization. Subsequently, the seller must perform a separate settlement function or perform further processing of this payment offline (traditional methods) [31]. The response code of the acquirer indicates if authorization is granted and, if authorization was requested, if payment was made, this can be known as double authentication methods, which could be found on credit cards or messages response before consumption (emails or SMS) as mentioned by [32].

Software development largely relates the design process to develop itself, as established in [33]. In the process, the development methodology is the fundamental part since this guides the process and the process that is established in the software operations to complete the transaction [34] [35].

The public entity presents the obligation in the delivery of the services to the taxpayer, the responsibility for guaranteeing the quality and quantity standards of the services that it offers. Public institutions are supported by legal documents which are valid to legally process the taxpayer for non-compliance with the services provided [36].

A taxpayer can pay the amounts owed on the DAG payment page, then press the Next Step button, that is, choose a payment method, on this payment method page there are 2 (two) payment methods, PayPal and credit cards, but in online payment systems is more focused on payment methods using the virtual account, when they finish choosing the taxpayers, they can press the Continue Payment button and the system sends an email to the account registered by the taxpayer as a verification payment method [10]

4.1 Development of mathematical modeling for decision making through neutrosophic logic and plithogenic logic in the digital transformation of commercialization

A plithogenic set is defined by 4 attributes, each of these attributes contains possible V values that appear between parentheses.

The attributes are described below and the possible values appear in parentheses:

V1	Market	v11	Advertising
		v12	Competitiveness
		v13	Credibility
V2	Technological means	v21	Safety
		v22	Friendly platform
V3	Variable retribution	v31	Profits
		v32	commissions
V4	Payment mode	v41	Diversity and innovation

The multi-attribute of dimension 5 has cardinality 3x2x2x1 = 12.
The degrees of contradiction between the values for each attribute are defined below:

cN (v11, v12) = cN (v11, v13) = cN (v13, v12) = 0.5
cN (v21, v22) = 0.3
cN (v31, v32) = 0.3
cN (v41, v41) = 0

As we can see, the dominant values for each attribute are: v_{13}, v_{22}, v_{31}, and v_{41}

Linguistic Expression	**Plithogenic number (T, I, F)**	$S([T,I,F]) = \frac{2+T-I-F}{3}$
Poor Importance (PI)	(0.12, 0.92, 0.97)	0.08
Less important (LI)	(0.17, 0.87, 0.92)	0.13
Low Importance (LWI)	(0.42, 0.67, 0.82)	0.31
Medium important MDI	(0.67, 0.62, 0.72)	0.44
Important (I)	(0.72, 0.37, 0.52)	0.61
More Important (MI)	(0.92, 0.27, 0.12)	0.84
Very important (VI)	(0.97, 0.07, 0.03)	0.96

Table 3. Plithogenic numbers

$$N(E) = \begin{pmatrix} \mathbf{(0,67; 0,62; 0,72)} & ; & (0,42; 0,67; 0,82) & ; & (0,72; 0,37; 0,52) & ; & (0,17; 0,87; 0,92) & ; & (0,17; 0,87; 0,92) & ; & (0,42; 0,67; 0,82) & ; & (0,67; 0,62; 0,72) & ; & (0,72; 0,37; 0,52) \\ (0,97; 0,07; 0,03) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & (0.12, 0.92, 0.97) & ; & (0,17; 0,87; 0,92) & ; & (0,17; 0,87; 0,92) & ; & (0,97; 0,07; 0,03) \\ (0,92; 0,27; 0,12) & ; & (0,72; 0,37; 0,52) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,97; 0,07; 0,03) & ; & (0.12, 0.92, 0.97) & ; & (0,97; 0,07; 0,03) & ; & (0,72; 0,37; 0,52) & ; & (0,97; 0,07; 0,03) \\ (0,72; 0,37; 0,52) & ; & (0,92; 0,27; 0,12) & ; & (0,92; 0,27; 0,12) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & (0,72; 0,37; 0,52) & ; & (0,97; 0,07; 0,03) \\ (0,42; 0,67; 0,82) & ; & (0.12, 0.92, 0.97) & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,42; 0,67; 0,82) & ; & (0.12, 0.92, 0.97) & ; & (0,42; 0,67; 0,82) \\ (0.12, 0.92, 0.97) & ; & (0.12, 0.92, 0.97) & ; & (0,17; 0,87; 0,92) & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) \\ (0,92; 0,27; 0,12) & ; & (0,72; 0,37; 0,52) & ; & (0,92; 0,27; 0,12) & ; & (0,97; 0,07; 0,03) & ; & (0.12, 0.92, 0.97) & ; & (0,97; 0,07; 0,03) & ; & \mathbf{(0,67; 0,62; 0,72)} & ; & (0,72; 0,37; 0,52) \\ (0,92; 0,27; 0,12) & ; & (0,97; 0,07; 0,03) & ; & (0,72; 0,37; 0,52) & ; & (0,92; 0,27; 0,12) & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & (0,42; 0,67; 0,82) & ; & \mathbf{(0,67; 0,62; 0,72)} \end{pmatrix}$$

Figure 3. Neutrosophic matrix under the plithogenic logic.

$$E = \begin{pmatrix} \mathbf{0.44} & ; & 0.31 & ; & 0.61 & ; & 0.13 & ; & 0.13 & ; & 0.31 & ; & 0.44 & ; & 0.61 \\ 0.96 & ; & \mathbf{0.44} & ; & 0.31 & ; & 0.31 & ; & 0.08 & ; & 0.13 & ; & 0.13 & ; & 0.96 \\ 0.84 & ; & 0.61 & ; & \mathbf{0.44} & ; & 0.96 & ; & 0.08 & ; & 0.96 & ; & 0.61 & ; & 0.96 \\ 0.61 & ; & 0.84 & ; & 0.84 & ; & \mathbf{0.44} & ; & 0.31 & ; & 0.31 & ; & 0.61 & ; & 0.96 \\ 0.31 & ; & 0.08 & ; & 0.31 & ; & 0.31 & ; & \mathbf{0.44} & ; & 0.31 & ; & 0.08 & ; & 0.31 \\ 0.08 & ; & 0.08 & ; & 0.13 & ; & 0.31 & ; & 0.31 & ; & \mathbf{0.44} & ; & 0.31 & ; & 0.31 \\ 0.84 & ; & 0.61 & ; & 0.84 & ; & 0.96 & ; & 0.08 & ; & 0.96 & ; & \mathbf{0.44} & ; & 0.61 \\ 0.84 & ; & 0.96 & ; & 0.61 & ; & 0.84 & ; & 0.31 & ; & 0.31 & ; & 0.31 & ; & \mathbf{0.44} \end{pmatrix}$$

	td
v41	1.7912
v13	1.7490
v21	1.6813
v32	1.5146
v11	1.4468
v12	1.3227
v31	1.0400
v22	0.7124

Figure 4. De-neutrosophied adjacent matrix and the values of the extremes of the NCM under the plithogenic logic

When v_{41} is activated, all other nodes are activated too, which means that the value of Diversity and innovation in the institutions in the subset of the Mode of payment will cause a positive influence by projecting as the dominant value within the plithogenic set, so that the customer has opportunities to select the payment platform.

For the evaluation of electronic payments in governments between subsets *Payment mode* and *Market,* it is determined by the results obtained.

v41	v13
I (0.72, 0.37, 0.52)	**MI** (0.97, 0.07, 0.03)

Table 4. Evaluations between Payment Mode (v41) and Market (v13)

Relationship between Payment Mode (v41) and Market (v13)

Neutrosophic Plitogenic Union	$S([T,I,F]) = \frac{2+T-I-F}{3}$
$(a1, a2, a3) \vee_p (b1, b2, b3) = (a1 \wedge_D b1, \frac{1}{2}[(a2 \wedge_D b2) + (a2 \vee_D b2)], a3 \wedge_D b3)$ $(a1, a2, a3) \vee_p (b1, b2, b3) = (0.6984; 0.0.22; 0.0156)$	0.8209

Assessment: It is on a sublevel closer to MSI than to I

The relationship of the subsets Payment mode [in its Diversity and innovation attribute (v41)] and Market [in its credibility attribute (v13)] is classified. A ranking is obtained with a degree closer to more important than important according to the plithogenic neutrosophic binding operator. Similarly, evaluations can be carried out for the rest of the subsystems, even between the different subsystems.

Conclusion

Electronic payment refers to the mode of payment that does not include physical cash or checks. Includes debit card, credit card, smart card, electronic wallet, etc. Now, Ecuadorian banking has undergone a significant transformation over time in terms of diversity and innovation. Developments in information and communication technology resulted in numerous innovations in Ecuador's payment system.

The payment systems described above offers a secure channel directly related to the transfer of credit/debit details for settlement in existing financial systems. This is also affected by transaction processing costs, ensuring that low-value transactions cannot be profitable. Recognized institutions can help in the adoption of online payment by providing a large installed base of customers.

This study has also found that these institutions play other crucial roles in online payment adoption. This results in the system gaining credibility and public awareness. Once this has been achieved, users evaluate the system based on factors such as simplicity, security, and reciprocity of benefits to stakeholders.

An electronic cash scheme, such as Visa, Mondex, and PayPal, offers the user the ability to pay to retailers and other consumers on the Internet, as well as on the high street, by phone, and at home. The payment requires no more participants than the taxpayer and the DAG, so it has no transaction processing fees and allows low-value transactions to be profitable. This uses inherent security mechanisms to ensure the security of transactions regardless of the transmission protocol used.

Electronic commerce on the Internet needs payment mechanisms that can serve as much diversity as real-world commerce. High-value transactions will require secure ways to use existing bank card mechanisms. In the end, in light of the success of the iTunes music store and the emergence of micropayments via mobile phones, it is necessary to re-examine the issue of micropayments.

The optimization capacity of neutrosophic logic was shown when integrating with plithogenic logic in decision-making. The advantages and generalization capacity of these proposals for decision-making and the management of the uncertainty generated by the systems were pointed out. It starts from the relevant characteristics of the plithogenic logic, highlights its high capacity to integrate the subsets Market, Technological means, Variable remuneration, and Mode of payment in each of its attributes.

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KPI and Logistics Dashboard Design Using Neutrosophic Statistics

Jorge Fernando Goyes García[1], Leonardo Humberto Carrión Hurtado[2], Mario Andrés León Naranjo[3] and Jenny Fernanda Enríquez Chugá[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: admfinanciero@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.leonardocarrion@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.marioleon@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.jennyenriquez@uniandes.edu.ec

Abstract. KPIs in logistics are key indicators to measure the evolution of the company and execute continuous improvement actions. This series of data, ratios, and percentages constitute a solid base on which to support our decision-making to achieve logistical excellence, by identifying with greater accuracy the opportunities for improvement to know the problem areas on time and understand the low yields. To ensure that the KPIs fulfill the purpose of generating a practical tool for all logistics professionals who wish to effectively control each of the operations that are implicit in the processes, their integration with the dashboards is necessary. This integration makes it possible to reflect through the graphic representation the KPIs involved in achieving the objectives of a strategy proposed by the company. In addition, this study allows an analysis through neutrosophic statistics and TOPSIS analysis to determine the factors that affect the delivery of products to the customer and determine the possible alternatives based on the use of the logistics KPIs integrated into the dashboard.

Keywords: Logistic KPIs, Neutrosophic Statistics, TOPSIS

1 Introduction

KPI stands for Key Performance Indicators, and its function is to provide indicators that allow measuring various aspects of a company [1], such as; production level, product quality controls [2], the economic and financial situation of the company, the performance of the workers in each of the activities entrusted [3], among others, which are related to the achievement of the organizational objectives of a company, since that is the reason for the study [4-6].

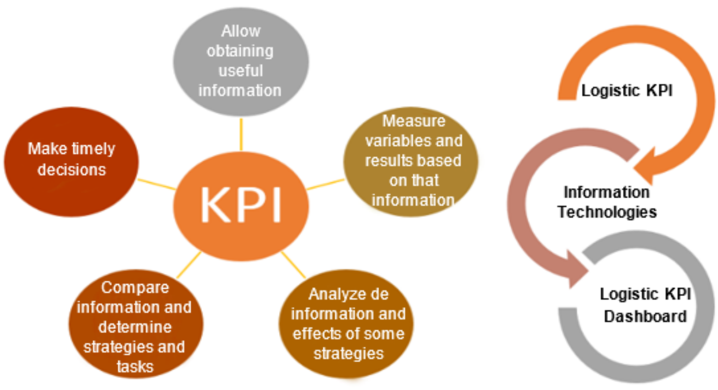

Figure 1. Advantages of KPIs and their integration into technology [7]

With the use of dashboards to visualize KPI metrics, you can get a clearer and more concrete view of what the financial situation of a company is and at what points you can improve production processes and/or administrative processes [7] since both are the ones that set the course of it and its success in the market [8]. For the selection of these parameters, the degree of linkage with the organization's objectives must be analyzed to carry out measurements based on a tangible goal [3, 9].

The KPIs on the dashboard provides strategies to entrepreneurs to boost a business and improve their capabilities in the market. In this sense, income will increase by benefiting partners and workers [4, 7, 10, 11].

Among the significant advantages of having the support of an expert in reading the KPIs [2], is that you will be able to immediately identify any fault detected through this instrument and will plan the most suitable way to attack and correct it, as well as select which are the KPIs with the most significant weight in the study [1]. Consequently, productivity will not be affected but reinforced by these proactive actions [12]. Regarding marketing, KPIs allow identifying in detail the factors that allowed the success or failure of a campaign [13], to improve or discard them for future campaigns [14].

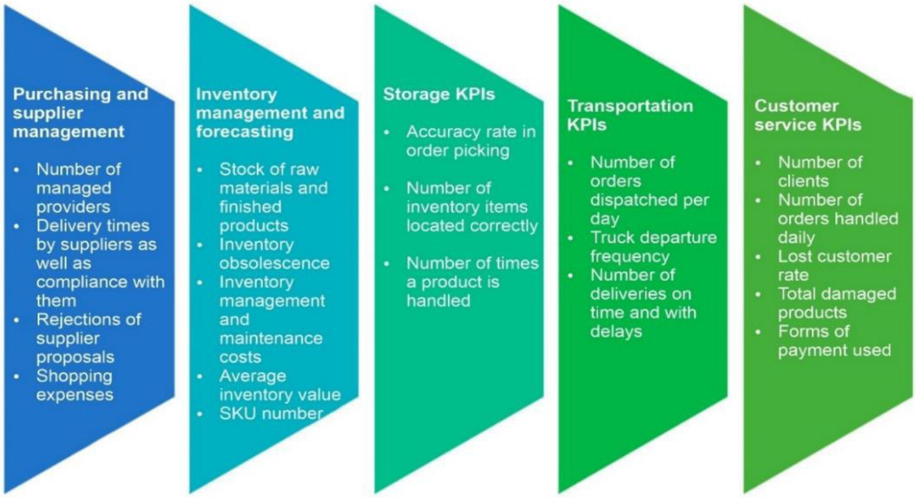

Figure 2. Logistics KPIs at each stage of the process. Source: [10]

The logistics process of a company is one of the most complex ones to monitor [15] since there are a large number of elements to take into account: different states in which the products are, geographical displacement, or stages that go through throughout the process [8, 16].

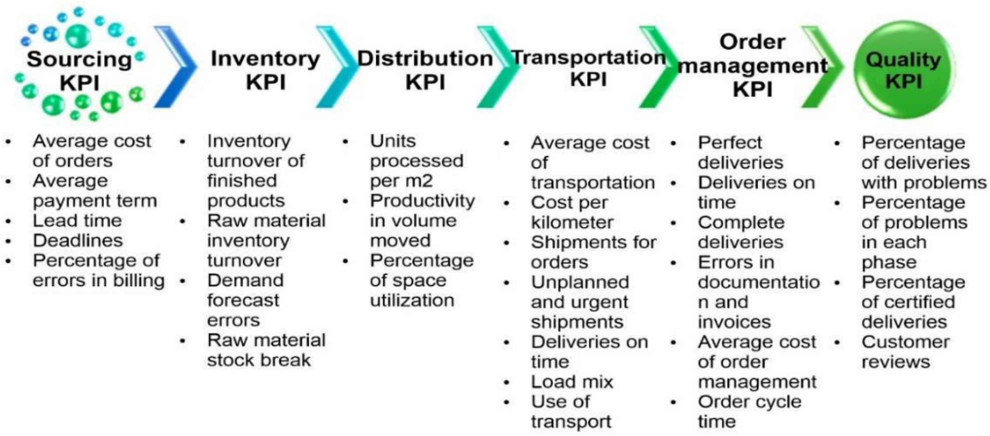

Figure 3. Logistics KPI based on its particularity and planned objective at each stage. Source: [17]

It should be noted that each logistics process has its peculiarities. Therefore, it is essential to set medium/long-term objectives [15, 18-21]. Moreover, the main objective of logistics KPIs is the rapid detection of any failure or deviation [7]. Thus, following up and continuously monitoring these indicators will help reduce costs and optimize the use of material and human resources during the development of the activity [14]. For the analysis of Logistics KPIs, this study defines:

- Problem situation: delays in product deliveries to customers
- The main objective: define the logistics KPI to detect possible deficiencies that influence delays in product deliveries to customers
- Specific objectives:

- Determine the factors that affect the variable analyzed
- Analyze logistics KPIs according to the stages of the process
- Carry out the measurement and modeling of the variable
- Project potential alternatives based on the company's strategy to achieve

From those above, the study is structured according to Figure 4 [22]. It should be taken into account that the analysis of the KPIs will be interrelated with the dashboards [11].

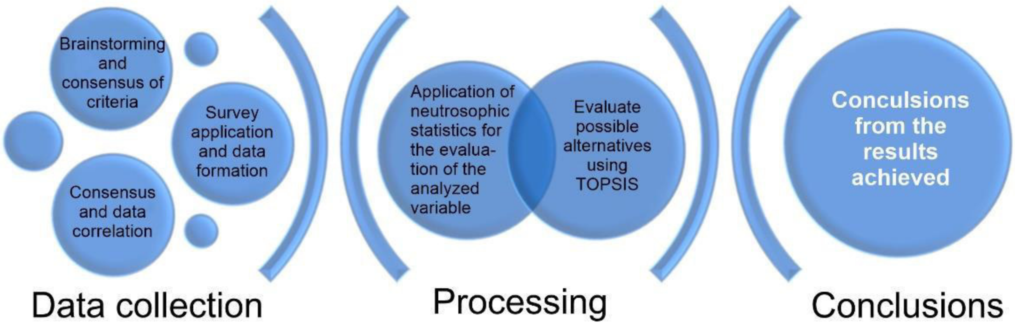

Figure 4. Development of the study of logistics KPIs. Source: Own elaboration.

2 Materials and methods

2.1 Neutrosophic statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that event E will occur, the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution[23], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [24]. In short, the Neutrosophic Logic, Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development. The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [25]. Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [26], while "I" is the indeterminacy part of the neutrosophic number.$N = a + bI$

The study of neutrosophic statistics refers to a neutrosophic random variable where y represents the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval. Following the neutrosophic mean of the variable when formulating:$X_l\, X_u I_N [I_l, I_u] (\bar{x}_N)$

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N} \sum_{i=1}^{n_N} X_{il}\ \bar{x}_b = \frac{1}{n_N} \sum_{i=1}^{n_N} X_{iu}\ n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral frames (NNS), it can be calculated as follows

$$\sum_{i=1}^{nN} (\bar{X} - \bar{X}_{iN})^2 = \sum_{i=1}^{nN} \begin{bmatrix} min \begin{pmatrix} (a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U) \\ (a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U) \end{pmatrix} \\ max \begin{pmatrix} (a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U) \\ (a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U) \end{pmatrix} \end{bmatrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{nN}(X_i - \bar{X}_{iN})^2}{{}^{n}N}; S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [27].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} X100;\ CV_N \in [CV_L, CV_U] \tag{5}$$

2.2 TOPSIS method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a technique characterized by its effectiveness and the simplicity of its principle in solving multi-criteria decision problems. The problem is to find the best-evaluated alternative [28]. In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution, and in turn, it is further away from the worst solution. It allows combining several heterogeneous attributes in a single dimensionless index, and this is because the attributes under evaluation are quite possibly expressed in different units or scales [28-46].

TOPSIS is based on the concept that the selected alternative must have the smallest Euclidean distance to an ideal solution and the greatest Euclidean distance to an anti-ideal solution [47]. Thus, the order of preference of the alternatives can be determined by a series of comparisons of these distances. Both solutions, the ideal and the anti-ideal, are fictitious solutions [27]. The ideal solution is a solution for which all the values of the attributes correspond to the optimal values of each attribute contained in the alternatives; the anti-ideal solution is the solution for which all the values of the attributes correspond to the least desired values of each attribute contained in the alternatives [26]. In this way, TOPSIS provides a solution that is the closest to a hypothetically better solution and the furthest from the hypothetically worst [48]. The process is described below:

1. Determine the objective and identify the attributes to evaluate.
2. Prepare a matrix based on the information available on the attributes. Each row corresponds to an alternative and each column to an attribute. The element in the array represents the non-normalized value of the attribute for the alternative.$x_j j_{th} i_{th}$
3. Calculate the normalized decision matrix. This is obtained by dividing each attribute value by the square root of the sum of the squares of each attribute value XJ. This is mathematically represented by equation (6):$R_{ij} x_j$
$$Rij = \frac{x_{ij}}{\sqrt{\sum_{m=1}^{k} x_{mj}^2}} \tag{6}$$
4. Determine the relative importance or weight for each attribute concerning the objective. This results in a set of weights w_j $(para\ j = 1,2,\dots,J)$ such that $\sum w_j = 1$. The weights are generally based on expert judgment and should reflect the relative importance assigned to the performance attributes evaluated. The range of possible values of w_j will only be limited by the ability of the decision group elements to distinguish the relative importance of the performance attributes analyzed. [26].
5. Obtain the normalized and weighted matrix. This is done by multiplying each element in the columns of the matrix by its corresponding weight. Therefore, the elements of the normalized and weighted matrix are expressed by equation 7:$V_{ij} R_{ij} w_j$
$$V_{ij} = w_j * R_{ij} \tag{7}$$
6. Obtain the ideal solution and the anti-ideal: The ideal solution can be expressed as (8) and anti-ideal (9). indicates the ideal value of the attribute considered among the values of the attributes for the different alternatives, while it indicates the worst value of the attribute considered among the values of the attributes for the different alternatives $V_j^+ V_j^-$[27].
$$V^+ = \{V_1^+, V_2^+, V_3^+, \dots, V_j^+\} \tag{8}$$
$$V^- = \{V_1^-, V_2^-, V_3^-, \dots, V_j^-\} \tag{9}$$
7. Calculate the Euclidean distances of each alternative to the ideal and anti-ideal solutions using the following equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^+)^2} \quad (10)$$

$$D_i^- = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^-)^2} \quad (11)$$

8. The relative closeness Pi of a particular alternative to the ideal solution is expressed by (12):

$$P_i = \frac{D_i^-}{(D_i^+ + D_i^-)} \quad (12)$$

9. In this step, a set of alternatives is generated in descending order according to the value of Pi, with the best alternative being the one with the highest value of Pi.
10. In this article, linguistic terms will be associated with SVNN, in such a way that the experts can carry out their evaluations according to the corresponding scale (Table 1).

Linguistic term	**SVNN**
Very Weak (VW)	(0.10, 0.75, 0.85)
Weak (W)	(0.25, 0.60, 0.80)
Medium Weak (MW)	(0.40, 0.70, 0.50)
Medium (M)	(0.50, 0.40, 0.60)
Medium Strong (MS)	(0.65, 0.30, 0.45)
Strong (S)	(0.80, 0.10, 0.30)
Very Strong (VS)	(0.95, 0.05, 0.05)

Table 1: Linguistic terms according to the strength of the weight in the alternatives

3 Results

3.1 Data collection

Once the different approaches have been analyzed in the introduction of the document, we apply the techniques above, as follows for a company that aims to deliver and distribute products with a certain level of fragility.

Variable analyzed: product delivery For a sample of n = 150, for each factor (f)

Code	**Initials**	**Factors that affect the compliance and quality of deliveries**
a	LARM	Late arrival of raw materials
p	IHP	Incorrect handling of the product
c	BDTC	Breach of delivery times to the customer
d	DP	Damaged products
o	IO	Inventory obsolescence

Table 2. Determining factors in product delivery

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to relate to the correct use of logistic KPIs. For each Logistics KPI group, an impact is analyzed in days that make up the logistics impacts in the efficient delivery of products for each factor.

Days	**Neutrosophic frequencies**				
	LARM	**IHP**	**BDTC**	**DP**	**IO**
1	[1 ; 2]	[1 ; 2]	[0 ; 0]	[0 ; 0]	[0 ; 1]
2	[1 ; 2]	[0 ; 0]	[0 ; 1]	[0 ; 0]	[0 ; 1]
3	[1 ; 1]	[0 ; 0]	[1 ; 2]	[1 ; 1]	[1 ; 1]
4	[0 ; 0]	[1 ; 1]	[1 ; 2]	[0 ; 1]	[1 ; 1]

5	[1 ; 1]	[1 ; 1]	[0 ; 1]	[0 ; 1]	[1 ; 2]
6	[1 ; 1]	[0 ; 0]	[1 ; 2]	[1 ; 1]	[1 ; 1]
7	[1 ; 1]	[1 ; 2]	[0 ; 1]	[0 ; 0]	[1 ; 1]
8	[0 ; 0]	[0 ; 1]	[1 ; 2]	[0 ; 0]	[1 ; 1]
9	[1 ; 2]	[0 ; 1]	[0 ; 0]	[0 ; 1]	[1 ; 2]
10	[1 ; 2]	[1 ; 1]	[0 ; 1]	[0 ; 0]	[1 ; 1]
11	[1 ; 2]	[0 ; 0]	[0 ; 0]	[0 ; 1]	[0 ; 0]
12	[1 ; 2]	[0 ; 1]	[0 ; 0]	[0 ; 0]	[1 ; 1]
13	[0 ; 0]	[1 ; 1]	[1 ; 1]	[0 ; 0]	[0 ; 0]
14	[1 ; 1]	[0 ; 1]	[1 ; 2]	[0 ; 1]	[0 ; 1]
15	[0 ; 0]	[0 ; 0]	[0 ; 1]	[1 ; 1]	[1 ; 2]
16	[1 ; 1]	[1 ; 2]	[1 ; 1]	[1 ; 2]	[1 ; 1]
17	[0 ; 0]	[1 ; 1]	[1 ; 1]	[1 ; 2]	[0 ; 1]
18	[1 ; 2]	[0 ; 1]	[0 ; 1]	[0 ; 0]	[0 ; 1]
19	[0 ; 0]	[0 ; 1]	[1 ; 2]	[1 ; 1]	[1 ; 1]
20	[1 ; 1]	[1 ; 1]	[1 ; 1]	[0 ; 1]	[1 ; 2]
1-150	**[83 ; 159]**	**[73 ; 140]**	**[72 ; 147]**	**[75 ; 155]**	**[83 ; 150]**

Table 3. Factors affecting order fulfillment and quality

Table 1 studies the factor effects on compliance and quality of deliveries by the logistics part for 150 days, with an occurrence level of [0; 2] for each factor per day with a total indeterminacy level of a = 76, p = 67, c = 75, d = 80, or = 67, with a level of representativeness of [44.66%; 51.61%], on the days that 2 effects per factor are registered, with a higher incidence of 50% in non-compliance with delivery times to the customer and products damaged by improper handling. As a result of the existing indeterminacy, the use of classical statistics is not possible, so it is necessary to use neutrosophic statistics for its better understanding.

3.2 Neutrosophic statistical analysis

The modeling of the data of affectations that influence the delivery of the orders to be controlled by each group of logistics KPIs (table 2). To understand which factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated and for the study of the variations of the affectations, the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$.. To determine which affectation requires a higher incidence of the logistic KPIs, the values are calculated $CV_N \in [CV_L ; CV_U]$

Factors	$\bar{x}_N$	***SN***	***CVN***
Breach of supply delivery times by the supplier	[0.553 ; 1.06]	[0.126 ; 0.988]	[0.228 ; 0.932]
Incorrect handling of the product	[0.487 ; 0.933]	[0.125 ; 1.015]	[0.257 ; 1.088]
Breach of delivery times to the customer	[0.48 ; 0.98]	[0.125 ; 0.965]	[0.26 ; 0.985]
Damaged products	[0.5 ; 1.033]	[0.125 ; 1.028]	[0.25 ; 0.995]
Inventory obsolescence	[0.553 ; 1]	[0.126 ; 1.018]	[0.228 ; 1.018]

Table 4. Neutrosophic statistical analysis of incidents in orders

Table 4 shows that non-compliance with delivery times for supplies by the supplier has higher incidence values than the other factors. This means that for the IPEP factor it is on average the one that most affects the fulfillment of order deliveries. In affirmation, the value for this factor is lower compared to the rest. This represents that the result of non-compliance with the delivery dates of the supplies by the supplier has a negative and more significant impact than the other factors in the delivery of the products to the customer (Figure 5).

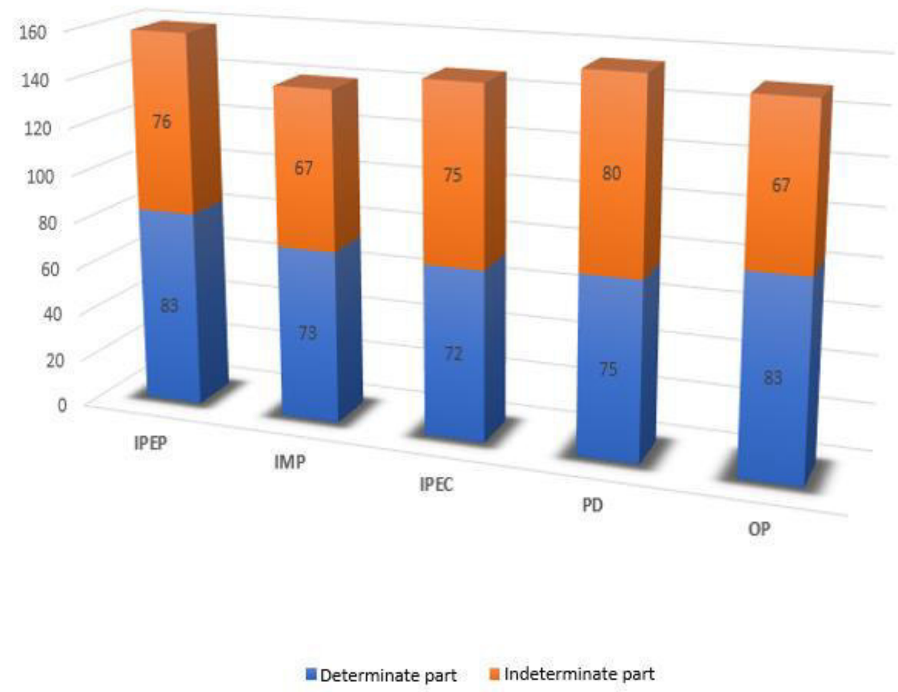

Figure 5. Neutrosophic bar graph of order incidences

3.3 Comparative analysis

To determine the associated referent indeterminacy measure for the form of neutrosophic numbers (Table 5). In the results obtained, it is observed that for the values they go from $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U] CV_N \in [CV_L\ ;\ CV_U] CV_N$0.228 to 0.932 with the indeterminacy measure 75.5 generates a negative impact to comply with the deliveries in the agreed time, as its influence on the other affectations. Logistics KPIs are required to focus on a higher level of monitoring on Supply KPIs.

Factors	$\bar{x}_N$	*SN*	*CVN*
LARM	0.553 + 1.06 I; I ∈ [0; 0.47]	0.126 + 0.988 I; I ∈ [0; 0.87]	0.228 + 0.932 I; I ∈ [0; 0.755]
IHP	0.487 + 0.933 I; I ∈ [0; 0.47]	0.125 + 1.015 I; I ∈ [0; 0.87]	0.257 + 1.088 I; I ∈ [0; 0.76]
BDTC	0.48 + 0.98 I; I ∈ [0; 0.51]	0.125 + 0.965 I; I ∈ [0; 0.87]	0.26 + 0.985 I; I ∈ [0; 0.73]
DP	0.5 + 1.033 I; I ∈ [0; 0.51]	0.125 + 1.028 I; I ∈ [0; 0.87]	0.25 + 0.995 I; I ∈ [0; 0.74]
IO	0.553 + 1 I; I ∈ [0; 0.44]	0.126 + 1.018 I; I ∈ [0; 0.87]	0.228 + 1.018 I; I ∈ [0; 0.77]

Table 5. Neutrosophic forms with the measure of indeterminacy

TOPSIS analysis

To determine the possible alternatives based on using the supply KPI more in line with the given situation, the TOPSIS modeling is used. The strategies to be evaluated are focused on monitoring the supply KPIs integrated into the dashboard and highlighting the following parameters:

- Delivery times. Analysis between the supplier and the company
- Balance between supply and demand. Monitor between what is demanded by the client and what is offered
- Lead time. Monitor the times from the supplier to the warehouse, first stage
- Managed providers. Analysis of suppliers managed to meet demand
- Quality of raw materials. Analysis of the quality management process in the supply stage
- Shopping Costs. Analysis of the costs for the acquisition of raw material

The results are shown in the following tables:

Alternatives	Purchasing and supplier management necessary	Inventory management and forecasting	Storage KPIs	Transportation KPIs	Customer service KPIs	Marketing KPI
Delivery times	(0,95; 0,05; 0,05)	(0,95; 0,05; 0,05)	(0,25; 0,60; 0,80)	(0,95; 0,05; 0,05)	(0,95; 0,05; 0,05)	(0,80; 0,10; 0,30)
Balance between supply and demand	(0,65; 0,30; 0,45)	(0,80; 0,10; 0,30)	(0,50; 0,40; 0,60)	(0,65; 0,30; 0,45)	(0,65; 0,30; 0,45)	(0,65; 0,30; 0,45)
Lead time	(0,95; 0,05; 0,05)	(0,25; 0,60; 0,80)	(0,25; 0,60; 0,80)	(0,95; 0,05; 0,05)	(0,95; 0,05; 0,05)	(0,95; 0,05; 0,05)
Managed providers	(0,65; 0,30; 0,45)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0,80; 0,10; 0,30)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
Quality of raw materials	(0,95; 0,05; 0,05)	(0,80; 0,10; 0,30)	(0,25; 0,60; 0,80)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
Shopping Costs	(0,95; 0,05; 0,05)	(0,65; 0,30; 0,45)	(0,50; 0,40; 0,60)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)

Table 6. Table of the weights assigned by the experts to each criterion

Alternatives	Purchasing and supplier management necessary	Inventory management and forecasting	Storage KPIs	Transportation KPIs	Customer service KPIs	Marketing KPI
Delivery times	0.12909	0.03907	0.08025	0.01111	0.01252	0.12867
Balance between supply and demand	0.19466	0.04639	0.04494	0.01676	0.01888	0.16339
Lead time	0.19466	0.01367	0.04494	0.01676	0.01888	0.19402
Managed providers	0.12909	0.00781	0.02568	0.01411	0.00318	0.03268
Quality of raw materials	0.19466	0.03907	0.04494	0.00282	0.00318	0.03268
Shopping Costs	0.19466	0.03077	0.08025	0.00282	0.00318	0.03268

Table 7. Weighted normalized matrix

Alternative	d-	d +	Ri	Order
Delivery times	0.05099	0.06597	0.43595	5
Balance between supply and demand	0.11550	0	1	1
Quality of raw materials	0.11198	0.03272	0.77387	4
Managed providers	0.04739	0.07607	0.38385	6
Lead time	0.11391	0.00732	0.93957	2
Shopping Costs	0.11265	0.01562	0.87818	3

Table 8. Matrix of distances and calculation of Ri for each of the alternatives

According to the results we obtained, it is preferred to enhance alternative 1, monitoring between supply and demand, or alternative 2, lead time, depending on the deficiency to be eradicated (figure 6). The preferred variants to determine and monitor the times in the first stage before reaching the warehouse to improve the precision of the movement of the products from the warehouse to the customer.

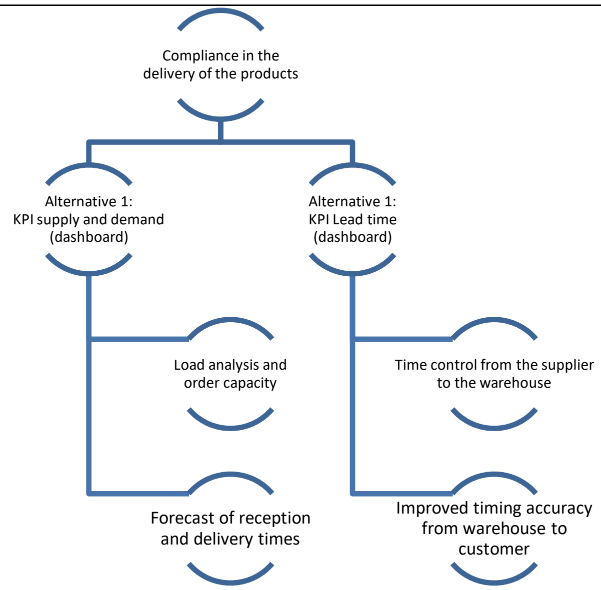

Figure 6. Alternatives implementation priorities.

Conclusions

- Logistics KPIs are highly recognized internationally by companies and institutions, for the level of information they provide in decision-making. The KPIs integrated with the dashboard illustrate the company's log by providing relevant information objectively and truthfully about all the processes that make up the chain. KPIs must be measurable, quantifiable, specific, temporary, and measurable.
- The analysis of the data made to the company determined deficiencies that in the form of a chain reaction affect the deliveries of the products delivered to the customer. When determining the factors that affect the process, the use of neutrosophic statistics is chosen due to the degree of indeterminacy in the analyzed variable, as it is not resolved by classical statistics.
- The neutrosophic statistical analysis shows a lower CV value for the late arrival of raw materials, as a key factor in the fulfillment of product deliveries to the customer. By integrating the result with TOPSIS, it seeks to promote alternatives to improve control in the supply stage, using the KPI of supplies integrated with the dashboard. Among the alternatives to apply, we have: monitoring between supply and demand or lead time according to the objective to be achieved.

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Prioritization of Software Requirements Using Neutrosophic TOPSIS

Fredy Pablo Cañizares Galarza[1], Nelson Patricio Becerra Arévalo[2], Edmundo José Jalón Arias[3], and Jorge Lenin Acosta Espinoza[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.fredycanizarez@uniandes.edu.ec

[2] Docente de la carrera de Sistemas. Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.nelsonbecerra@uniandes.edu.ec

[3] Coordinador de la carrera de Sistemas. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.edmundojalon@uniandes.edu.ec

[4] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.jorgeacosta@uniandes.edu.ec

Abstract. Prioritizing software requirements is one of the most significant and complex tasks for software developers. It involves a multi-criteria decision process to balance the benefit of each requirement and its cost, considering different factors and dimensions, many of which are qualitative. Although numerous prioritization methods have been developed to date, the appropriate treatment in cases of the uncertainty and indeterminacy inherent in human decisions is limited. In the present work, the neutrosophic TOPSIS is proposed as a method of prioritizing requirements. This multi-criteria and multi-expert method uses linguistic terms associated with Single Value Neutrosophic Sets and allows the inclusion of aspects such as the importance of the criteria and the weight of expert evaluations. A case study is used to show the applicability of the proposal.

Keywords: Requirements prioritization, neutrosophic TOPSIS, SVNS, requirements engineering.

1 Introduction

The quality of the software is a fundamental element to guarantee the success of a software project, which is why it is considered an essential competitive factor in the companies that develop it [1]. The ISO/IEC 8402: 1994 standard defines software quality as the totality of characteristics that make it capable of satisfying established or implicit customer needs [7]. This concept encompasses various characteristics such as security, availability, and performance, which are usually organized under the structure of quality models, defined in turn as the specification of the required characteristics that a software system must exhibit [3].

To improve and ensure quality, it is necessary to formalize it in requirements right from the beginning. A correct definition and analysis of the requirements is one factor contributing to the success of software projects [4]. The prioritization of requirements is a complex decision-making process through which it is determined which functionalities are adequate to include in each release of the software product to be developed [10]. Numerous authors have treated it as one of the activities with the highest levels of complexity in Requirements Engineering and essential for the success of projects [5].

Requirements Engineering has been considered since the '90s as an essential process in systems development and especially in the development of software systems. Decisions made during these early stages of development are crucial and difficult since information is incomplete, imprecise, and subject to numerous changes [11]. Furthermore, these decisions are fundamental, since they will significantly influence the entire life cycle of the software system [13].

The prioritization of requirements is a complex decision-making process through which it is determined which functionalities are adequate to include in each release of the software product to be developed [10]. Projects generally have more candidate requirements than time, and cost constraints allow them to implement. The PR helps to identify the sets that are critical to the project's success, those that will be located in the first releases, leaving the trivial ones for later deliveries. This allows ordering the total set of requirements, allowing the formation of subsets and their assignment to each release [4].

In the initial stages of a software development project, the requirements are generally imprecise. As the project progresses and the understanding of the product grows, the requirements are specified in detail. Requirements prioritization is a process that can be done at different times in the life cycle, with requirements at different levels of abstraction.

The requirements are prioritized taking into account different variables, imposed by the needs and context of the organizations. According to the analyzed bibliography, we have value, importance, unfavorable effects, cost, time, risk, volatility, and customer satisfaction among the most used variables.

Although different methods have been proposed for the prioritization of requirements, among which the use of aggregation operators to merge the information [5, 10], and the techniques Numerical Assignment, MoSCoW, Priority Groups, Bubble Sort stand out. Binary Search Tree, AHP, Hundred Dollar, and Minimal Spanning Tree [6], these methods show the lack of treatment of uncertainty and the indeterminacy of human evaluations and decision-making.

This work aims to present a method for the prioritization of requirements based on the multi-criteria and multi-expert decision method TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) in its neutrosophic variant [2, 8]. Its effectiveness characterizes this technique and the simplicity of its principle in solving multi-criteria decision problems where the selection is based on finding the alternative closest to the ideal solution and moves further away to the worst solution.

The neutrosophic variant of TOPSIS is based on Neutrosophy. Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities. Logic and neutrosophic sets constitute generalizations of Zadeh's logic and fuzzy sets of Atanassov's intuitionist logic [9]. Incorporating the neutrosophic sets into TOPSIS ensures that uncertainty and indeterminacies are taken into account. Experts will evaluate in linguistic rather than numerical terms, which is a more natural form of measurement for humans.

A case study is used to demonstrate the applicability of the Neutrosophic TOPSIS for the prioritization of software requirements.

2 Materials and methods

This section details the main concepts and techniques that will be used in this study. Let X be a universe of discourse, a Single Value Neutrosophic Set (SVNS) A over X has the following form [12-24]:

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d \quad (1)$$

Where $u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ v_a(x): X \to [0,1]$

With $0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \forall\, x \in X$

The intervals denote the memberships to true, indeterminate, and false from x in A, respectively. $u_a(x), r_a(x)$ y $v_a(x)$. For convenience a SVNS will be expressed as A = (a, b, c), where a, b, c ∈ [0.1] and satisfies 0 ≤ a + b + c ≤ 3. The SVNS arose with the idea of applying the neutrosophic sets for practical purposes. Some operations between SVNS are expressed below:

1. Let $A_1 = (a_1, b_1, c_1)$ and $A_2 = (a_2, b_2, c_2)$ ∈SVNS, the sum between A_1 y A_2 is defined by:
   $A_1 \oplus A_2 = (a_1 + a_2 - a_1a_2, b_1b_2, c_1c_2)$
   (2)
2. Let $A_1 = (a_1, b_1, c_1)$ and $A_2 = (a_2, b_2, c_2)$ ∈ SVNS the multiplication between A_1 y A_2 is defined by:
   $A_1 \otimes A_2 = a_1a_2, b_1 + b_2 - b_1b_2, c_1 + c_2 - c_1 + c_2)$
   (3)
3. The product by a positive scalar $\lambda \in \Re$ with SVNS, A = (a, b, c) is defined by:
   $\lambda A = \left(1 - (1-a)^{\lambda}, b^{\lambda}, c^{\lambda}\right)$
   (4)
4. Let $\{A_1, A_2, \ldots, A_n\}$∈ SVNS(x), where $A_j = (a_j, b_j, c_j)$ (j = 1, 2, …, n), then, the Single Valued Neutrosophic Weighted Average Operator is defined by:
   $P_w(A_1, A_2, \ldots, A_n) = \langle 1 - \prod_{j=1}^{n}\left(1 - T_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(I_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(F_{A_j}(x)\right)^{w_j}\rangle$
   (5)
   Where: $w = (w_1, w_2, \ldots, w_n)$ is vector of $A_j (j = 1,2, \ldots, n)$ such that $w_n \in [0,1]$ y $\sum w_j = 1$.
5. Let A = (a, b, c) be a single neutrosophic number, a score function S of a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and falsity membership degree is defined by:
   $S(A) = \frac{1+a-2b-c}{2}$
   (6)
   Where $S(A) \in [-1,1]$
6. Let a vector SVNS such that and are vectors such that then Distance measure between and is as follows: $A^* = (A_1^*, A_2^*, \ldots, A_n^*) A_j^* = (a_1^*, b_2^*, c_2^*)(j = 1,2, \ldots, n)\ B_i = (B_{i1}, B_{i2}, \ldots, B_{im})\ (i = 1,2, \ldots, m) m B_{ij} = \left(a_{ij}, b_{ij}, \ldots, c_{ij}\right)\ (i = 1,2, \ldots, m)(j = 1,2, \ldots, n), B_i A^*$

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^*\right)^2 + \left(b_{ij} - b_j^*\right)^2 + \left(c_{ij} - c_j^*\right)^2\right\}\right)^{\frac{1}{2}} \quad (7)$$

The TOPSIS method for SVNS consists in that, assuming it is a set of alternatives and it is a set of criteria, the following steps will be carried out [2]:$A = \{\gamma_1, \gamma_2, \dots, \gamma_m\} B = \{\delta_1, \delta_2, \dots, \delta_n\}$

1. Determine the weight of the experts

To determine the weight of the experts, the selected specialists self-assess their level of knowledge on the subject according to a linguistic scale associated with SVNS values. Table 1 shows the linguistic scales to be used for the self-assessment of the experts with their associated SVNS.

Linguistic term	Evaluation	SVNS
Extremely high	EH	(1,0,0)
Very very high	VVH	(0.9, 0.1, 0.1)
Very high	VH	(0.8, 0.15, 0.20)
High	H	(0.70,0.25,0.30)
Little high	LH	(0.60, 0.35, 0.40)
Medium	M	(0.50, 0.50, 0.50)
Between low and medium	ML	(0.40, 0.65, 0.60)
Low	L	(0.30,0.75,0.70)
Very low	VL	(0.20, 0.85, 0.80)
Very very low	VVL	(0.10,0.90,0.90)
Extremely low	EL	(0; 1; 1)

Table 1. Linguistic terms and their SVNS for step 1.

If it is the SVNS corresponding to the t-th decision-maker (t = 1, 2,…, k), the weight of each expert is calculated by the following formula:$A_t = (a_t, b_t, c_t)$

$$\lambda_t = \frac{a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)}{\sum_{t=1}^{k} a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)} \quad (8)$$

where: $\lambda_t \geq 0$ y = $1\sum_{t=1}^{k} \lambda_t$

2. Construction of the neutrosophic decision matrix of aggregated unique values

This matrix is defined by, where, and used to aggregate all individual assessments.$D = \sum_{t=1}^{k} \lambda_t d_{ij} d_{ij} = (a_{ij}, b_{ij}, c_{ij})$. According to each criterion, the expert evaluations of each decision are also made based on a scale of linguistic terms associated with SVNS. Table 2 shows the scale to use in this case.

Linguistic term	Evaluation	SVNS
Extremely important	EI	(1,0,0)
Very very important	VVI	(0.9, 0.1, 0.1)
Very important	VI	(0.8, 0.15, 0.20)
Important	I	(0.75,0.25,0.30)
Medium	M	(0.50, 0.50, 0.50)
Less important	LI	(0.40, 0.65, 0.70)
Almost nothing important	ANI	(0.25,0.75,0.80)
Not important	NI	(0; 1; 1)

Table 2. Linguistic terms and their SVNS for step 2.

Once the evaluations offered by the experts have been obtained, it is calculated as the aggregation of the evaluations given by each expert, using the weights of each one with the help of equation 5.$d_{ij}\ \left({a_{ij}}^t, {b_{ij}}^t, {c_{ij}}^t\right)$

In this way, a matrix D = is obtained, where each is an SVNS (i = 1,2, .., m; j = 1,2,…, n).$\left(d_{ij}\right)_{ij} d_{ij}$

3. Determination of the Weight of the criteria

Suppose that the weight of each criterion is given by where it denotes the relative importance of the criterion. If it is the evaluation of the criterion by the t-th expert. $W = (w_1, w_2, \dots, w_n), w_j\ \delta_j w_j^t = a_j^t, b_j^t, c_j^t \delta_j$. Then the aggregation function of equation (5) is used to add the weights.$w_j^t\ \lambda_t$

4. Construction of the neutrosophic decision matrix of the weighted mean of unique values with respect to the criteria

$D^* = D \otimes W$, where $d_{ij}^* = W_j \otimes d_{ij} = (a_{ij}, b_{ij}, c_{ij})$ (9)

5. Calculation of the ideal positive and negative SVNS solutions

The criteria can be classified as cost type or benefit type. Let Δ_1 be the set of criteria type benefits and Δ_2 criteria type cost. The ideal alternatives will be defined as follows:

$\gamma^+ = \left(a_{\gamma^+w}(\delta_j), b_{\gamma^+w}(\delta_j), c_{\gamma^+w}(\delta_j)\right)$ (10)

Denote the positive ideal solution corresponding to G_1

$\gamma^- = \left(a_{\gamma^-w}(\delta_j), b_{\gamma^-w}(\delta_j), c_{\gamma^-w}(\delta_j)\right)$ (11)

Denote the negative ideal solution, corresponding to G_2

Where

$$a_{\gamma^+w}(\delta_j) = \begin{cases} max_i a_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_1 \\ min_i a_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (12)$$

$$b_{\gamma^+w}(\delta_j) = \begin{cases} min_i b_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_1 \\ max_i b_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (13)$$

$$c_{\gamma^+w}(\delta_j) = \begin{cases} min_i c_{\gamma_i w}(\delta_j), & si \ j \in \Delta_1 \\ max_i c_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (14)$$

$$a_{\gamma^-w}(\delta_j) = \begin{cases} min_i a_{\gamma_i w}(\delta_j), & \text{si} \ \ j \in \Delta_1 \\ max_i a_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (15)$$

$$b_{\gamma^-w}(\delta_j) = \begin{cases} max_i b_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_1 \\ min_i b_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (16)$$

$$c_{\gamma^-w}(\delta_j) = \begin{cases} max_i c_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_1 \\ min_i c_{\gamma_i w}(\delta_j), & si \ \ j \in \Delta_2 \end{cases} \quad (17)$$

6. Calculation of the distances to the ideal positive and negative SVNS solutions

The distances to the ideal positive and negative SVNS solutions are calculated with the help of Equation (7), leaving the following expressions:

$$s_i^+ = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2\right\}\right)^{\frac{1}{2}} \quad (18)$$

$$s_i^- = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2\right\}\right)^{\frac{1}{2}} \quad (19)$$

7. Calculation of the Proximity Coefficient (PC)

The PC of each alternative is calculated concerning the positive and negative ideal solutions.

$$\tilde{\rho}_j = \frac{s^-}{s^+ + s^-} \quad (20)$$

Where: $0 \leq \tilde{\rho}_j \leq 1$

8. Determination of the order of the alternatives

As in the classical method, the alternatives are ordered in descending order, starting with the one that most closely approximates the ideal solution (greater relative proximity). The selected case study consists of prioritizing five requirements (Ri) belonging to an information system of a software project. The criteria to be taken into account for prioritization were established as 1) technical difficulty, 2) cost, 3) risk, and 4) value for the project.

3 Results

As a result of the first step, the experts' self-assessments on their level of knowledge in software development were obtained. Their evaluations and corresponding weights are shown in table 3.

Expert	1	2	3	4	5	6	7	8	9	10
Evaluation	VVH	VH	VH	VVH	VVH	VVH	VH	EH	VVH	VH
λ_t	0.103	0.096	0.096	0.103	0.103	0.103	0.096	0.104	0.103	0.096

Table 3. Results of the experts' weight determination

The matrices of the expert evaluations of each requirement according to each criterion are shown in tables 4, 5, 6, and 7.

Requirement	Expert									
	1	2	3	4	5	6	7	8	9	10
R1	VI	VI	VI	VI	VI	VVI	VI	VI	VVI	I
R2	VI	VI	VI	I	VI	VI	VI	VI	VVI	VI
R3	VI	VI	VI	I	I	VI	VI	VI	I	VI
R4	VI	VI	VI	VVI	VVI	VI	VVI	VI	VI	VI
R5	VI	VI	VI	VI	VI	VVI	VI	VI	VI	VI

Table 4. Evaluation of requirements by experts in terms of the criterion *Technical difficulty*

Requirement	Expert									
	1	2	3	4	5	6	7	8	9	10
R1	VI	VI	VVI	VI	VI	VI	VVI	VI	VI	I
R2	I	I	M	I	I	I	I	VI	I	VI
R3	VI	VVI	VI	VI	VI	VI	VI	VI	VI	VI
R4	VI	VI	VVI	VI	I	VI	VI	VI	VI	VI
R5	I	I	VI	I	I	VI	I	I	I	I

Table 5. Evaluation of requirements by experts in terms of the criterion *Cost*

Requirement	Expert									
	1	2	3	4	5	6	7	8	9	10
R1	VI	VI	VI	VI	VI	VI	VVI	VI	VVI	VVI
R2	I	I	I	I	I	I	I	I	VI	I
R3	VI	VI	VI	VI	VI	I	VI	VVI	VI	VI
R4	VI	I	VI	VI	VI	VI	I	VI	VI	VVI
R5	VI	VVI	VI	VVI	VI	VVI	VI	VI	VI	VI

Table 6. Evaluation of requirements by experts in terms of the criterion *Risk*

Requirement	**Expert**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
R1	VVI	VVI	VVI	VI	VI	VVI	VVI	VI	VVI	VVI
R2	I	M	I	I	I	I	I	I	I	I
R3	VI	VVI	VVI	VI	VI	VI	VI	VVI	I	VI
R4	VI	VI	I	VI	VI	I	VI	VI	VI	VI
R5	VI	I	VI	VI	VI	VI	VI	VI	VI	I

Table 7. Evaluation of requirements by experts in terms of the criterion *Value to the project*

From the SVNS associated with the linguistic variables used, the evaluations given by the experts were added to each requirement according to each criterion (See table 8).

Requirement	**Criterion**			
	Technical difficulty	***Cost***	***Risk***	***Value to the project***
R1	(0.823, 0.145, 0.18)	(0.821, 0.146, 0.182)	(0.837, 0.133, 0.163)	(0.876, 0.113, 0.124)
R2	(0.809, 0.152, 0.194)	(0.745, 0.241, 0.291)	(0.756, 0.237, 0.288)	(0.733, 0.267, 0.315)
R3	(0.786, 0.176, 0.227)	(0.813, 0.144, 0.187)	(0.81, 0.152, 0.194)	(0.833, 0.14, 0.17)
R4	(0.838, 0.133, 0.162)	(0.808, 0.152, 0.195)	(0.805, 0.159, 0.202)	(0.791, 0.166, 0.217)
R5	(0.814, 0.144, 0.186)	(0.761, 0.226, 0.277)	(0.838, 0.133, 0.162)	(0.791, 0.165, 0.216)

Table 6. Neutrosophic decision matrix of single aggregated values

The weight of the criteria was then determined. The weight that the experts assigned to each criterion appears in Table 9.

Criterion	Expert									
	1	2	3	4	5	6	7	8	9	10
Technical difficulty	VI	VVI	VI	VI	VI	VI	VI	VI	I	VI
Cost	I	VI	I	VI	I	I	I	I	I	VI
Risk	VI	VI	VI	VVI	VI	VI	VI	VI	VI	VVI
Value to the project	I	I	VI	VI	M	I	I	I	I	I

Table 9. Evaluation of the weight of each criterion according to the experts

Through aggregation, the weight of the criteria expressed in SVNS was calculated, as shown in Table 10.

Criterion	Weight (SVNS)
Technical difficulty	(0.81, 0.15, 0.2)
Cost	(0.77, 0.22, 0.27)
Risk	(0.83, 0.14, 0.17)
Value to the project	(0.74, 0.24, 0.29)

Table 10. Weight of criteria

The neutrosophic decision matrix was constructed from the weighted mean of unique values with respect to the criteria (step 4), as shown in Table 11.

Requirement	Criterion			
	Technical difficulty	*Cost*	*Risk*	*Value to the project*
R1	(0.665, 0.265, 0.34)	(0.558, 0.429, 0.454)	(0.691, 0.253, 0.309)	(0.651, 0.328, 0.38)
R2	(0.654, 0.281, 0.351)	(0.57, 0.404, 0.479)	(0.624, 0.343, 0.412)	(0.545, 0.445, 0.515)
R3	(0.635, 0.301, 0.378)	(0.623, 0.328, 0.404)	(0.668, 0.269, 0.335)	(0.619, 0.349, 0.412)
R4	(0.677, 0.265, 0.326)	(0.619, 0.335, 0.409)	(0.664, 0.275, 0.341)	(0.588, 0.368, 0.445)
R5	(0.658, 0.274, 0.345)	(0.583, 0.392, 0.469)	(0.692, 0.253, 0.308)	(0.588, 0.368, 0.445)

Table 11. Weighted aggregate decision matrix.

The ideal positive and negative SVNS solutions calculated in step 5 are shown in Table 12.

Criterion	Positive ideal value	Negative ideal value
Technical difficulty	(0.677, 0.265, 0.326)	(0.635, 0.301, 0.378)
Cost	(0.623, 0.328, 0.404)	(0.558, 0.429, 0.479)
Risk	(0.692, 0.253, 0.308)	(0.624, 0.343, 0.412)
Value to the project	(0.651, 0.328, 0.38)	(0.545, 0.445, 0.515)

Table 12. SVNS positive and negative ideal solutions by criteria.

The distances to the ideal positive and negative SVNS solutions, as well as the Proximity Coefficient (PC) and the resulting order of the requirements, are shown in table 13.

Requirement	d +	d-	Pc	Order
R1	0.075656582	0.153348908	0.330370169	4
R2	0.165651411	0.027118707	0.859321001	1
R3	0.043823603	0.08169519	0.349139776	3
R4	0.005244914	0.088172458	0.056144951	5
R5	0.147150174	0.140844952	0.51094675	2

Table 11. Distances to ideal solutions, proximity coefficient, and order of alternatives

The order of priority resulting from the requirements is, therefore: R2> R5> R3> R1> R4.

Conclusions

Requirements prioritization is used to define the order of execution of requirements based on their priority or importance with respect to the points of view of all interested parts. Researchers have proposed many requirements prioritization techniques, and there is no single technique that can be used for all types of projects. For an adequate adjustment to the uncertainty and indeterminacy of human decision-making, the use of TOPSIS in its neutrosophic variant is proposed.

With the application of neutrosophic TOPSIS, it is possible to efficiently estimate the order of priority of the requirements based on the selected criteria. The assessment of each requirement according to each criterion, the weighting of each evaluation of the expert according to their level of knowledge on the subject, as well as the weighting of the experts of the importance of each criterion, is carried out through linguistic terms associated with SVNS, which allows the treatment of uncertainty and indeterminacy.

In the selected case study, five software requirements were analyzed under the criteria of technical difficulty, cost, risk, and value for the project. It was determined that the order of priority of the requirements should be: 1) R2, 2) R5, 3) R3, 4) R1 and 5) R4.

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Assessment of the Relevance of a Breast Cancer Rehabilitation Program based on a Neutrosophic Linguistic Scale

Carlos VinicioChiluisaGuacho[1], Nairovys Gómez Martínez[2], Yaritnza Hernández Coromoto[3], Riber Donoso Noroña[4] and Dennys Raúl Dupotey Hernández[5]

[1]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.carloschiluisa@uniandes.edu.ec
[2]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.nairovysgomez@uniandes.edu.ec
[3]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.yaritnzahernandez@uniandes.edu.ec
[4]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.riberdonoso@uniandes.edu.ec
[5]Gobernación de Cundinamarca, Secretaría de salud y dimensión vida saludable y condiciones no transmisibles, Bogotá Colombia; E-mail: dennysdupotey1@gmail.com

Abstract. This investigation aims to assess the degree of efficacy of a breast cancer rehabilitation program in Ecuador. To this end, a group of experts evaluated the efficacy of the program using the Delphi method. Once experts were rigorously selected, they used a linguistic scale for assessing the program in different aspects. Every element of the linguistic scale was associated with a neutrosophic number, and finally statistically processed. The advantage to use neutrosophy is the possibility to deal with the imprecision in the assessment and to count on a linguistic scale, which undoubtedly usually is more appropriate to express opinions than a numerical one.

Keywords: rehabilitation, breast cancer, neutrosophic linguistic scale.

1 Introduction

Cancer is a group of diseases defined by the existence of an exaggerated multiplication of malignant cells that can invade tissues, organs and spread at a distance, [1]. That is why there have been several authors who have systematized and defined this disease as a "process of uncontrolled growth and dissemination of cells that can appear practically anywhere in the body." [2,3]. It is also considered to be formed from cells in the breast that have grown abnormally and multiplied to form a lump or tumor.

In various studies by international organizations, they state that since the 18th century, that has been one of the main causes of death in the world, representing the second cause of death in most developed countries and some developing countries, [4].

The World Health Organization (WHO) considers that breast cancer is a major problem in developed countries and increasingly in developing countries, as this disease represents the leading cause of cancer death in the world. It is estimated that 1out of 9 to 12 women with risk factors will develop the disease in her lifetime, [5].

While on the other hand, the Pan American Health Organization (PAHO) states that in the American continent and the Caribbean the trend is similar. Thus, breast cancer represents 29% of all cancer cases and is the second cause of death from malignant tumors, where lung cancer is the first one; but for the year 2030, PAHO estimates more than 596,000 new cases and more than 142,100 deaths in the region, [6,7]. This is a matter that makes this issue a serious health problem both for this area and for the world.

Metastatic breast cancer is considered to present a picture of disease evolution in stages I, II, III, which develops metastasis of cancer in sites and/or organs considered outside the limits of the mammary area. That is one of the reasons this disease is considered dangerous, so it is better to carry out preventive actions when the patient is in the so-called stage 0.

Based on these arguments, Piñeros ([8]) asserts that breast cancer is one of the most important and vulnerable. Because the breast has a sexual meaning, motherhood, beauty, and femininity, the experience of removal or loss of one or both breasts, brings with it an impoverishment of the body image with the perception of feeling mutilated.

There is a variable age for the diagnosis of this disease, but it is without any doubt 50 years old women where there is a greater number of cases, since it reaches levels up to 75% of breast cancers after menopause, [6]. This question makes this population group at risk, so they should systematically practice palpation, self-examination and then continue with others that are carried out in different health institutions.

Malignant disease of the breast begins as a simple, painless nodule of variable size, more frequently in the superior-external quadrant of the breast, which may or may not show signs of superficial fixation or muscle planes, and is accompanied by axillary lymphadenopathy, [1].

It is, therefore, necessary to carry out a systematic self-examination and before the presence of the symptoms that are reflected below, the patient should see a doctor as soon as possible:

- Shooting pain in some part of the breast that persists after menstruation,
- Changes in the color or appearance of the skin of the breast,
- Dimples or sagging of the skin or palpation of lumps that were not previously palpable,
- Fluid discharge from the nipple, noting the appearance (clear, milky, or bloody), [7].

The surgical technique for the treatment of breast cancer varies depending on the type of lesion and its extension. The choice of this will be determined by a previous procedure, called *sentinel lymph node biopsy* (SLNB), in which the sentinel lymph node is identified and made the decision whether to remove and examine it, that is, that lymph node at cancer cells are likely to spread. In this way, unnecessary dissection of unaffected lymph nodes is avoided, thus reducing the risk of lymphedema from 20% to 3.5-11%, [9-12].

The disease can develop due to genetic and hormonal factors (not modifiable) and lifestyle (modifiable), but among those with a greater contributory burden are hormonal and genetic factors, [6]. That is why post-operative rehabilitation is a viable alternative and that in most cases it manages to improve the quality of health of these patients.

That is why physical exercise and massage programs can prevent the presence of lymphedema. Aspects that have been systematized by various authors and have already been approved by the oncological college of several countries as part of the ongoing care of patients operated on for this pathology, [13-15].

Another rehabilitation alternative for breast cancer-operated patients is occupational therapy, [9,16]. This is aimed at enabling them to carry out activities of daily life. Therefore, it is necessary to imbricate both trends of rehabilitation in an inclusive program.

Based on the previous arguments, this research proposes an integrative rehabilitation program for breast cancer patients, which, before being applied in the different hospitals of the Republic of Ecuador, must be evaluated by a group of experts to know and improve it to obtain satisfactory results in its implementation.

Therefore, the objective of the present work is to identify the relevance of the rehabilitation program for patients operated for breast cancer, using the criterion method of experts and with emphasis on the neutrosophic linguistic scale. Each expert was evaluated for selecting the most qualified, latter Delphi method was applied to evaluation. Delphi method consists of the independent evaluation of experts during many rounds until the final evaluation converges. For evaluation, we provided a linguistic scale associated with neutrosophic numbers. So, this combination of linguistic terms and neutrosophic numbers allows us to deal with imprecision and also with accuracy when experts asses with linguistic terms.

2 Materials and Methods

This section describes the main characteristics and procedures of the Delphi method and the fundamental bases that support the use of the neutrosophic linguistic scale.

2.1 Preliminaries in the Delphi method

Delphi method belongs to the so-called subjective forecasting methods and is based on the use of the intuitive judgment of a group of experts who issue criteria on a certain problem, [17,18]. That is why it is very effective to know the degree of relevance of some scientific projection.

This method offers multiple advantages due to its confidentiality, since it allows the freedom of opinions of the experts, encourages creativity, improves and redesigns the proposals that are subject to evaluation. Decision alternatives are offered without encouraging conflict between the experts.

An important aspect to take into account in this method is to theoretically understand who are considered experts. That is why they are considered a group of people or organizations capable of offering, with a maximum of competence, conclusive assessments on a certain problem, make real forecasts on the effect, applicability, feasibility, and relevance that the proposed solution may have in practice and provide recommendations on what to do for its improvement, [17].

This method is developed in the following stages:

1. Target identification,
2. Selection of experts,
3. Choice and application of the methodology,
4. Information processing.

The five values scale with positive Likert statements was used as an evaluative criterion.

- Very suitable (VS) five points,
- Fairly suitable (FS) four points,
- Suitable (S) three-point,
- Poorly suitable (PS) two points,
- Not suitable (NS) one point.

2.2 Neutrosophic evaluative scale

Definition 1:

([19,20]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that according to Definition 1, $T_A(x), I_A(x), F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x), I_A(x), F_A(x)$ can be subintervals of $[0, 1]$.

Definition 2:

([20-23]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic number* (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Linguistic term	SVN numbers
Very suitable (VS)	(1,0,0)
Fairly adequate (FS)	(0.70,0.25,0.30)
Suitable (S)	(0.50,0.50,0.50)
Poorly suitable (I)	(0.30,0.75,0.70)
Not suitable (NS)	(0,1,1)

Table 1: Linguistic terms of the scale

Let A = (T, I, F) be a single-valued neutrosophic number, a *scoring function* $s: [0, 1]^3 \to [0, 1]$ related to a single-valued neutrosophic value, based on the degree of belonging to the truth, the degree of belonging to the indeterminacy, and the degree of belonging to falsehood is defined by ([24]):

$$s(A) = \frac{2+T-F-I}{3} \quad (1)$$

The definition of the *precision index* is given in Equation 2.

$$a(a) = T - F \quad (2)$$

Where $a: [0, 1]^3 \to [-1,\ 1]$.

2.3 General characteristics of the rehabilitation program

Each rehabilitation session was divided into three stages, namely, initial, main and final. The first one was intended to condition the muscles and joints for subsequent activity, while the main part included the following groups of exercises:

- Low-impact aerobic exercise,
- Muscle-strengthening exercises,

- Joint mobility exercises,
- Fine motor exercises,
- Pulley exercises.

We worked with an intensity of very light (60% of heartbeats per minute) in the first 10 weeks, to light (70% of heartbeats per minute) in the remaining 13 weeks.

The calculation of the percentage of heartbeats per minute necessary to work was carried out according to the formula: $\text{maximum HR} = (220 - \text{age})0.6$ for 60% and $\text{maximum HR} = (220 - \text{age})0.7$ for 70%.

2.4 Statistical analyzes

The statistical analyzes were performed with SPSS v. 20 (SPSS Inc, Chicago, IL, United States). The data relating to the descriptive statistics are presented through the distribution of frequencies, while Kendall's coefficient of agreement and the χ^2 contrast was used to determine the existence or not of significance in the community of interests of the experts, [25].

3 Results

To develop this section, the stages described above for the application of this method are retaken ([17]).

1. Target identification
   The objective is identified: to assess the theoretical-methodological coherence and the degree of applicability of a breast cancer rehabilitation program.
2. Selection of experts:
   A survey was applied to the possible experts to measure their coefficient of competence (K), through their self-assessment. According to the categories of high (H), medium (M), and low (L), with respect to the sources of argument proposed in a standard table established for this purpose and the coefficient of competition was calculated using the formula $K = (Kc + Ka)/2$.

Where,

Kc: It is the coefficient of knowledge or information that the expert has about the problem, which is calculated based on the expert's assessment on a scale from 0 to 10 and multiplied by 0.1, so that:

The value zero (0) indicates a complete ignorance of the problem being evaluated.

The value ten (10) indicates full knowledge of the aforementioned problem. Among these borderline (extreme) evaluations, there are nine (9) intermediate ones.

Ka: It is the coefficient of argumentation or justification of the criteria of the experts, determined as the sum of the points obtained from the standard table to which reference has been made.

K: is the coefficient of competence of the experts and allows them to be classified according to what is agreed in:

- $0.8 \leq K \leq 1 \Rightarrow$ high competition,
- $0.5 \leq K < 0.8 \Rightarrow$ average competition,
- $K < 0.5 \Rightarrow$ low competition.

The survey was sent to 26 possible experts, after calculating the coefficient of competence, 16 were included in the research since they were in the high and medium categories. In other words, all those with a low Ka were excluded. Table 2 shows experts' distribution:

Academic level	N	%
Doctors (Ph.D)	5	31.25
Masters (MSc.)	7	43.75
Rehabilitation Specialist (RS)	4	25

Table2 2: Expert characterization

3-Choice and application of the methodology

For the work of the experts in the evaluation of the proposed program described in the present investigation, the Delphi methodology is used. Thus, this allows the application of consultation rounds, to identify if there is a coincidence between the experts' criteria when evaluating a set of indicators, previously established and that are listed below:

- Stages of the rehabilitation session,

- Selected exercises,
- Intensity of rehabilitation,
- Possibility of being applied in practice.

4-Information processing

After tabulating the information offered by the experts, the results are shown in Table 3:

Indicators to be evaluated by the experts	VS	FS	S	PS	NS
Stages of the rehab session	14 (87.5%)	1 (6.25%)	1 (6.25%)		
Selected exercises	15 (93.75%)	1 (6.25%)			
Rehabilitation intensity	14 (87.5%)	2 (12.5%)			
Possibility of being applied in practice	15 (93.75%)	1 (6.25%)			

Table 3. Results of the tabulation of the criteria offered by the experts after evaluating the rehabilitation program.

When performing a descriptive analysis of these results, the following is noticed:

Referring to the indicator "stages of the rehabilitation session", most of the experts (14 or 87.5%) agreed that they were very adequate and that they were in correspondence with the majority of rehabilitation programs for both patients operated on breast cancer, like other diseases of the osteomyoarticular system. For its part, one expert, or 6.25%, assessed this indicator as quite adequate, while that same amount valued it as adequate. It is noteworthy that there were no negative criteria or evaluations.

In the selected "exercises indicator", most of the experts also agreed that this was very adequate. This was reflected in that 15 or 93.75% out of the total of the experts indicated this category. Only one (6.25%) considered the exercises contained in the presented rehabilitation program to be quite adequate, it is also worth noting that this indicator did not receive an evaluative category or unfavorable criteria.

In the "indicator intensity of rehabilitation", it is noteworthy that the majority of the experts in consultations consider that these are very adequate since 14 of them (87.5%) gave this evaluative category. While only two (12.5%) of the total classified it as quite adequate. Therefore, no unfavorable evaluative category was received.

The indicator possibility of "being applied in practice", an important group of experts considered that it has a very adequate evaluative category, results that were endorsed by 15 experts or 93.75% of the total. On the other hand, only one (6.25%) considered that it is quite adequate. These results are very favorable and important because they come from a group of professionals with high and medium knowledge of this subject.

After the consultation was completed, some modifications to the program were relocated under the criteria issued by the experts, among which the following stand out:

- Make a description of the exercises to be used in the initial part of the rehabilitation session,
- Include pulley exercises,
- Describe how to perform the intensity calculation.

Finally, to determine the validity of the experts' criteria, the Kendall coefficient of concordance was used to determine the existence or not of significance in the experts' community of interests.

To do this, it begins with the formulation of the statistical hypothesis:

Nullity hypothesis (H_0): there is no community of preference among the experts.

Alternative hypothesis (H_1): there is a community of preferences among the experts.

Prefixing as significance level $\alpha = 0.05$.

Kendall's coefficient of agreement	Alpha value	N-1 GL	S2 / CHI (Boards)	S2 / CHI (Calculated)
0.84	0.05	4	14.067	88.511

Table 4. Inferential statistics results

As observed in the table presented above, Kendall's coefficient of agreement reaches a value of 0.84, so it can be considered the existence of a high agreement between the expert evaluations, this is corroborated with the χ^2 contrast in which 14.067 was less than its calculated value (88.511), so the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted.

From the linguistic assessment, a numerical final result is given as follows:

- Every assessment is converted from a linguistic term into its associated neutrosophic number, according to Table 1.
- Secondly, every neutrosophic number is converted into a crisp value using Equation 1 of the scoring function.
- The arithmetic mean of the results is calculated.
- If the moderator of the Delphi method wants to output a linguistic term, the numerical results obtained above are compared with the scoring function of every neutrosophic number in Table 1, and the linguistic term associated with the closest one to the obtained value is assigned.

Then, applying the precedent procedure, we obtained:

- Stages of the rehabilitation session: 0.95104 or "Approximately Very suitable".
- Selected exercises: 0.98229 or "Approximately Very suitable".
- Rehabilitation intensity: 0.96458 or "Approximately Very suitable".
- Possibility of being applied in practice: 0.98229 or "Approximately Very suitable".

So, the collected criteria were favorable, they express that the program proposed in this research is correctly designed; which guarantees the adequate practical application to achieve the rehabilitation of breast cancer operated patients. Issue by which it can be stated that it contributes to the enrichment of the proposal to achieve more effective practical application and thus improve the quality of life of the patients.

Conclusion

In this paper, we presented the analysis of the theoretical and methodological references on the assessment of the relevance of a breast cancer rehabilitation program. The use of the neutrosophic linguistic scale shows the existence of different bibliographic sources on the subject, however, programs that integrate various types of treatment for these patients are required. The assessment based on linguistic terms and neutrosophic numbers allows containing the accuracy to evaluate with linguistic values and also the imprecision with neutrosophic numbers.

The interpretation of the results derived from the criteria of the experts consulted makes it evident that there are positive criteria, aspects that were ratified with Kendall's coefficient of agreement, which was less than 0.005, therefore that ratified the existence of an agreement between them.

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Indeterminate Control Diagrams as Health Control Tools

Elizabeth Germania Vilema Vizuete[1], Alina Rosa Soria Acosta[2], María Verónica Aveiga Hidalgo[3] Clara Eliza Pozo Hernández[4] and Maylevis Morejón Valdés[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: direccionenfermeria@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.alinasoria@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.mariaaveiga@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.clarapozo@uniandes.edu.ec
[5]Universidad Autónoma de Baja California, México, Email: maylevis.morejon@uabc.edu.mx

Abstract. In recent decades, the development of techniques that allow continuous or periodic blood pressure measurement, both systolic and diastolic, in different individuals has shown that it experiences spontaneous variations in 24 hours. The variability of blood pressure has been calculated based on the standard deviation, and it has been possible to determine that this, with significant differences between individuals, behaves in such a way that the systolic pressure is higher than the diastolic. It has also been reported that the fluctuation is more significant in hypertensive patients than in normotensive patients, as the level of indeterminacy exists. Control charts, as in classical statistics, use the upper limit of control (ULC) and lower limit of control (LLC) to contain the existing uncertainties in the variable, although it would be advantageous to verify it using ambulatory blood pressure monitoring. The prognosis can be improved by ensuring an increase in blood pressure control in high-risk patients. This study focuses on the variations to which the variable is exposed by a level of indeterminacy existing with neutrosophic statistics. It is obtained that adult patients have the greatest affectations of this disease, which is why they require greater control and medical attention, and more precise equipment to obtain a successful result.

Keywords: Control charts, blood pressure, neutrosophic statistics.

1 Introduction

Health is a state of complete physical, mental, and social well-being, not only the absence of disease or illness, according to the World Health Organization (WHO) definition in its constitution approved in 1948 [1]. So a healthy person can live their dreams entirely. Today health is a process in which the individual moves on a health-disease axis, approaching one or the other extreme as the balance is reinforced or broken [2].

Among the diseases that affect balance is blood pressure, which is defined as the force of the blood pushing against the walls of the arteries. Every time the heart beats, it pumps blood into arteries [3].

Hypertension is the term used to describe high blood pressure. Blood pressure is highest when the heart beats, pumping blood. This is called systolic pressure. When the heart is at rest, between beats, blood pressure drops. This is defined as diastolic pressure [4, 5]. To control blood pressure, patients need to know the ideal values and the causes for concern. The blood pressure reading uses these two numbers; the systolic number is placed before or above the diastolic number. For example, 120/80 means a systolic pressure of 120 and a diastolic of 80 [6].

Blood pressure category	Systolic	Diastolic
Normal	-of 120	-of 80
Elevated	120 - 129	-of 80
Arterial Hypertension Level 1	130 - 139	80 - 89
Arterial Hypertension Level 2	140 and +	90 and +

Table 1: Blood pressure values according to the American Heart Association. Source [5]

In most people, systolic blood pressure rises steadily with age due to increased stiffness of the large arteries, long-term plaque build-up, and increased cardiovascular and heart disease [5]. As a result, patients are more likely to be told that blood pressure is too high as people become older [7]. Many factors can affect blood pressure: the amount of water and salt in the body, the state of kidneys, the nervous system or blood vessels, and hormone levels [8].

Today it is considered an incurable disease, but measurable, thanks to the correct use of the sphygmomanometer and controllable by maintaining a healthy life. Baumanometers or sphygmomanometers are instruments that measure BP, the best known being the mercury one; these need maintenance operations because they slowly lose their adjustment with continued use; in addition, aneroid sphygmomanometers decompensate with a simple blow, losing reliability [9].

The American Heart Association recommends using an automatic home blood pressure monitor that is worn on forearm. Wrist or finger blood pressure monitors are also available but may not be as accurate.

In recent decades, the development of techniques that allow continuous or periodic blood pressure measurement in different individuals has shown that it experiences spontaneous variations. These variations have been calculated based on the standard deviation in the 24-hour period, which has made it possible to determine that the variability of the mean arterial pressure is around 10% of the mean value with large differences between individuals and that the systolic variability pressure is higher than diastolic pressure [10], [11].

To define reading in the systolic and normal diastolic pressure, it is necessary to know the upper control limits (UCL) and lower control limits (LCL) (Table 1), represented in graphs. The Control charts help in the detection of unnatural models of variation in the data that result from repetitive processes and provide criteria to detect a lack of statistical control; these are applied in variables where the ranges at both frequency limits represent stability. A process is under statistical control when the variability is due only to "common causes" [12].

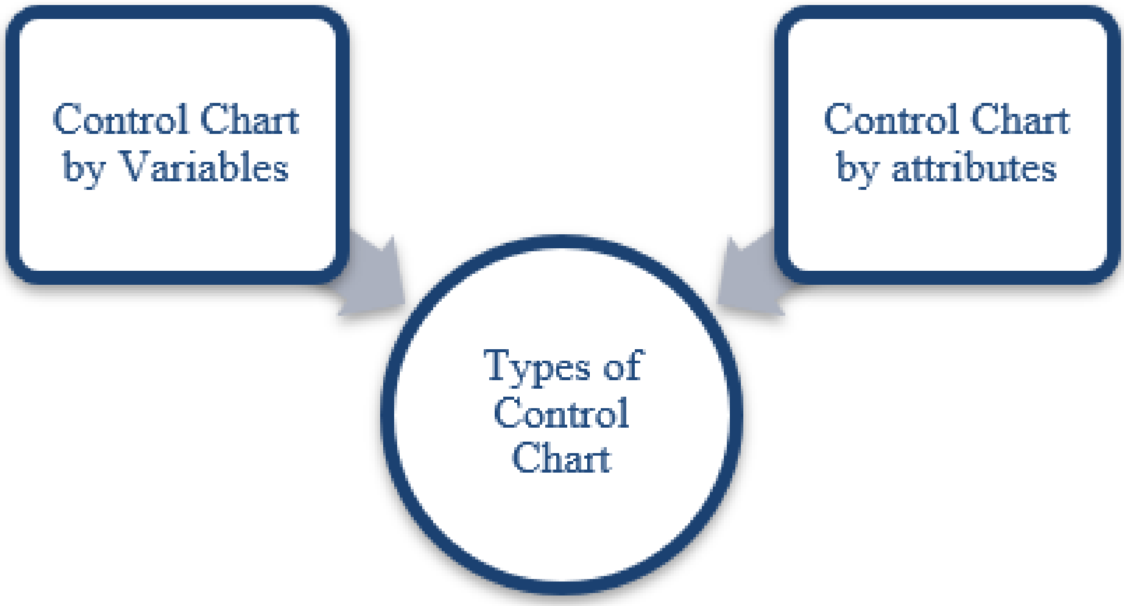

Figure 1: Types of Control Charts. Own elaboration

They are called variable control charts when the measurements can adopt a continuous range of values, for example length, weight, concentration, while attribute control charts are defined when the taken measures are not continuous [13, 14].

Control charts or control diagrams are used to control the development of production processes and identify possible instabilities and abnormal circumstances; what is intended with this type of analysis is to control the processes to ensure that they work correctly [15], [16]. A diagram serves to examine whether a process is in a stable condition or to ensure that it remains in that condition, while in health, these control charts allow verifying if a variable (BP) is within the parameters or limits required or a team is in optimal condition.

The control charts are implemented on the observed characteristics with the final objective of identifying the existence of assignable causes; these can not only identify the different types of assignable causes but also facilitate finding the capacity of the process that is based on the results of the estimation of the process parameters [17] [18].

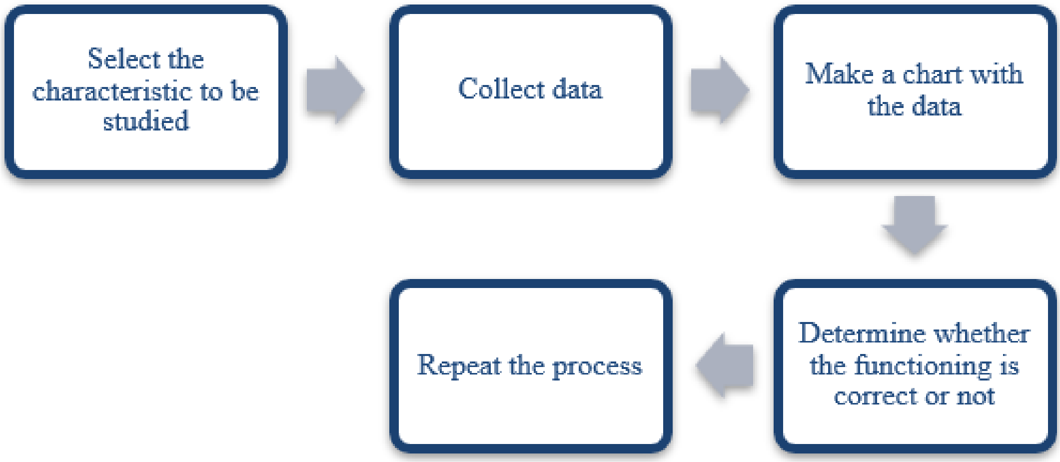

Figure 2: Steps to follow to create a control chart or diagram. Own elaboration

The main advantage of these fuzzy charts is their sensitivity over their conventional counterparts [19]. In addition, the designs of these graphs are enormously flexible and allow users to manage the vague data obtained during the measurement process [20-22].

Candidates	Initials	Amount of people	Scale (years)	Variable	Sub-element
Group 1	P1	40	20 - 30	Blood pressure	• Diastolic (PD), • Systolic (PS)
Group 2	P2	40	31 - 50		
Group 3	Q3	40	51 - +70		

Table 2. Dimensions of the neutrosophic study. Own elaboration

For the analysis of the Control Diagrams, this study defines:

- Problem situation: Changes in the normal reading of blood pressure systolic and diastolic at different stages of life.
- Main objective: define the variations of the variable in the different stages of life
- Specific objectives:
  - Determine the variations that affect the analyzed variable
  - Carry out the measurement and modeling of the variable
  - Evaluation of the different equipment in the measurement of blood pressure

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. For example, the Neutrosophic Probability of an event E is the probability that event E will occur [23], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability, nsup≤3 +.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [24], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [25]. In short, the Neutrosophic Logic[26, 27], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development. The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [28-33].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers [34], while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the corresponding lower and upper level that the studied variable can reach in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable $(\bar{x}_N)$when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N} \sum_{i=1}^{n_N},\ X_{il}\, \bar{x}_b = \frac{1}{n_N} \sum_{i=1}^{n_N},\ X_{iu}\, n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows:

$$\sum_{i=1}^{nN} (\bar{X} - \bar{X}_{iN})^2 = \sum_{i=1}^{nN} \begin{bmatrix} min\begin{pmatrix} (a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U) \\ (a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U) \end{pmatrix} \\ max\begin{pmatrix} (a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U) \\ (a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U) \end{pmatrix} \end{bmatrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{nN} (X_i - \bar{X}_{iN})^2}{n_N}; S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [35].

$$\frac{\sqrt{S_N^2}}{\bar{X}_N} X100;\ CV_N \in [CV_L, CV_U] CV_N= \tag{5}$$

3 Results

Data collection

For the modeling and analysis of the results, 3 groups of 20 people were selected (Table 2). Blood pressure is taken from the patients included in the study for 10 days, and the variations are processed with the use of neutrosophic statistics to obtain the ranges of indeterminacy of the variable in the measurement of normal blood pressure. Two measurements were made for each day, and they were taken as ULC and LLC for DP and SP according to Table 1.

Variable analyzed: arterial hypertension For a sample of n = 10 days, for each group

Code	Initials	Candidates
a	P1	Group 1
b	P2	Group 2
c	Q3	Group 3

Table 4. Coding of candidates for modeling. Own elaboration

As a result of the existing indeterminacy, the use of neutrosophic statistics is necessary for its better understanding, since the use of classical statistics is not possible. For the development of the statistical study, the neutrosophic frequencies of the variable in each SP and DP sub-element and their variations are analyzed.

Days	Neutrosophic frequencies		
	P1	P2	Q3
1	[106; 107]	[118; 122]	[124; 125]
2	[104; 105]	[118; 123]	[123; 123]
3	[102; 107]	[116; 121]	[122; 131]
4	[105; 114]	[110; 118]	[128; 133]
5	[102; 104]	[120; 130]	[121; 128]

6	[103; 113]	[114; 118]	[122; 129]
7	[109; 119]	[118; 128]	[125; 132]
8	[105; 108]	[111; 114]	[129; 135]
9	[100; 109]	[110; 120]	[122; 124]
10	[100; 101]	[115; 118]	[128; 135]

Table 5. Neutrosophic frequencies of SP. Own elaboration

Days	Neutrosophic frequencies		
	P1	P2	Q3
1	[60; 63]	[78; 80]	[84; 84]
2	[60; 60]	[77; 78]	[88; 90]
3	[70; 70]	[76; 77]	[88; 92]
4	[68; 73]	[77; 78]	[81; 81]
5	[63; 64]	[72; 73]	[82; 84]
6	[62; 64]	[70; 74]	[87; 89]
7	[61; 64]	[78; 81]	[81; 82]
8	[60; 64]	[80; 84]	[88; 91]
9	[61; 65]	[72; 74]	[83; 83]
10	[70; 70]	[75; 77]	[86; 90]

Table 6. Neutrosophic frequencies of PD. Own elaboration

Tables 5 and 6 show the pressure variations in stable health conditions for people of different groups for the 10 days analyzed, with an occurrence level of 2 times per day for each group. It is visible that the measurements vary depending on the times the blood pressure is measured, although it is noteworthy that for each group there is a level of indeterminacy for aPS= 3, bPS=3, cPS= 3 and aPD= 10, bPD=3, cPD= 3, with a level of representativeness for the third group or older adult.

Neutrosophic statistical analysis

From the neutrosophic statistical analysis for the measurement of blood pressure (Table 7 and 8), it is observed that the representative mean, $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means for SP and DP and their variations at the time of defining a normal arterial pressure are calculated. The contribution of the neutrosophic standard deviation $S_N \in [S_L; S_U]$ determines in which group a greater interest is required and where the measurement changes are more frequent as the person gets older $CV_N \in [CV_L\ ;\ CV_U]$.

Candidates	$\bar{x}_N$	YN	CVN
P1	[103.6; 108.7]	[3,674; 6,247]	[0.035; 0.057]
P2	[115; 121.2]	[5,196; 5,848]	[0.045; 0.048]
Q3	[124.4; 129.5]	[3,796; 4,644]	[0.031; 0.036]

Table 7. Neutrosophic statistical analysis of SP. Own elaboration

Candidates	$\bar{x}_N$	*YN*	*CVN*
P1	[64 + 66 I]	[6,567; 4,875]	[0.103; 0.074]
P2	[76 + 78 I]	[4,884; 4,385]	[0.064; 0.056]
Q3	[85 + 87 I]	[3,144; 4,556]	[0.037; 0.052]

Table 8. Neutrosophic statistical analysis of DP. Own elaboration

This means that for group 3 it is, on average, the one that affects the variations in blood pressure the most. On the other hand, the value of CV_N determines that it is more coherent when it comes to having more precise results due to the history that people have throughout of the life. Most medical studies establish a period of 7 to 10 days to determine through the results if the person has decompensating problems. It should be noted that the existence of LLC and ULC is indicated to give a definitive diagnosis (Figure 5). For this study, we will have for LLCDP ≤ 80 and ULCSP ≤ 120

From the results modeled in charts, we obtained:

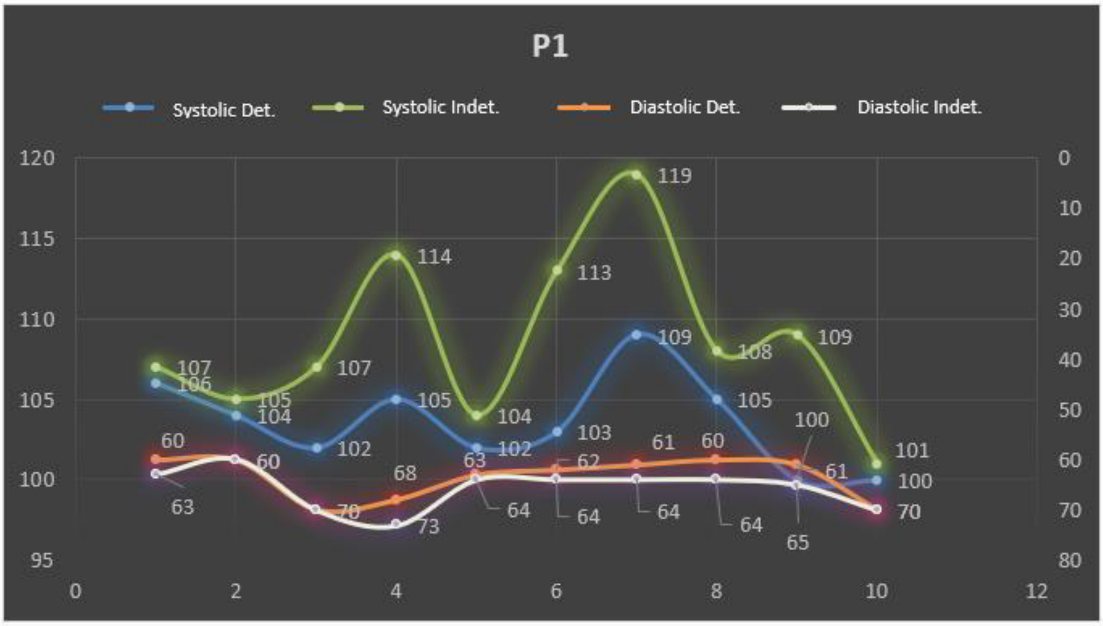

Figure 3. Neutrosophic scatter plot of the measurement variations for SP and DP in P1. Source: Own elaboration

In figure 3 for the P1 group, it is observed that the SP levels are between [100; 119], while in DP it ranges between [60; 73], with levels of indeterminacy existing for both sub-elements that are included in LLC and ULC.

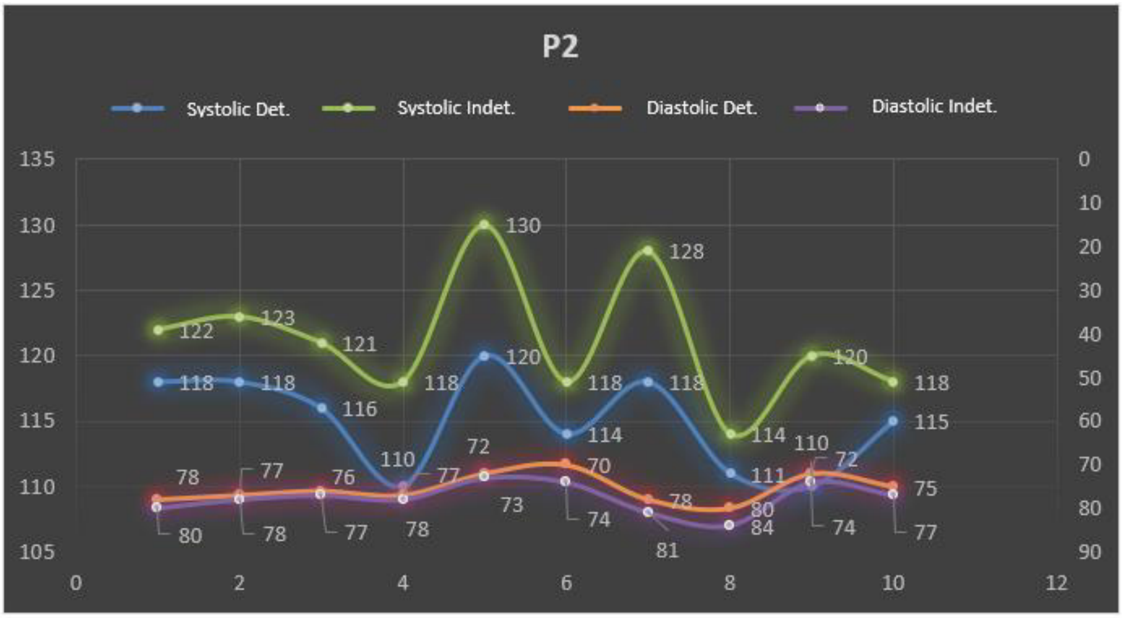

Figure 4. Neutrosophic scatter plot of the measurement variations for SP and DP in P2. Own elaboration

In the figure for group P2 it is observed that the levels of SP are between [110; 130], while in DP it ranges between [70; 84], with existing levels of indeterminacy for both sub-elements that are 90% included in LLC and only 50% is included in ULC for this range. It is evident that it is considered a not-so-normal pressure measurement for many health specialists when the patient was younger due to the physical and external changes that the person is exposed to.

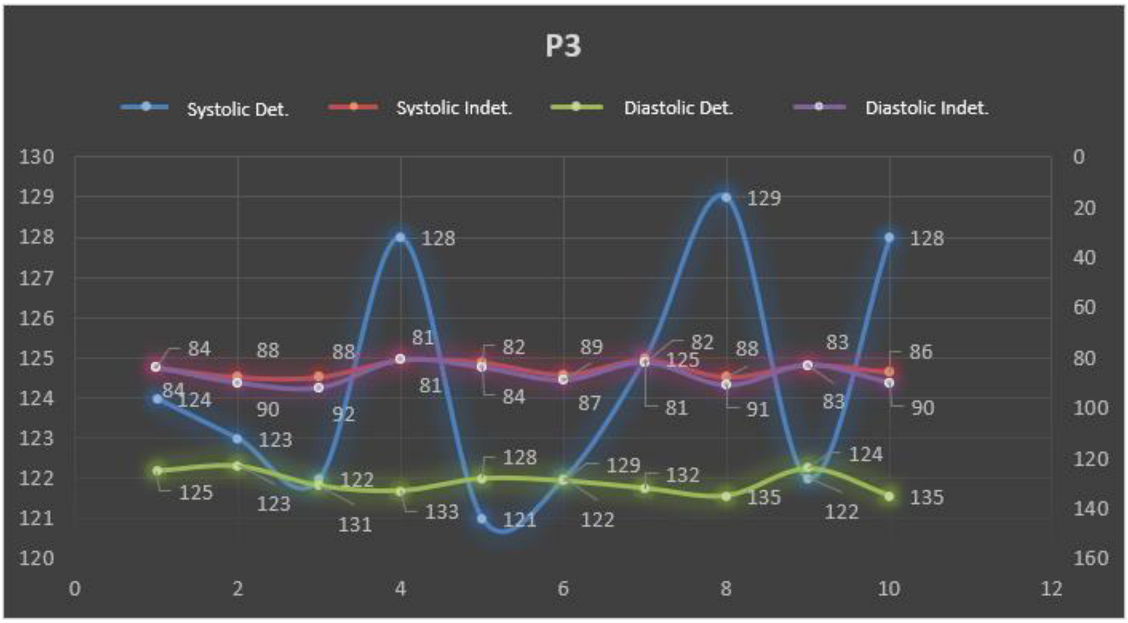

Figure 5: Neutrosophic scatter plot of the measurement variations for SP and DP in P3. Source: own elaboration

In the figure for the P3 group, it is observed that the levels of SP are between [129; 135], while in DP it goes between [81; 92], with an appreciable increase in the existing levels of indeterminacy for both sub-elements that are outside the ranges of LLC and ULC.

Comparative analysis

To determine the measure of indeterminacy regarding the measurements, it is associated for each and to the form of neutrosophic numbers. In the results obtained, it is observed that for the values they go from$\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U] CV_N \in [CV_L ; CV_U] CV_N$0.031 to 0.035 for systolic pressure and diastolic pressure from 0.037 to 0.103, with the levels of indeterminacy according to tables 9 and 10.

From the results obtained in the existing indeterminacy, it can be deduced that for patients between 51 and more than 70 years of age, there is a consistent and precise level of information when determining the variations in the measurement of blood pressure since as the patient debuts with this disease, more measurements are made throughout life and thus more information to analyze the existing uncertainties. Therefore, as a final result, a higher level of monitoring should be focused on patients in group 3.

Group	$\bar{x}_N$	YN	CVN
P1	104 + 109 I; I ∈ [0; 0.46]	3,674 + 6,247 I; I ∈ [0; 0.41]	0.035 + 0.057 I; I ∈ [0; 0.38]
P2	115 + 121 I; I ∈ [0; 0.50]	5,196 + 5,848 I; I ∈ [0; 0.11]	0.045 + 0.048 I; I ∈ [0; 0.63]
Q3	124 + 130 I; I ∈ [0; 0.46]	3,796 + 4,644 I; I ∈ [0; 0.18]	0.031 + 0.036 I; I ∈ [0; 0.13]

Table 9: Neutrosophic forms with a measure of indeterminacy for PS. Own elaboration

Group	$\bar{x}_N$	YN	CVN
P1	64 + 66 I;I ∈ [0; 0.30]	6,567 + 4,875 I;I ∈ [0; 0.34]	0.103 + 0.074 I;I ∈ [0; 0.39]
P2	76 + 78 I;I ∈ [0; 0.26]	4,884 + 4,385 I;I ∈ [0; 0.11]	0.064 + 0.056 I;I ∈ [0; 0.14]
Q3	85 + 87 I;I ∈ [0; 0.23]	3,144 + 4,556 I;I ∈ [0; 0.31]	0.037 + 0.052 I;I ∈ [0; 0.28]

Table 10: Neutrosophic forms with indeterminacy measure for PD. Own elaboration

Partial solutions

Aging is one of the main factors that cause blood pressure to increase more than it should, as the arteries harden with age, becoming less elastic, so a healthier diet and exercise practice would help control blood pressure variations in systolic and diastolic pressure.

- Patients with tension problems can control their levels thanks to modern devices adapted for use at home, for this reason, it is necessary for this group of people to have access to these, as well as to be handy and precise.

Conclusions

From the results, after having modeled the blood pressure variable, we concluded that:

- Control charts constitute a technology in the statistical field that allow health personnel to act quickly in case of inadequate performance of medical equipment that causes an increase in the variations in the modeled variables; however, it must be made explicit that the variables with more significant fluctuation it is necessary to apply the ULC and LLC depending on the conditions and the changing environment. An example of these is blood pressure, which, as these limits exist, can be violated by increasing indeterminacy and require new limits to control depending on age.
- The results of the neutrosophic statistics show that the use of the ULC and LLC in the control charts allows obtaining normal readings in fluctuations of variables with an existing level of indeterminacy and far from the precision of classical values.
- It is evidenced that adult patients present a trend and greater variation in normal blood pressure measurements. It is summarized that new ULC and LLC should be introduced depending on the groups of people and those secondary diseases that motivate the variations for the minimum and maximum.
- Although the main causes of the variation in blood pressure have not been determined, there is evidence that numerous nervous, reflex and behavioral factors are involved in the variations of the variable, so it is necessary to include the limits in the variation of the variation the indeterminacy. The neutrosophic statistical analysis shows a lower CVN value for people in the third group, where the measurements of this variable are more consistent when defining the indeterminacy.

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Neutrosophic and Plithogenic Statistical Analysis in Educational Development

Fernando Castro Sánchez[1], Jorge Hernán Almeida Blacio[2], María Gabriel Flores Bracho[3], Danilo Rafael Andrade Santamaria[4] and Ricardo Sánchez Casanova[5].

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador
Email: ua.fernandocastro@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador
Email: us.jorgealmeida@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador
Email: ui.mariaflores@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador
Email: up.daniloandrade@uniandes.edu.ec
[5] Vicedecano de Investigación y Posgrado, Universidad de la Habana , Cuba.
Email: ricardo.sanchez@matcom.uh.cu

Abstract. Education in the history of humanity briefly establishes the general characteristics of education over time. Throughout life, the student goes through more than 18 years in the classrooms, because education has rigorously changed throughout history, as a result of the evolution of some universities during the processes carried out until changing categories and an improvement in the evaluated indicators. On the other hand, governments and leading entities of education speak of the application of standards of educational quality, the efficiency of the educational system, and sustainability of financing and quality of spending to ensure that students develop knowledge, skills, and attitudes in specific situations, in different contexts for solving problems and interacting with the main dimensions, with their factors or sub-dimensions, limitations or critical nodes and challenges of education. This study analyzes the effects that affect educational development through the neutrosophic statistical study with the application of plithogenic sets.

Keywords: education, neutrosophic statistics, plithogenic sets

1 Introduction

This research collects the perspectives and experiences of teachers and analyzes the Ecuadorian educational system to determine how it influences the educational reality of the country. The educational changes made in recent years have not achieved the objectives set by the Ministry of Education and the Ministry of Higher Education, Science and Technology. Education is a right of people throughout their lives and an inescapable and inexcusable duty of the State. It constitutes a priority area of public policy and state investment, a guarantee of equality and social inclusion, and an essential condition for good living. Individuals, families, and society have the right and responsibility to participate in the educational process [1-8].

Education contributes to the achievement of great transformations of humanity and in turn, it is the educational transformations supported by philosophy that give meaning to human existence. Thus, it is not without reason that education has historically been the motor that drives all social processes. Hence we can say that it is crucial to address this issue [9-12].

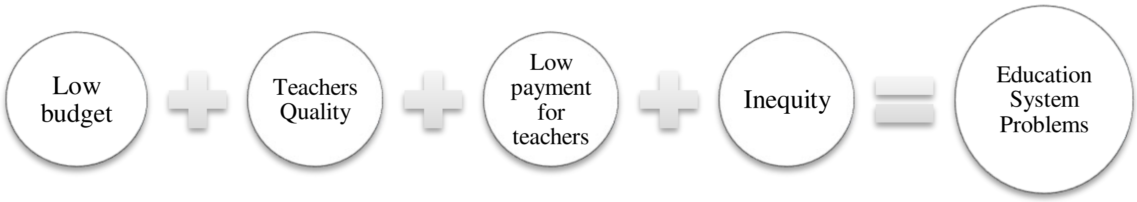

Figure 1. Problems of education systems

The Ministry of Education has assumed the leadership of the system and guarantees the right to education of Ecuadorians and their permanence in it. In the last 6 years, nearly 500,000 teachers were trained and although investment in education has tripled, quality has declined [13]. Furthermore, dropouts and reprobation in education were higher, so redistribution of the State's budget invests in education, quality spending policies, and an accountability system are actual goals to be achieved. At present, a revision of the standards and the curriculum is being carried out to strengthen the quality of education, the more poverty decreases, the quality of life improves because basic needs are met [14, 15].

Although the quality of education in Ecuador has improved, it lacks highly trained professionals and technicians, and that is why on many occasions, there is a need for millionaire hiring of foreigners to take those positions that need a certain degree of knowledge. In addition, this shortage decreases the development of our economy and all national life, because to a large extent, the main problem of national education is the little budget that is assigned to education in the country [16-18].

The actual society demands to have a higher quality education, an imperative of the demanding world in which we are immersed, which has created the urgent need that the work of man is much more effective, for which greater preparation is required. This is an active task of a psycho-physical-social order that allows understanding the new realities according to the level of inner maturation of the subjects. It is a reality that belongs to the space-time becoming of all people [19, 20]. The Ecuadorian educational system has progressed in recent times, but it has some obstacles and critical nodes to resolve. To think about the foundations of education in history and the transformations in current Ecuadorian education implies determining its entelechy, understanding the limitations, achievements, and challenges that the educational problem brings along [21, 22]. For the analysis of the development of education, this study defines:

- Problematic Situation: effects on educational development
- Main objective: define the main factors that affect development in education
- Specific objectives:
  - ✓ Determine the dimensions of the analyzed variable
  - ✓ Analyze the effects at each stage of the process
  - ✓ Carry out the neutrosophic statistical measurement and modeling of the variable
  - ✓ Determine the interrelation of each dimension in the plithogenic set of education
  - ✓ Present potential solutions to mitigate the impact of the factors on the variable

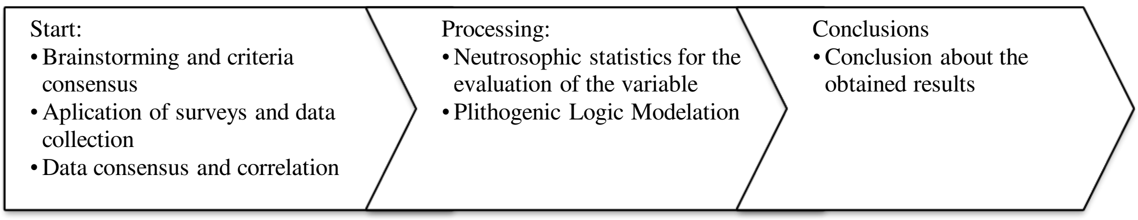

Figure 2: Stages of the study of educational development

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that event E will occur [23], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = \big(T(x), I(x), F(x)\big)$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [24], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [25]. In short, the Neutrosophic Logic [26, 27], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development [28-49].

The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [50]. Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [51], while "I" is the indeterminacy part of the neutrosophic number N.

$N = a + bI.$

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l y $X_u I_N$ represents the corresponding lower and upper level that the studied variable can reach in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}\ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu}\ n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral frames (NNS) it can be calculated as follows:

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\begin{bmatrix} \min\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \\ \max\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \end{bmatrix}, I\epsilon[I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [52].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U] \tag{5}$$

Mathematical modeling through neutrosophic logic to plithogenic logic

Neutrosophic sets were introduced in the literature by F. Smarandache since fuzzy intuitionistic sets could only handle incomplete information, but not the indeterminate and inconsistent information, which commonly exists in fuzzy systems. The term neutrosophy means knowledge of neutral thought and this neutrality represents the main distinction between fuzzy logic and fuzzy intuitionist [27]. In neutrosophic sets, the indeterminacy is explicitly quantified through a new parameter I. True membership (t), indeterminate membership (I), and false membership (F) are independent of each other and the sum between them satisfies the inequalities $0 \leq T + I + F \leq 3$. In fuzzy intuitionistic sets, the uncertainty depends on the degree of membership and the degree of non-membership [26]. In neutrosophic sets, the indeterminacy factor (I) is independent of the true and false values. There are no restrictions between the degree of truth, the degree of indeterminacy, and falsehood [24, 53-55].

If U is a universe of discourse, a Neutrosophic Set (NS) is characterized by three membership functions $\mathrm{uA(x), rA(x), vA(x)} : \mathrm{X} \rightarrow\ ]0-, 1+[$, which satisfy the condition $0 \leq -\inf \mathrm{uA(x)} + \inf \mathrm{rA(x)} + \inf \mathrm{vA(x)} \leq \sup \mathrm{uA(x)} + \sup \mathrm{rA(x)} + \sup \mathrm{vA(x)} \leq 3+$ for all $\mathrm{x} \in \mathrm{X}$. $\mathrm{uA(x), rA(x)}$ and $\mathrm{vA(x)}$ are the membership functions of truth, indeterminacy, and falsehood of x in A, respectively y your images are standard or non-standard subsets of $]0-, 1+[$.

When approaching the perspective of indeterminacy and contradiction, as is the case with Gödel's incompleteness theorem, he states that any proposition in a mathematical axiom system will present a degree of truth (T), falsehood (F), and indeterminacy (I). Neutrosophy, therefore, establishes a unique solution for the existence of paradoxes in philosophy [50]. Plithogenic advocates for the connections and unification of theories and ideas in varied fields of science [56].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a type of opposites: <A> and <antiA>), neutrosophy (dynamics of a type of opposites and their neutrals: <A> and <antiA> and <neutA>) , since Plithogeny

studies the dynamics of many types of opposites and their neutrals and non-opposites (<A> and <antiA> and <neutA>, <B> and <antiB> and <neutB>, etc.), and not opposites (<C>, <D>, etc.) all together. As an application and particular case derived from Plithogeny, the plithogenic set is an extension of the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set, and has multiple scientific applications [56].
So, (P, a, V, d, c) is called a plithogenic set

1. Where "P" is a set, "a" is an attribute (multi-dimensional in general), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x to the set P with respect to some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P;
2. "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.
3. Functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that experts need to solve.
4. Then, the following notation is used:
5. $x(d(x, V))$, where $d(x, V) = (d(x, v), \text{for all } v \in V), \forall x \in P$.
6. The attribute value contradiction degree function is calculated between each attribute value regarding the dominant attribute value (denoted by v_D) in particular, and with regard to other attribute values as well.
7. The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Longrightarrow$), equivalence ($\Longleftrightarrow$), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of values of the attribute based on a t-norm and a t-conorm. Most plithogenic aggregation operators are linear combinations of a fuzzy t-norm (indicated by) with a fuzzy t-conorm (indicated by), but nonlinear combinations can also be constructed. $\wedge D$ and $\vee D$ [57].

If the t-norm is applied on the value of the dominant attribute denoted by, and the contradiction between and is, then it is applied on the value of the attribute as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2), \tag{6}$$

Or, using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \tag{7}$$

Similarly, if the t-conorm applies to the value of the dominant attribute denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then v_2 applies to the value of the attribute as follows

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2), \tag{8}$$

Or, using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2), \tag{9}$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \tfrac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right), \tag{10}$$

The plithogenic neutrosophic junction is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \tfrac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right), \tag{11}$$

In other words, if something applies to membership, the opposite applies to non-membership, while in indeterminacy the average between them is what applies. Plithogenic neutrosophic inclusion is defined as follows:
Since the degrees of contradiction are:
$c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5$,
We apply
$a_2 \geq [1 - c(a_1, a_2)]b_2$ o $a_2 \geq (1 - 0.5)b_2$ o $a_2 \geq 0.5b_2$, while $c(a_1, a_3) = c(b_1, b_3) = 1$
So, having the opposite is true for $a_1 \leq b_1$ if and only if
$a_3 \geq b_3$, therefore $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only if $a_1 \leq b_1$, $a_2 \geq 0.5b_2$, y $a_3 \geq b_3$.

Next, an algorithm for the resolution of this research is presented where Plithogeny will be merged with the algorithm of Neutrosophy. From this moment on, expressions 2 to 8 must be applied to execute the operations of the classical algorithm with plithogenic numbers. For the elaboration of a single decision matrix, the median of the plithogenic numbers is calculated for each combination, for all specialists. The median is calculated using the following formula:

$$\mathrm{median}_{i=1}^{m}\{\mathrm{PN_i}\} = (\mathrm{median}_{i=1}^{m}\{\mathrm{T(PN_i)}\}, \mathrm{median}_{i=1}^{m}\{\mathrm{I(PN_i)}\}, \mathrm{median}_{i=1}^{m}\{\mathrm{F(PN_i)}\}), \quad (12)$$

Where $\mathrm{PN_i}$, are plithogenic numbers, $\mathrm{T(PN_i)}$ are their true components, $\mathrm{I(PN_i)}$ are their indeterminate components and $\mathrm{F(PN_i)}$are their false components. In other words, Equation 8 means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components. To compare the relationships between the quadrants, the following formula is used to blur a neutrosophic number [58]:

$$\mathcal{S}([\mathrm{T,I,F}]) = \frac{2+\mathrm{T}-\mathrm{I}-\mathrm{F}}{3} \quad (13)$$

- Determine for each line of the pairwise comparison matrix, a weighted sum based on the sum of the product of each cell by the priority of each alternative or corresponding criterion.
- For each line, divide its weighted sum by the priority of its corresponding alternative or criterion
- Determine the λmax mean of the result of the previous stage.
- Calculate the consistency index (CI) for each alternative or criterion

$$CI = \frac{\lambda_{max} - m}{m-1} \quad (14)$$

Where m is the number of alternatives

- Determine the Random Index (RI) from table 2
- Determine the consistency ratio index (the ratio between the consistency index and the random index)

3 Results

3.1 Data

Development in education has been one of the challenges for governments to achieve the professional level demanded. For the modeling of this work, a group of experts was created to analyze the data collected in the information collection stage. As a consensus, the experts determined for the modeling:

Set: Education, $=\forall\ F_{V_n}\ \{F_{V_1}, F_{V_2}, F_{V_3}\}$

Subsets:

- System efficiency, $=\forall\ F_{V_{1n}}\ \{F_{V_{11}}, F_{V_{12}}, F_{V_{13}}\}$
- Educational quality, $=\forall\ F_{V_{2n}}\ \{F_{V_{21}}, F_{V_{22}}\}$
- Sustainability of financing and quality of spending, $=\forall\ F_{V_{3n}}\ \{F_{V_{31}}, F_{V_{32}}\}$

Variable: Development in education. Code (E)

Factors (F): Impacts on the development of education (Figure 3)

Sample: 145 days

Scale: [0, 6] (See table 1)

Linguistic Expression	Scale	Phytogenic number (T, I, F)	$\mathcal{S}([\mathrm{T,I,F}]) = \frac{2+\mathrm{T}-\mathrm{I}-\mathrm{F}}{3}$
Poor Importance (PI)	0	(0.12, 0.92, 0.97)	0.08
Fewer important (FI)	1	(0.17, 0.87, 0.92)	0.13
Low Importance (BI)	2	(0.42, 0.67, 0.82)	0.31
Medium important MDI	3	(0.67, 0.62, 0.72)	0.44
Important (I)	4	(0.72, 0.37, 0.52)	0.61
Most Important (MI)	5	(0.92, 0.27, 0.12)	0.84
Very important (VI)	6	(0.97, 0.07, 0.03)	0.96

Table 1: Linguistic expression for determining the level of importance of the factor on the variable

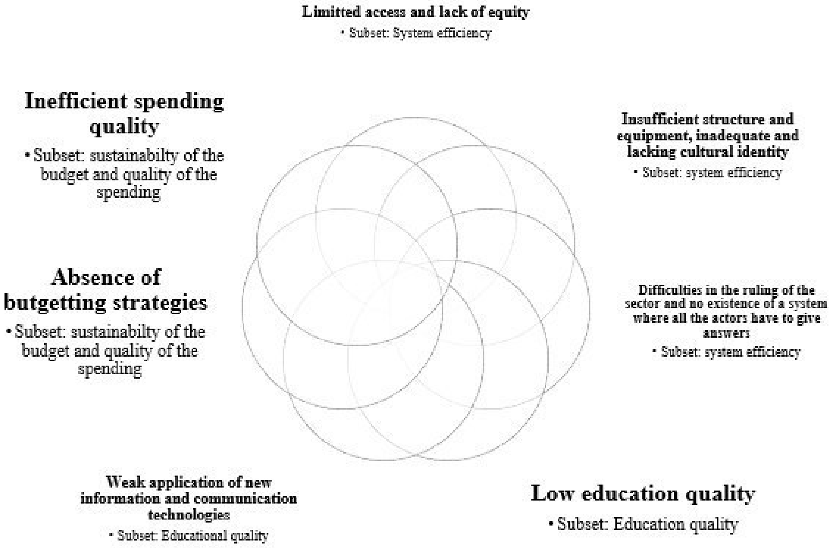

Figure 3. Plithogenic set of development in education

To model the neutrosophic statistics of the neutrosophic set, it is suggested to code the name of the variable and its representation in graphs and tables.

3.2 Method development

Stage I. Neutrosophic statistical analysis

By modeling the variable with the use of neutrosophic statistics, the absolute frequencies are obtained to determine the level of involvement in the development of education, $F_n = \{F_{V_{11}}, F_{V_{12}}, F_{V_{13}}, F_{V_{21}}, F_{V_{22}}, F_{V_{31}}, F_{V_{32}}\}$ in a sample of 145 days of research (Table 2). It is noted:

- For the *System Efficiency* dimension, the factor $\mathrm{F}_{\mathrm{V}_{12}}$ has an incidence of 35.2%. It shows that insufficient infrastructure and equipment, inadequate and lacking cultural identity, are positioned as an element that slows down the efficiency of the educational system.
- For the educational quality dimension, the factor $\mathrm{F}_{\mathrm{V}_{21}}$ has an incidence of 51.4%. It shows that the low quality of education is positioned as a factor that affects the development of education.
- For the dimension Sustainability of financing and quality of spending, the factor $\mathrm{F}_{\mathrm{V}_{31}}$ has an incidence rate of 51.9%. It shows that the absence of financing strategies is positioned as a financial factor that hinders educational development.

To obtain the level of incidence of each factor in its dimension, as the measure of indeterminacy for modeling, a scale of $0 \leq F_{V_n} \geq 1$, was set, so that the relative membership level within the subset is determined, as well as the neutrosophic set from the neutrosophic frequency $F_n = \{F_{V_{11}}, F_{V_{12}}, F_{V_{13}}, F_{V_{21}}, F_{V_{22}}, F_{V_{31}}, F_{V_{32}}\}$ (table 3).

Days	**Neutrosophic frequencies**						
	System Efficiency			**Educational quality**		**Sustainability of financing and quality of spending**	
	V11	**V12**	**V13**	**V21**	**V22**	**V31**	**V32**
1	[3 ; 5]	[2 ; 5]	[2 ; 5]	[2 ; 3]	[1 ; 1]	[3 ; 3]	[1 ; 4]
2	[1 ; 4]	[0 ; 3]	[1 ; 1]	[0 ; 0]	[1 ; 3]	[1 ; 4]	[0 ; 3]
3	[3 ; 5]	[3 ; 6]	[3 ; 3]	[2 ; 5]	[0 ; 0]	[3 ; 3]	[3 ; 6]
4	[2 ; 5]	[2 ; 3]	[2 ; 3]	[0 ; 1]	[1 ; 4]	[3 ; 6]	[2 ; 2]
5	[2 ; 2]	[2 ; 3]	[1 ; 3]	[2 ; 3]	[0 ; 0]	[1 ; 3]	[2 ; 4]
6	[2 ; 5]	[0 ; 0]	[0 ; 1]	[3 ; 5]	[2 ; 2]	[3 ; 5]	[3 ; 4]
7	[2 ; 2]	[0 ; 0]	[3 ; 3]	[1 ; 2]	[1 ; 4]	[1 ; 3]	[1 ; 4]
8	[2 ; 3]	[3 ; 5]	[3 ; 6]	[1 ; 1]	[2 ; 2]	[0 ; 0]	[1 ; 3]
9	[1 ; 1]	[0 ; 0]	[3 ; 3]	[2 ; 3]	[1 ; 2]	[0 ; 1]	[2 ; 4]
10	[3 ; 4]	[0 ; 3]	[0 ; 2]	[1 ; 4]	[1 ; 3]	[1 ; 1]	[1 ; 3]
11	[3 ; 3]	[2 ; 5]	[3 ; 5]	[1 ; 4]	[0 ; 3]	[1 ; 3]	[1 ; 1]
12	[2 ; 4]	[1 ; 4]	[0 ; 3]	[0 ; 1]	[2 ; 4]	[1 ; 3]	[2 ; 5]

13	[1 ; 2]	[0 ; 3]	[0 ; 1]	[2 ; 3]	[3 ; 4]	[3 ; 6]	[3 ; 3]
14	[2 ; 2]	[3 ; 6]	[2 ; 3]	[0 ; 2]	[2 ; 2]	[3 ; 3]	[3 ; 4]
15	[1 ; 2]	[0 ; 1]	[1 ; 3]	[2 ; 4]	[1 ; 3]	[2 ; 2]	[1 ; 1]
16	[0 ; 0]	[1 ; 2]	[3 ; 3]	[1 ; 1]	[1 ; 4]	[1 ; 3]	[2 ; 4]
17	[1 ; 3]	[0 ; 2]	[1 ; 3]	[0 ; 2]	[3 ; 6]	[2 ; 2]	[2 ; 2]
18	[0 ; 2]	[2 ; 4]	[1 ; 2]	[2 ; 5]	[0 ; 3]	[3 ; 6]	[3 ; 3]
19	[0 ; 3]	[0 ; 2]	[0 ; 3]	[1 ; 3]	[0 ; 2]	[1 ; 1]	[3 ; 4]
20	[3 ; 5]	[3 ; 6]	[2 ; 3]	[0 ; 0]	[2 ; 4]	[3 ; 4]	[0 ; 2]
0-145	[153 ; 293]	[134 ; 312]	[143 ; 282]	[145 ; 299]	[130 ; 283]	[177 ; 347]	[151 ; 322]

Table 2. Neutrosophic frequency for each plithogenic subset in educational development

Of the neutrosophic frequencies observed for development in education, for a sample of 145 days analyzed, there is a total indeterminacy level of:

Subset V1, $V_{11} = 140, V_{12} = 178, V_{13} = 139$, with representativeness levels of $[72.01\% ;\ 81.73\%]$,

Subset V2, $V_{21} = 154, V_{22} = 153$, with representativeness levels of $[70.57\% ;\ 81.63\%]$,

Subset V3, $V_{31} = 170, V_{32} = 171$, with representativeness levels of $[64.27\% ;\ 69.88\%]$.

It is highlighted that the problems of insufficient infrastructure and equipment, inadequate and without cultural identity affect 81.63 in the development in education, in the days of greatest incidence.

From the results of the modeling, it is observed that the incidence relationship between each factor associated with its dimension affects the development of education (table 3).

For the analysis of the representative mean as a function of $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means of the factors are calculated and for the study of the variations of the subsets V1, V2, V3, they are determined by the values of the neutrosophic standard deviation $S_N \in\ [S_L; S_U]$, to determine in which factor there is greater coherence and precision when measuring the neutrosophic set $CV_N \in [CV_L\ ;\ CV_U]$ (Figure 4)

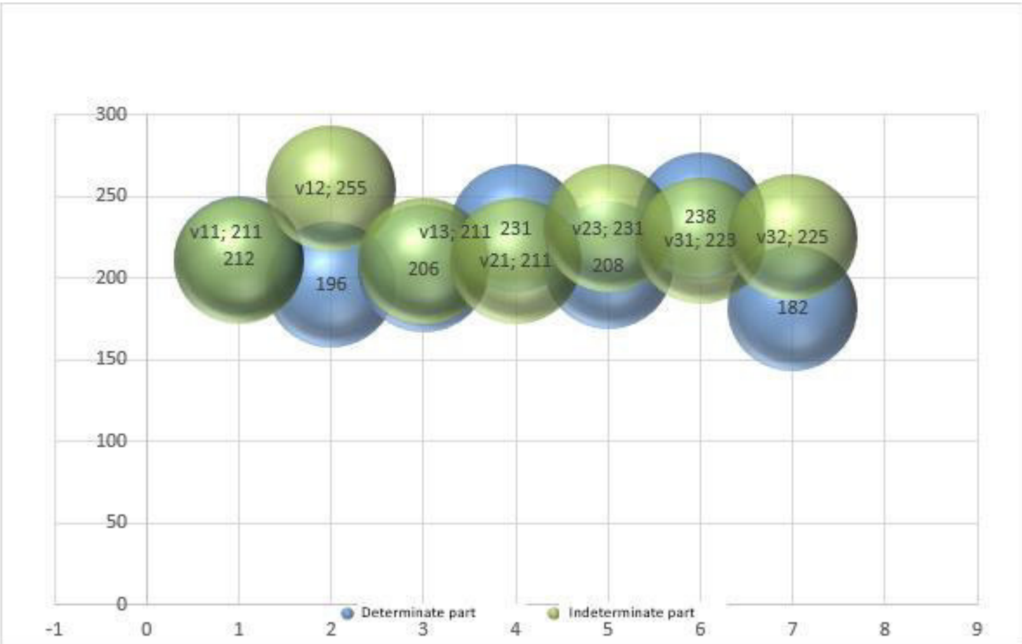

Figure 4. Neutrosophic bubble graph and its plithogenic interrelation of each factor and dimension.

Comparative analysis

The modeling of the neutrosophic statistics defines the associated indeterminacy factor for $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in\ [S_L; S_U]$ and $CV_N \in\ [CV_L\ ;\ CV_U]$ in the form of neutrosophic numbers (Table 3). From the results obtained, it is observed that for the CV_{NV} values for the:

Subset V1, from 0.493 to 0.637with the indeterminacy measure of $[21.3\% ;\ 45.0\%]$,

Subset V2, from 0.504 to 0.509with the measure of indeterminacy from $[34.0\% ;\ 40.8\%]$,

Subset V3, 0.438 to 0.492with the measure of indeterminacy from $[31.0\% ;\ 35.0\%]$.

COD	Dimension	COD	Sub-dimension or factor	Scale	Phytogenic number (T, I, F)	dn (x; Vn)	Attribute value	$\bar{x}$N	YN	CVN
V1	System Efficiency	v11	Limited access to education and lack of equity	[0; 6]	(0.72, 0.37, 0.52)	0.3	I	1,391 + 2,664 I;I ∈ [0; 0; 47.8]	0.686 + 2.386 I;I ∈ [0; 0; 71.2]	0.493 + 0.896 I;I ∈ [0; 0; 45.0]
		v12	Insufficient infrastructure and equipment, inadequate and lacking cultural identity	[0; 6]	(0.92, 0.27, 0.12)	0.4	M: YES	1,218 + 2,836 I;I ∈ [0; 0; 57.1]	0.82 + 2.425 I;I ∈ [0; 0; 66.2]	0.673 + 0.855 I;I ∈ [0; 0; 21.3]
		v13	Difficulties in the governance of the sector and lack of an accountability system for all actors in the system	[0; 6]	(0.72, 0.37, 0.52)	0.3	I	1.3 + 2,564 I;I ∈ [0; 0; 49.3]	0.72 + 2.22 I;I ∈ [0; 0; 67.6]	0.554 + 0.866 I;I ∈ [0; 0; 36.0]
V2	Educational quality	v21	Low quality of education	[0; 6]	(0.97, 0.07, 0.03)	0.51	VI	1,318 + 2,718 I;I ∈ [0; 0; 51.5]	0.664 + 2.077 I;I ∈ [0; 0; 68.0]	0.504 + 0.764 I;I ∈ [0; 0; 34.0]
		v23	Weak application of new information and communication technologies	[0; 6]	(0.67, 0.62, 0.72)	0.49	MDI	1,182 + 2,573 I;I ∈ [0; 0; 54.1]	0.602 + 2.212 I;I ∈ [0; 0; 72.8]	0.509 + 0.86 I;I ∈ [0; 0; 40.8]
V3	Sustainability of financing and quality of spending	v31	Lack of financing strategies	[0; 6]	(0.97, 0.07, 0.03)	0.51	VI	1,609 + 3,155 I;I ∈ [0; 0; 49.0]	0.705 + 2.128 I;I ∈ [0; 0; 66.9]	0.438 + 0.674 I;I ∈ [0; 0; 35.0]
		v32	Poor quality of spending	[0; 6]	(0.67, 0.62, 0.72)	0.49	MDI	1,373 + 2,927 I;I ∈ [0; 0; 53.1]	0.675 + 2.11 I;I ∈ [0; 0; 68.0]	0.492 + 0.721 I;I ∈ [0; 0; 31.8]

Table 3. Neutrosophic measures with levels of indeterminacy for each plithogenic subset of development in education

Although the need to use the lowest percentage level of indeterminacy to obtain accurate and homogeneous results influences with a greater degree and a low level of indeterminacy than the other factors in the development of education. For each determining factor in the pertaining subset and its hierarchy level in the plithogenic set as established: CV_N

- Low quality of education
- Insufficient infrastructure and equipment, inadequate and lacking cultural identity
- Lack of financing strategies

Stage II. Development of mathematical modeling through neutrosophic logic to plithogenic logic in the development of education

Plithogenic set: Development of education (table 3)

The plithogenic set is defined for three subsets V1, V2, and V3

That is why a plithogenic set is defined that consists of 7 attributes, each of these attributes contain possible values (table 3), with their respective plithogenic particularities and possible values in the linguistic expression to determine the level of importance of the factor on the variable (table 1).

The multi-attribute of dimension 3 has cardinality 3x2x2 = 12.

The degrees of contradiction between the values for each attribute are defined below:

$c_N (v_{11}, v_{12}) = c_N (v_{12}, v_{13}) = 0.3$

$c_N (v_{21}, v_{22}) = 0.1$

$c_N (v_{31}, v_{32}) = 0.1$

As we can see, the dominant values for each attribute are: v_{12}, v_{21}, and v_{31}

When v21, v12, and v31 are activated, all the other nodes are activated, which means that the incidence value caused by the low quality of education in the institutions is influenced by the deterioration of the infrastructure and insufficient, inadequate equipment and without identity cultural, has a negative influence by projecting itself as a dominant value within the plithogenic set of education, in such a way that it constitutes an impairment in professional and educational growth preceded by the absence of financing strategies.

To determine a level of solution, it is necessary to know which subsets to act on through the relationship and the level of importance, as follows:

- Educational quality and System Efficiency
- Educational quality and absence of financing strategies
-

V_{12}	V_{21}	V_{31}
M: YES (0.92, 0.27, 0.12)	**VI** (0.97, 0.07, 0.03)	**VI** (0.97, 0.07, 0.03)

Low quality of education (v21) and insufficient infrastructure and equipment, inadequate and lacking cultural identity (v12)

Neutrosophic Plithogenic Union	$S([T,I,F]) = \frac{2+T-I-F}{3}$	**Evaluation**
$(a1, a2, a3) \vee p\ (b1, b2, b3) = (a1 \wedge D\ b1, \frac{1}{2}[(a2 \wedge D b2) + (a2 \vee D\ b2)], a3 \wedge D\ b3)$	0.9061	It is in a sublevel

(a1, a2, a3) ∨p (b1, b2, b3) = (0.892, 0.17, 0.004)		between I and MI

Low quality of education (v21) and absence of financing strategies (v31)

Neutrosophic Plithogenic Intersection	$S([T,I,F]) = \frac{2+T-I-F}{3}$	**Evaluation**
(a1, a2, a3) ∧p (b1, b2, b3) = (a1∧D b1, $\frac{1}{2}$[(a2∧Db2)+ (a2∨D b2)], a3∨D b3) (a1, a2, a3) ∧p (b1, b2, b3) = (0.94, 0.07, 0.059)	0.9372	It is on a sublevel between MI and VI

Table 4. Evaluations between v_{12}, v_{21}, and v_{31}

There is a stronger relationship between the subsets of educational quality and sustainability of financing and quality of spending [in its attribute (v21) and (v31)] than between educational quality and system efficiency, taking into account the most predominant factors. A relationship is obtained one degree closer to more important than very important according to the plithogenic neutrosophic union and intersection operator. So the solutions must be focused on solving the factors (v21) and (v31) that affect the development of education.

Partial solutions:

- To increase the quality of education in the different localities of the country, it is necessary the creation of an institute that is in charge of designing, experimenting, and gradually disseminating the educational innovations that are required.
- The governing bodies on educational development must promote and finance projects for the educational sector to promote professional development.
- It must be understood that education is one of the main development tools of a country, providing opportunities for the population and allowing progress towards a more equitable and egalitarian country.

Conclusions

- Ecuador has presented innumerable advances in education, however, like most countries in the region, there is still a long way to go, and one of them is the educational quality that is still deficient.
- Neutrosophic statistics revealed that among the factors that most affect educational development are the low quality of education; insufficient infrastructure and equipment, inadequate and without cultural identity, and absence of financing strategies, corresponding to the dimension it belongs.
- The analysis of the mathematical modeling through the neutrosophic logic to the plithogenic logic determined within the plithogenic set of development in education, which subsets were compromised by directly influencing educational development. The relationship between the subsets of educational quality and sustainability of financing and quality of spending was at a sub-level between MI and VI. Objectively, these nodes must be influenced to reduce their incidence and activation of the remaining nodes.

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Handling of Indeterminacy in Statistics. Application in Community Medicine

Jorge Enrique Lana Cisneros[1], Carlos López Barrionuevo[2], Elsy Labrada González[3] and Alex Gabriel Lara Jácome

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.jorgelana@uniandes.edu.ec

[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: decanaturafcm@uniandes.edu.ec

[3] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.elsylabrada@uniandes.edu.ec

[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.alexlara@uniandes.edu.ec

Abstract. Currently, humanity has made significant progress in the development of telecommunications and the economic, social, and health sectors; probably, in the same way, a series of pathogenic organisms have evolved considerably, causing harm to humanity. That is why Health Sciences has resorted to the technological advances offered by the industrial and telecommunications era. Among the tools of great help to combat infectious agents are statistical tools, which contribute a decisive step in advancing scientific studies aimed at communities and society. The application of Statistics in Health Sciences is essential to apply its knowledge in preventive activities, health promotion, and clinical studies. This knowledge allows students to face more complex courses and content and formulate better scientific criteria for analyzing and developing healthcare and research activities. Although a level of evidence has been achieved in the recommendations for tracking the health problems faced by the communities and the possible treatments to be applied in patients, there are still certain levels of indeterminacy in the analyzed data that generate arbitrary or discretionary opinions outside the scope of the classical statistics which can be better covered if processed by neutrosophic statistics.

Keywords: community medicine, neutrosophic statistics,

1 Introduction

The great social changes of the last decades have allowed significant achievements in technological development, research, and the availability of information. The increasing volume and accelerated appearance of data have led to a decrease in their timing and validity and complicate the need for health professionals to be responsibly updated [1]. The doctor needs to have and adopt tools such as bibliographic search techniques and formal rules to evaluate the literature, which allows the selection and prioritization of the generous information that circulates and which helps to face the challenge of professional updating [2, 3].

The need for a statistical approach is now well recognized in research and practice in the disciplines that constitute health [4], subdivided into communities or populations in which the laws of large numbers and random fluctuations apply [5].

The analysis of the health situation is based on an exhaustive review of statistical data with a clinical-epidemiological and social approach to identify the problems of the individual, families, and the community [6], as well as its possible solutions [7] when developing the work of the health team [8]. As a teaching instrument, it is considered that the objective is for the student to get ahold of the procedure, actively, independently, consciously, and creatively, using the clinical-epidemiological and statistic method [9], and the planning of strategies with a cultural-historical and integral approach [10].

Statistical information makes use of personal and family medical records, vaccination cards, and the insertion of data of interest in clinical forms [11-14]. Subsequently, an integral analysis is made; the problems and their origin are identified; priorities and solutions are established to reduce risk and promote a healthy life; and finally, an action plan is drawn up with tasks and different activities that must solve the identified problems [15]. Each activity must have its completion date and the person responsible identified; the activities or tasks will be monitored and evaluated in a participatory way [16] so that responsibility is maintained while comparing the modifications with those of the analysis of the health situation that has preceded it [17]. All of the above must be reflected in a document and presented to the population so that the patient contributes with ideas and solutions to the identified problems [18].

The extent of statistical knowledge and skills that public health professionals need to acquire [17] area very important, because knowledge of statistical principles and methods and competence in their application is needed for the effective exercise of health in the community and society [19] [20], and additionally for the understanding and interpretation of the data [21]. This study is focused on analyzing one of the many variables that interact in the health field to achieve consensus between arbitrary or discretionary opinions, as indeterminate elements regarding the criteria evaluated in a scientific context [22], with the use of neutrosophic statistics [23] [24].

Based on the analysis referred to in the study and the level of indeterminacy in the neutrosophic statistical data, this study focuses on:

- Problem situation: differences in criteria when making a clinical decision in tracking the health problems faced by communities
- Main objective: determine the levels of evidence in the recommendations for tracking health problems in community medicine
- Specific objectives:
    - Determine the factors and degrees of recommendations for preventive practices by specialists in the clinical pictures presented.
    - Carry out the measurement and modeling of the neutrosophic variable
    - Present potential alternatives when evaluating the existing indeterminacies of the analyzed variable

Regarding the structuring of the study, the following is exposed:

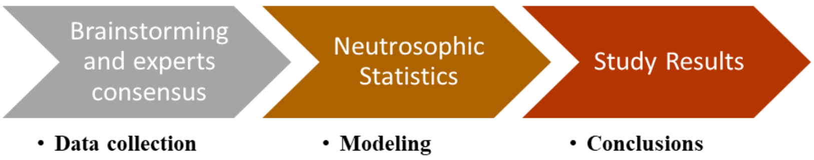

Figure 1: Structure of the study.

2 Materials and methods

<u>Neutrosophic statistics</u>

[25-46] Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that event E will occur [47], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$NP(x) = (T(x), I(x), F(x)),$

Where T(x) represents the probability that the value x occurs, F(x) represents the probability that the value x does not occur, and I(x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [48], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them.

Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [49].

In short, the Neutrosophic Logic [50, 51], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development.

The Neutrosophic Descriptive Statistics includes all of the techniques to summarize and describe the characteristics of the neutrosophic numerical data [52].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers [53], while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable when formulating ($\bar{x}_N$):

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \quad (1)$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N} \sum_{i=1}^{n_N} X_{il}, \bar{x}_b = \frac{1}{n_N} \sum_{i=1}^{n_N} X_{iu}, n_N \in [n_l, n_u] \quad (2)$$

is a neutrosophic random sample. However, for the calculation of neutral frames (NNS), it can be calculated as follows.

$$\sum_{i=1}^{n_N}(X_i-\bar{X}_{iN})^2=\sum_{i=1}^{n_N}\begin{bmatrix}\min\begin{pmatrix}(a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U)\\(a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U)\\(a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U)\end{pmatrix}\end{bmatrix},I\epsilon[I_L,I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2=\frac{\sum_{i=1}^{n_N}(X_i-\bar{X}_{iN})^2}{n_N};\ S_N^2\epsilon[S_L^2,S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is than the other factors. For example, NCV can be calculated as follows[54].

$$CV_N=\frac{\sqrt{S_N^2}}{\bar{X}_N}\times 100;\ CV_N\epsilon[CV_L,CV_U] \tag{5}$$

3 Results

Data collection

Statistics make it possible to analyze situations in which the sample includes random components that contribute significantly to the variability of the data obtained. In community health, the random components are due, among other aspects, to the knowledge or the impossibility of measuring some determinants of the health and disease statuses and the variability in the responses given by the patients who are subjected to the same treatment.

For the development of the neutrosophic statistical study, it is recommended by the experts to analyze the levels of evidence in the recommendations for tracking health problems from the statistical study bases in community medicine (Table 1).

<u>Development of the method</u>

For the neutrosophic statistical modeling of the clinical decision of the health specialist, five factors are selected equivalent to five clinical decisions that exist in the health field, based on typical conditions in the community and society (Table 2).

Variable	Coding	Sample by factor	Scale
Levels of evidence in the recommendations for tracking health problems in community medicine	ERPS	100	$[0;\ 1], \forall F_n$ ERPS = 0 (false) ERPS = 1 (True) $ERPS\ \neq 0.5$ (Existing indeterminacy in ERPS)

Table 1. Characteristics of the variable. Own elaboration

It should be taken into account that the recommendations are subject to constant updates motivated by advances in clinical research and the contributions of statistical information at the international level.

Factor	**Clinical diagnosis of the patient**	**Grade**	**Recommendations of preventive practices by specialists**	**Scale**	**Range of acceptance of the clinical decision regarding treatment**
F1	Hypertension screening in people over 18 years of age.	A	Intervention is recommended. Good evidence was found that the measure	[0; 1]	$[0;\ 1], \forall F_1$ ERPS = 0 (false) $0 \leq ERPS \geq 1$;
F2	Breast cancer screening with mammography every	B	Intervention is recommended. Moderate evidence was found that the measure improves	[0; 1]	

	1-2 years in women aged 40 and over.		health outcomes. The benefits outweigh the risks		ERPS = 1 (True)
F3	Routine screening for osteoporosis in postmenopausal women under 60 years of age.	C	There is no recommendation for or against the intervention. At least moderate evidence was found that the measure improves health outcomes. The benefits are very similar to the risks.	[0; 1]	$ERPS \neq 0.5$ (Level of acceptance of the recommendation among specialists)
F4	Screening for pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound, or serological markers.	D	It is recommended against performing the intervention. We found moderate evidence that the measure is ineffective. The risks outweigh the benefits.	[0; 1]	ERPS = 0.5 (Indeterminacy of ERPS level, other clinical studies are required to make a consensual and accepted decision)
F5	Routine screening for dementia in the elderly	I	The evidence is insufficient to recommend for or against the intervention.	[0; 1]	

Table 2. Process of basing clinical decisions based on the definitive diagnosis of the patient. Own elaboration

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to relate the consensus of clinical decisions based on the definitive diagnosis of the patient. For each factor, a clinical decision agreed by health specialists is analyzed before a definitive diagnosis of the patient in days that make up the set of clinical decisions regarding treatment in a group of patients (Table 3).

Days	**Neutrosophic frequencies**				
	A	**B**	**C**	**D**	**I**
1	[0.3; 1]	[0.2; 1]	[0.2; 1]	[0.3; 1]	[0.4; 1]
2	[1 ; 1]	[0.2; 1]	[0.2; 1]	[0.1; 1]	[0.9; 1]
3	[0.5; 1]	[0.9; 1]	[0.3; 1]	[0.7; 1]	[0.5; 1]
4	[0.8; 1]	[0; 1]	[0.5; 1]	[0.5; 1]	[1 ; 1]
5	[1 ; 1]	[0.1; 1]	[0.7; 1]	[0.8; 1]	[0; 1]
6	[0.6; 1]	[0; 1]	[0.4; 1]	[0.1; 1]	[0.8; 1]
7	[1 ; 1]	[0; 1]	[0.1; 1]	[0.2; 1]	[0.9; 1]
8	[0.8; 1]	[0.7; 1]	[0.3; 1]	[1 ; 1]	[0.6; 1]
9	[0.6; 1]	[1 ; 1]	[0.8; 1]	[0.1; 1]	[0.9; 1]
10	[0; 1]	[0.6; 1]	[0.5; 1]	[0; 1]	[0.5; 1]
11	[0.3; 1]	[0.8; 1]	[0.3; 1]	[0.4; 1]	[0.3; 1]
12	[0.1; 1]	[0.4; 1]	[0.8; 1]	[0.2; 1]	[0.5; 1]
13	[0.5; 1]	[0.8; 1]	[0.8; 1]	[0.5; 1]	[1 ; 1]
14	[0.1; 1]	[0.9; 1]	[0.4; 1]	[0.5; 1]	[0.2; 1]
15	[0.9; 1]	[0.9; 1]	[0; 1]	[0.9; 1]	[0.3; 1]
16	[0.5; 1]	[1 ; 1]	[0.8; 1]	[0.2; 1]	[0.5; 1]
17	[0.7; 1]	[0.3; 1]	[0.9; 1]	[0.6; 1]	[0.6; 1]
18	[1 ; 1]	[0.6; 1]	[0.1; 1]	[0.2; 1]	[0.1; 1]
19	[0; 1]	[1 ; 1]	[0.5; 1]	[0.4; 1]	[0.3; 1]
20	[0.4; 1]	[0.2; 1]	[0.5; 1]	[0.4; 1]	[0; 1]
0-100	[51.1; 100]	[49.9; 100]	[48.9; 100]	[50.4; 100]	[53.9; 100]

Table 3. Relative neutrosophic frequency of the ERPS level. Own elaboration

Table 3 analyzes the level of ERPS for a sample of 100 patients from the community for each factor, of which the level of acceptance of health specialists about the clinical decision regarding treatment is measured. From the neutrosophic frequencies, it can be observed with a level of acceptance of the clinical decision regarding the treatment of $[0;\ 1]$ for each clinical picture reviewed with a level of total indeterminacy of $A = 48.9, B = 50.1, C = 51.1, D = 49.6, I = 46.1$, with a level of representativeness of $[46.1\%;\ 51{,}1\%]$, on the days that complex clinical pictures are evaluated. of patients, where the preliminary screening results have a level of contradiction or indeterminacy close to 0.5 per factor analyzed, with a higher incidence of factors *screening for breast cancer with mammography every 1-2 years in women over 40 years of age and screening for pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound or serological markers.* Given the existing levels of indeterminacy, the use of classical statistics is not appropriate, so it is necessary to use neutrosophic statistics for a better understanding.

<u>Neutrosophic statistical analysis</u>

While modeling the data on the level of acceptance of the clinical decision regarding the treatment of affectations of the evaluated patients, it can be observed that factors 2 and 4 require studies with a level of depth to determine an accurate prognosis (Table 4). To understand which factor implies a representative mean, $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated, and for the study of the variations of the affectations, the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$. To determine which factor requires a level of evidence in the recommendations for tracking health problems in community medicine, the values $CV_N \in [CV_L ; CV_U]$ are calculated.

Factors	$\bar{x}_N$	YN	CVN
Hypertension screening in people over 18 years of age.	0.852 + 1.667 I	0.157 + 0.808 I	0.184 + 0.485 I
Breast cancer screening with mammography every 1-2 years in women aged 40 and over.	0.832 + 1.667 I	0.16 + 0.811 I	0.192 + 0.487 I
Routine screening for osteoporosis in postmenopausal women under 60 years of age.	0.815 + 1.667 I	0.129 + 0.728 I	0.158 + 0.437 I
Screening for pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound, or serological markers.	0.84 + 1.667 I	0.107 + 0.704 I	0.127 + 0.422 I
Routine screening for dementia in the elderly	0.898 + 1.667 I	0.125 + 0.721 I	0.139 + 0.433 I

Table 4. Neutrosophic statistical analysis of the level of ERPS. Own elaboration

Table 4 shows that for the routine screening of dementia in the elderly, health specialists needed a level of clinical studies to achieve consensus in the clinical decision lower than the other factors analyzed. This means that the I degree recommendation for the corresponding type of clinical picture is, on average, the one that most influences when it comes to obtaining the consensus of the specialists without having to resort to the results of studies of great clinical complexity. On the other hand, the CV_{ND} analysis for this factor is lower compared to the rest. This represents that for the screening of pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound, or serological markers there is a level of contradiction and uncertainty when deciding a treatment if there are no weight elements to apply D degree recommendation with the necessary clinical tests (Figure 2)

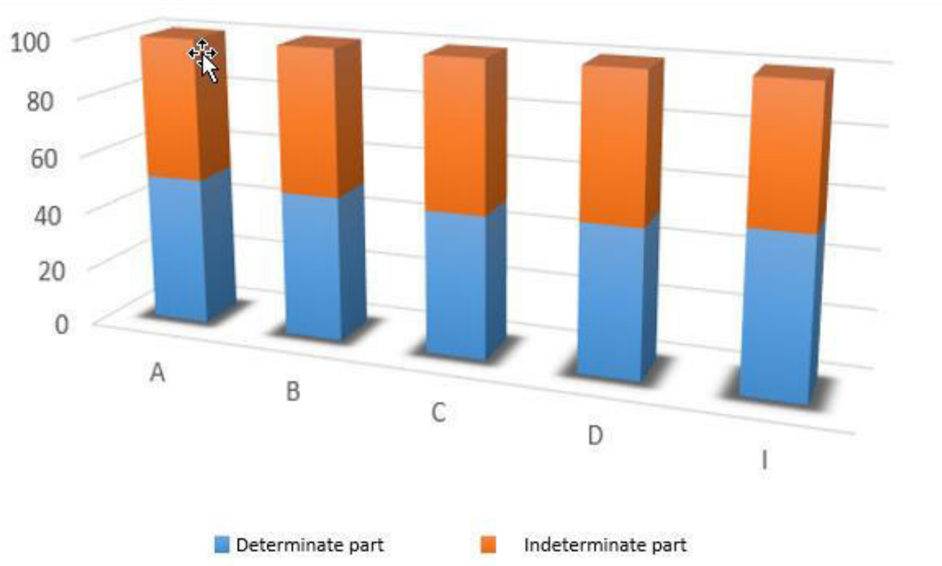

Figure 2. Neutrosophic bar graph of ERPS incidents from clinical specialists. Own elaboration

Comparative analysis

To determine the associated indeterminacy measure $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L ; CV_U]$ for the form of neutrosophic numbers (Table 5). In the results obtained, it is observed that the values go from 0.127 to 0.192 with the measure of indeterminacy of 69.9 generated by *screening for pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound, or serological markers*. It is required for these clinical pictures that more in-depth studies be directed for screening tracking of health problems in community medicine and the search for statistical studies on the subject where contradictions and indeterminacies are diversified in various degrees of recommendation to obtain a level of consensus of specialists within the analyzed element of the neutrosophic set of the community.

Factors	$\bar{x}_N$	***YN***	***CVN***
F1	0.852 + 1.667 I; I $\in [0; 0.48]$	0.157 + 0.808; I $\in [0; 0.80]$	0.184 + 0.485 I; I $\in [0; 0.62]$
F2	0.832 + 1.667 I; I $\in [0; 0.50]$	0.16 + 0.811 I; I $\in [0; 0.80]$	0.192 + 0.487 I; I $\in [0; 0.60]$
F3	0.815 + 1.667 I; I $\in [0; 0.51]$	0.129 + 0.728 I; I $\in [0; 0.82]$	0.158 + 0.437 I; I $\in [0; 0.63]$
F4	0.84 + 1.667 I; I $\in [0; 0.49]$	0.107 + 0.704 I; I $\in [0; 0.84]$	0.127 + 0.422 I; I $\in [0; 0.69]$
F5	0.898 + 1.667 I; I $\in [0; 0.46]$	0.125 + 0.721I; I $\in [0; 0.82]$	0.139 + 0.433 I; I $\in [0; 0.67]$

Table 5. Neutrosophic forms with a measure of indeterminacy

The results obtained in the study propose promoting alternatives based on the results of preliminary clinical studies in patients with presented clinical pictures. The variants presented allow actions to be taken based on the level of indeterminacy and acceptance of the levels of evidence in the recommendations for tracking health problems in community medicine (Figure 3).

Partial solutions

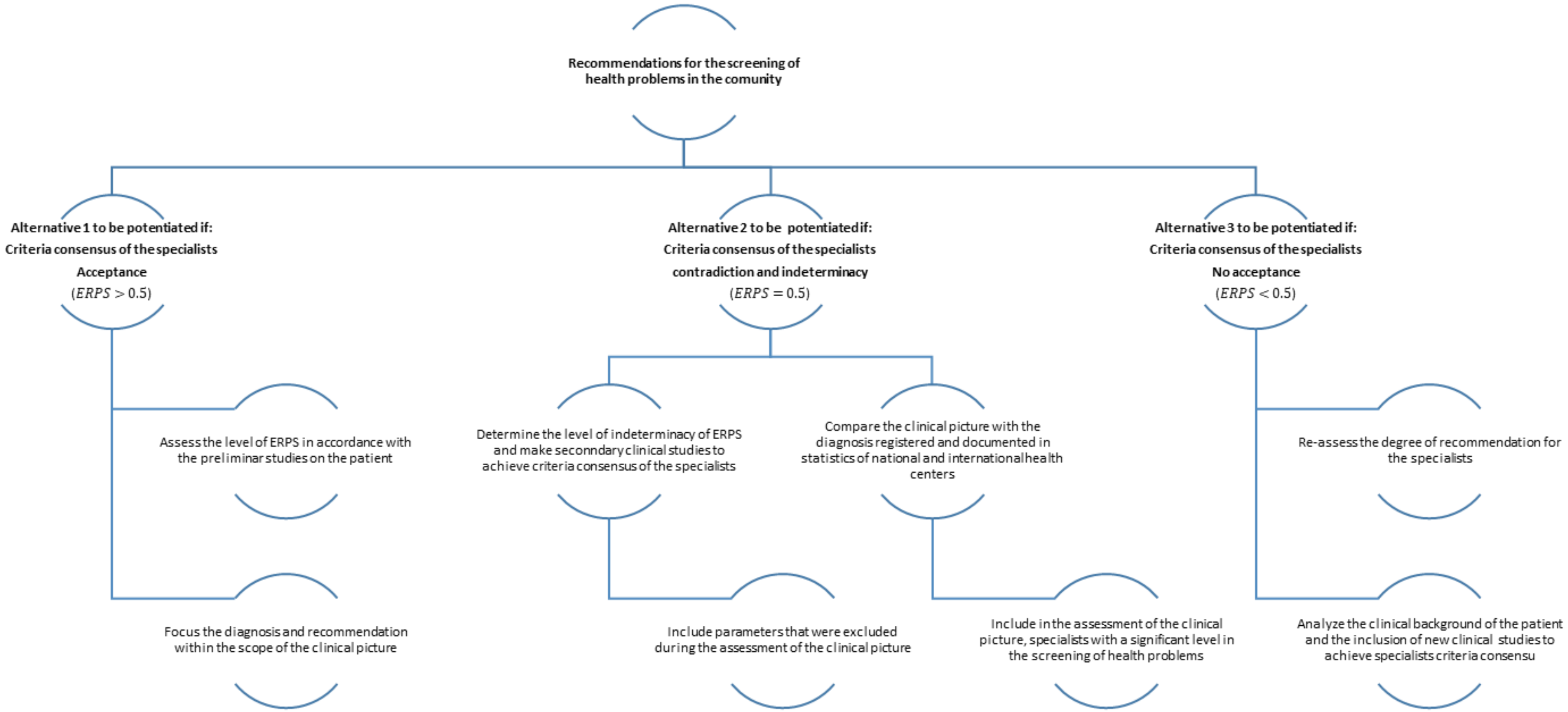

Figure 3. Alternatives based on the neutrosophic states of the ERPS variable [0; 1]. Own elaboration

Conclusions

- Statistical analysis in medicine provides knowledge of the population's health status by considering the different indicators for the population, scientific contributions, and statistical studies of diagnoses of clinical pictures. Although, the scenario measures deviations from the health status and not the health itself, it must be taken into account that the community health situation may vary greatly in short periods and the learning of the elaboration of the analysis of the health situation has a formative character for the learners.
- Neutrosophic statistics reveal a more direct approach in community health, considering among the investigations the indeterminacies of the variables that influence the health field. This study made it possible to evaluate the levels of evidence in the recommendations for the screening of health problems in community medicine, among which the screening factor for *pancreatic cancer in asymptomatic adults using abdominal palpation, ultrasound, or serological markers* as an element with a CV of 69.9% of indeterminacy for the analyzed sample so that it affects the moment of giving a diagnosis and a correct grade of recommendation.
- Neutrosophic statistics are present in each health field dimension, subdivided into neutrosophic components of the analyzed variable. Each alternative responds to each neutrosophic state of the variable in the neutrosophic set. Statistical studies and research are required to determine variables with a level of indeterminacy in the field of study.

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Legal Causal Reasoning. Cause-effect Analysis using a Neutrosophic Environment

José Rodolfo Calle Santander[1], Rously Atencio González[2], Alipio Cadena Posso[3] and Wilson René Paredes Navarrete[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.josecalle@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.rouslyatencio@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.alipiocadena@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.wilsonparedes@uniandes.edu.ec

Abstract. Causal reasoning is implicit in all areas of human life, which is why it is strongly applied within the legal framework. This is valid in both criminal and civil proceedings. For the construction of legal causal models, moral reasoning and understanding of the subject are required. It is a process that implies subjectivity and neutrality. Therefore, it is intended to illustrate the usefulness of causal analysis techniques for decision-making in the dynamics of legal reasoning in a neutrosophic environment given the subjectivity of the process. For that purpose, the methods applicable to this research will be enunciated and will be illustrated in a case study. With the use of the Ishikawa Diagram, Pareto analysis, and Neutrosophic Cognitive Maps, we were able to establish the cause-effect tree as well as the main conclusions concerning legal causal reasoning applied to the increment of traffic accidents in Ecuador.

Keywords: legal causal reasoning, decision making, subjectivity, neutrosophic environment

1. Introduction

Detecting and reasoning with causal relationships are essential for daily life. For this reason, the concept of causality and its wide variety of phenomena occupies a central place in many areas of psychological knowledge: from the study of perception and learning, reasoning and judgment, to comparative studies of language, social cognition, and the research methodology. This may be affected by age since some authors affirm that adults show a type of reasoning guided by a different nature [1].

Two types of competencies come into play in adult causal inferences. These may serve common purposes but are different [1]:

- ✓ one, of the general domain that allows the identification of conditional probabilistic relationships between events and their updating based on the results of systematic interventions;
- ✓ another, metacognitive and highly sensitive to the context, which makes possible the representation of new information dissociated from the domain and previous knowledge.

The first arises early in childhood, the second does not, but appears spontaneously at some specific point during physical and mental development [1].

In general, it can be said that, in all reasoning, premises are the starting point of the inference and the foundation for the conclusion. The inferential process is responsible for the nexus between the two components. Inferential processes operate when questions are resolved by appealing to available information or knowledge. From the knowledge that one has regarding a certain problem situation, ideas can be related to each other, but for this, it is not enough to have all the necessary information to reach a valid conclusion [2].

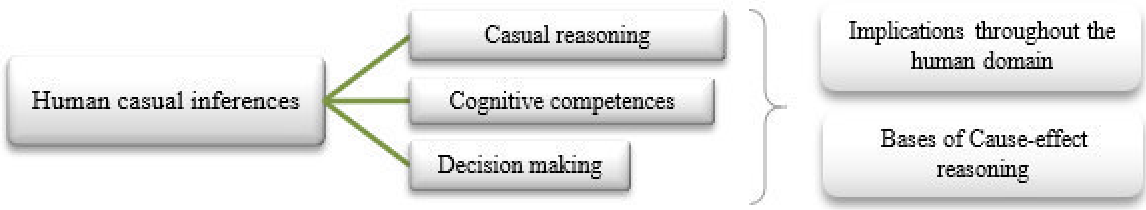

Figure 1: Adult causal inferences.

Causal reasoning is ubiquitous in law. This is valid in both criminal and civil proceedings. Thus, criminal offenses are analyzed in terms of two key elements: the action of the accused (criminal law) and the accused's mental state at the time of the action [3]. This is endorsed in what is stated by [4, 5]:

> Legal reasoning is the ability to legally qualify facts that generate legal controversies to resolve them on legal-objective bases with legal, logical and rational validity. (p. 15). (...) To reason legally, then, is to build a solution or "solutions" or vehicles to conflicts that people are not capable of solving by themselves, in the application of rational bases solidly established by the legal system (p. 17)

Figure 2 illustrates the dependence of legal and moral reasoning on causal understanding and the relatively sophisticated use of counterfactual reasoning. The notion of causality is embedded in legal doctrine and also implicit in moral reasoning. Although it is said that it is not clear precisely what this notion of causality is equivalent to, how it relates to scientific or everyday conceptions of causality, and how it supports our legal and moral decisions. It can be argued that legal decisions should be consistent with moral judgments, and the latter is based on common sense principles [3].

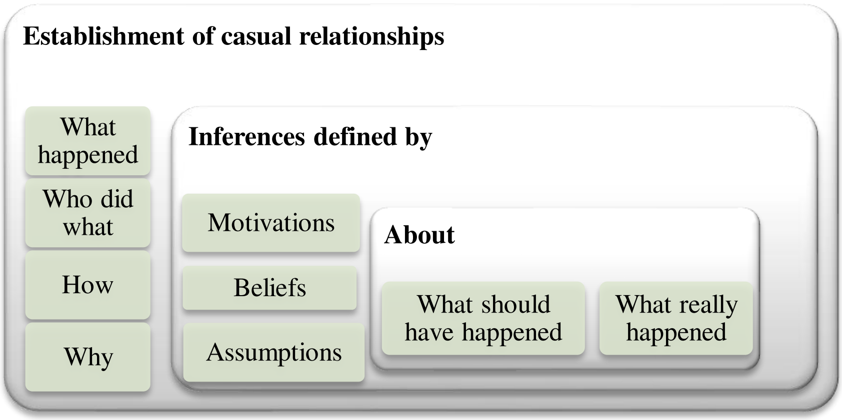

Figure 2: Construction of causal models for legal reasoning.

Legal casual analysis operates with two notions: factual and legal or proximate causation. They are supposed to work in two stages: initially, the factual causes of a case are identified; then one (or more) of them is selected as a legal cause. The separability of these steps has been questioned, both for theoretical reasons and in terms of the actual practice of first instance judges. But the conceptual distinction is standard in legal texts [3, 4]. Factual causation is assumed to correspond to what happened in the case, regardless of any legal assessment or judgment. Knowing this depends on the details of the case, the evidence and arguments presented, and everyday assumptions about how people and things work. These are complemented by expert knowledge (for example, in medical or scientific contexts). The standard test of causation is the test *but/for* which is defined as the action of the defender is a factual cause of the result. Which is essential for making a final decision [3].

There is no room for prejudices, stereotypes, or false generalizations in judicial work, since incurring them would imply an unacceptable error of appreciation [4]. However, this type of reasoning does have a high level of subjectivity implicit. For its management under uncertainty and for its objective of explaining why a particular conclusion is reached, causal models can be used. These models are very useful in making decisions under uncertainty and can be used to carry out evidential reasoning [6-8] as exposed by [4]:

Legal research can be divided into three distinct but interrelated phases:

1. Explanatory: What happened?
2. Evidential: What is the evidentiary support? Proof?
3. Attributive: Who or what is responsible?

Therefore, causal models are practical tools to understand these complex systems and establish causes to predict their effects. It can then be said that causal reasoning is useful in decision-making for two fundamental reasons: it is natural and easy to understand and it is convincing [6-8].

Due to its versatility in factor research, the Neutrosophic Cognitive Maps are used from the theory of Neutrosophy proposed by Florentin Smarandache. Neutrosophy is a useful theory that is increasing the inclusion of this theory enriches the possibilities of analysis, mainly due to two issues: the addition of the notion of indeterminacy and the possibility of calculating using linguistic terms [7, 8]. The decision to apply this technique lies in the fact that this represents knowledge through a directed graph. In which, the value in modulus of the value measures the strength between the relationship. Which will enrich the causal legal reasoning.

Based on the above, this article aims to illustrate the usefulness of causal analysis techniques for decision-making in the dynamics of legal reasoning in a neutrosophic environment given the subjectivity of the process.

For this, the methods applicable to this research will be enunciated and will be illustrated in a case study. From now on this article is made up of several sections with the explanation of the methods to be used, the presentation of the case study, and the demonstration of the main objective of the research. Finally, the discussion of the case and the conclusions reached based on the results obtained.

2 Methods

For the resolution of the problem, techniques of cause-effect analysis are used in a neutrosophic environment to illustrate its usefulness in legal reasoning. Due to which the notions of interest for this article are detailed below:

2.1 Tools for the analysis of causes

2.1.1 Ishikawa diagram

A Cause and Effect diagram represents various elements (causes) of a system that can contribute to a problem (effect). It was developed in 1943 by Professor Kaoru Ishikawa in Tokyo. It is sometimes called the Ishikawa or Fishbone Diagram. It is an effective tool for studying processes and situations and developing a data collection plan [9]. It is used to identify the possible causes of a specific problem. The graphical nature of the Diagram allows groups to organize large amounts of information about the problem and determine exactly the possible causes. Finally, the probability of identifying the main causes increases. The Cause and Effect Diagram should be used when people can answer “yes” to one or both of the following questions:

1. Is it necessary to identify the main causes of a problem?
2. Are there ideas and/or opinions about the causes of a problem?

Frequently, people closely associated with the problem under study have formed opinions about the causes of the problem. However, these opinions may conflict or fail to express the main cause. The use of a Cause and Effect Diagram makes it possible to bring all these ideas together for study from different points of view.

The development and use of Cause and Effect Diagrams are most effective after the process has been described and the problem is well defined. By that time, team members will have a good idea of what factors should be included in the Diagram. They can also be used for purposes other than root cause analysis. The format of the tool lends itself to planning. For example, a group could brainstorm the “causes” of a successful event, such as a seminar, conference, or wedding. As a result, they would produce a detailed list grouped into the main categories of things to do and include for a successful event.

Although this technique does not offer an answer to a question, as other tools such as Pareto Analysis and Histograms do, it is a vehicle to help teams have a common conception of a complex problem. For this, all its elements and relationships must be visible at any level of detail required.

2.1.2 Pareto analysis

Pareto diagram was presented in 1930 by Jurán in his Quality Control Manual based on what was described in 1909 by Vilfredo Pareto under the principle of "the few vital, the many trivial". This diagram is based on problem analysis and is used to present data, drawing attention to the causes of the greatest incidence in the problem at hand. Aims to determine 20% of the causes that provoke 80% of the problems [10, 11]. Its main advantages are:

- ✓ It allows focusing on the aspects whose improvement will have the most significant impact, thus optimizing efforts.
- ✓ Provides a quick and easy view of the relative importance of issues.
- ✓ It helps prevent some causes from getting worse by trying to fix other less significant ones.
- ✓ His graphical view of the analysis is easy to understand and encourages the team to continue with improvement.

The following algorithm is run to execute it:

a) Collect the data and tabulate it.
b) Calculate absolute and cumulative frequency, relative unit, and cumulative frequency.
c) Graph by locating all the causes along the coordinate axis ordered from highest to lowest incidence and correspond with their percentages along the ordinate axis. Finally, the cumulative polygonal line is constructed, and the causes that are up to 80% will be those with the highest incidence.

2.2 Neutrosophic Cognitive Maps

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [12-14]. NCMs were introduced by [15] in 2003. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995 [16]. This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty[13, 17-25].

[16] exposes that FCMs constitute a technique that has received increasing attention due to its possibilities for representing causality. The following is a set of definitions necessary for working with NCMs. Firstly, let formally expose the original definition of neutrosophic logic as it is shown in [26].

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [27, 28].

Definition 1. (See [29, 30]) Let K be the ring of real numbers. The ring generated by K∪I is called a *neutrosophic ring* if it involves the indeterminacy factor in it, where I satisfies $I^2 = I$, I+I = 2I, and in general, I+I+...+I = nI, if k∈, then k.I = kI, 0I = 0. The neutrosophic ring is denoted by K (I), which is generated by K∪I, i.e., K(I) = <K∪I>, where <K∪I> denotes the ring generated by K and I.

Definition 2. A *neutrosophic matrix* is a matrix $A = [a_{ij}]_{ij}$ i =1, 2, …, m and j = 1, 2, …, n; m, n≥1, such that each $a_{ij} \in K(I)$, where K(I) is a neutrosophic ring, see [31].

Let us observe that an element of the matrix can have the form a + bI, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. Then, the usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example, $\begin{pmatrix} -1 & I & 5I \\ I & 4 & 7 \end{pmatrix}\begin{pmatrix} I & 9I & 6 \\ 0 & I & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21I & 27I & -6+25I \\ -28+I & 49+13I & 35+6I \end{pmatrix}$

Additionally, a *neutrosophic graph* is a graph that has at least one indeterminate edge or one indeterminate node [26, 32]. The *neutrosophic adjacency matrix* is an extension of the adjacency matrix in classical graph theory. $a_{ij} = 0$ means nodes i and j are not connected, $a_{ij} = 1$ means that these nodes are connected and $a_{ij} = I$, which means the connection is indeterminate (unknown whether it is or not). Fuzzy set theory does not use such notions.

On the other hand, if the indetermination is introduced in a cognitive map as it is referred to in [33], then this cognitive map is called a *neutrosophic cognitive map*, which is especially useful in the representation of causal knowledge [27, 34]. It is formally defined in Definition 4.

Definition 3. A *Neutrosophic Cognitive Map* (NCM) is a neutrosophic directed graph with concepts like policies, events, among others, as nodes and causalities or indeterminacy as edges. It represents the causal relationship between concepts.

The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [33]:

- ✓ Outdegree (v_i) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of the outgoing relationships (c_{ij}) of the variable.
  $$od(v_i) = \sum_{i=1}^{n} c_{ij} \quad (1)$$
- ✓ Indegree (v_i) is the sum of the column elements. It reflects the strength of relations (c_{ij}) outgoing from the variable.
  $$id(v_i) = \sum_{i=1}^{n} c_{ji} \quad (2)$$
- ✓ Total centrality (total degree td (vi)), is the sum of the indegree and the outdegree of the variable.
  $$td(v_i) = od(v_i) + id(v_i) \quad (3)$$

The variables are classified according to the following criteria, see [35]:

a) The transmitting variables are those with od (vj)> 0 and id (vi) = 0.
b) The receiving variables are those with od (vj) = 0 and id (vi)> 0.
c) Ordinary variables satisfy both od (vj) ≠ 0 and id (vi) ≠ 0.

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights [32]. Static analysis in Neutrosophic Cognitive Maps (NCM), see [34], initially contains the neutrosophic number of the form (a + bI, where I = indetermination) [36]. It requires a process of de-neutrosophication as proposed in [33], where I ∈ [0, 1] and it is replaced by their values maximum and minimum.

Finally, we work with the average of the extreme values, which is calculated using Equation 5, which is useful to obtain a single value as it is referred to in [37]. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (4)$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (5)$$

3 Case study "Traffic Accidents"

The Ecuadorian present is threatened with the occurrence of traffic accidents, especially those that take human lives. Every year, about 1,200 people die as a result of a traffic accident. In this situation, young people are more exposed: most of their deaths in Ecuador are caused by traffic accidents. According to statistics, diseases, HIV, homicides, or suicide have lower death rates than traffic accidents. The figures correspond to the Births and Deaths report, prepared by the NISC (National Institute of Statistics and Censuses) [38-46]. This was the main cause for 19.2% of adolescents (10 to 19 years) to lose their lives, as well as 26.8% of young people (20 to 30 years). The report date back to 2018, the last year published by this institution on its website.

More than 300 thousand traffic accidents were registered in the last 10 years. Despite the restrictions due to the COVID-19 pandemic, traffic accident statistics are on the rise. An increase in the amount was perceived when several cantons went into the yellow phase and added about 500 car crashes between May and June in the canton of Guayas. On a national scale, the figures are similar. During April, one of the months with the greatest impact of the coronavirus in the coastal provinces, there were 512 traffic accidents in the country. In June the figure rose to 1,165.

According to the National Traffic Agency, the five leading causes of accidents are:

- ✓ Using the cell phone, watching video screens, or putting on makeup behind the wheel.
- ✓ Speeding.
- ✓ Failure to maintain a safe distance from the vehicle in front.
- ✓ Sudden lane changes.
- ✓ Do not walk through security zones.

Drivers are to blame for the majority of traffic accidents in Ecuador, according to NISC. The *inexperience and irresponsibility of the driver* with 49.6% is the first cause of accidents. It is followed by *speeding* (15.9%), *disrespect for traffic signs* (11.9%), *drunkenness* or *drugs* (7.5%), *bad crossing/invading lane* (6.2%), the *irresponsibility of the pedestrian* (4.5%), and *other causes* (4.3%).

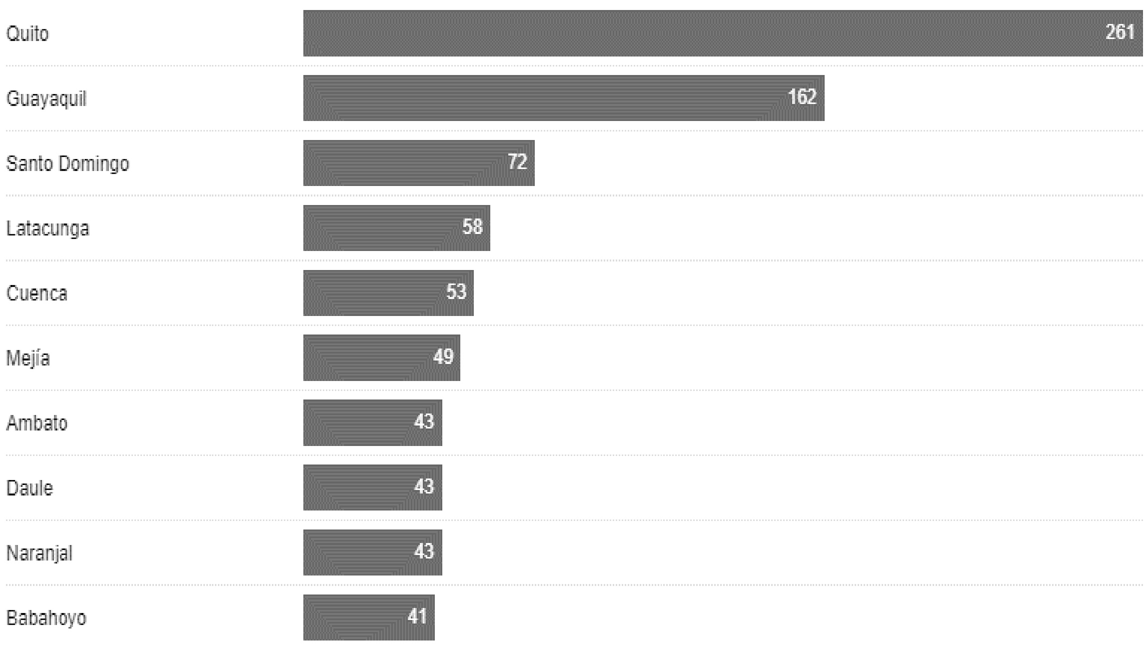

Figure 3: Cantons with the biggest number of deaths caused by traffic accidents. Source: [39]

In Ecuador, there are sanctions for offenders who commit these violations, but according to what the experts have stated, this does not prevent the causes, it only mitigates the occurrence of the event. In themselves, most take place due to the irresponsibility of the authors. An example of this is the provisions of article 106 of the Organic Law of Land and Road [47]: Traffic offenses are actions or omissions that, while being able to be foreseen, but not wanted by the perpetrator, are verified due to negligence, irresponsibility, or inexperience, or due to non-observance of the laws, regulations, resolutions and other traffic regulations. (p. 55)

4 Results

The methods described will be applied to direct the causal legal reasoning to the possible solution of the following problem: increase in traffic accidents in Ecuador.

4.1 Ishikawa diagram

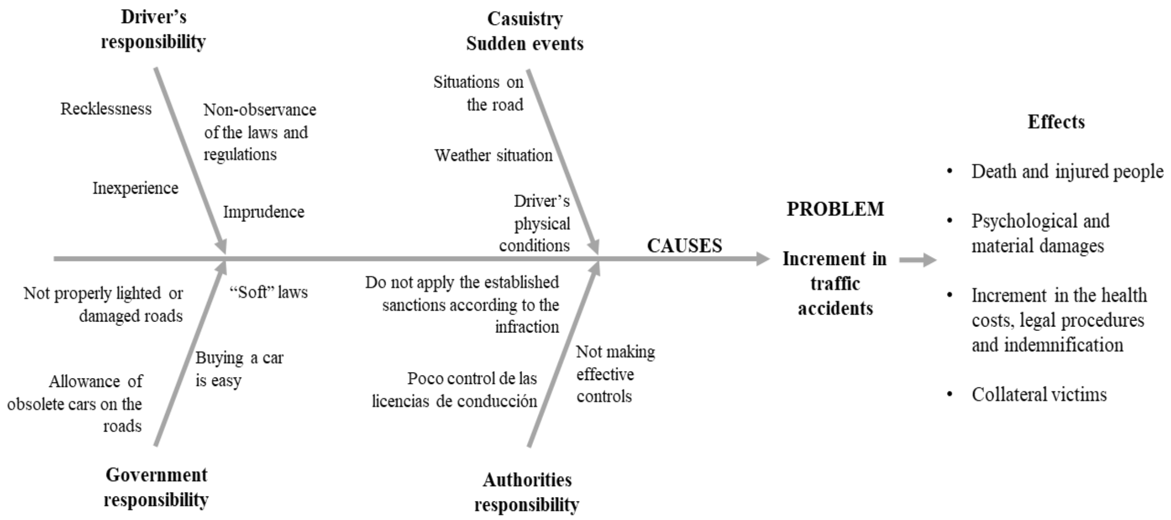

Figure 3: Ishikawa diagram and cause-effect tree.

4.2 Pareto analysis

To obtain the data, we searched for the statistical information of the accidents that occurred in the period analyzed in [40]. As can be seen in figure 4, the causes that provoke the highest level of incidence (83.33% accumulated frequency) are effective control (EC), vehicle acquisition (VA), license control (Lic), non-observance of the law (NL), negligence (N), inexperience (In), imprudence (Imp), *soft* application (SL) of the law as well as failure to punish drivers as established for the offense committed (NP).

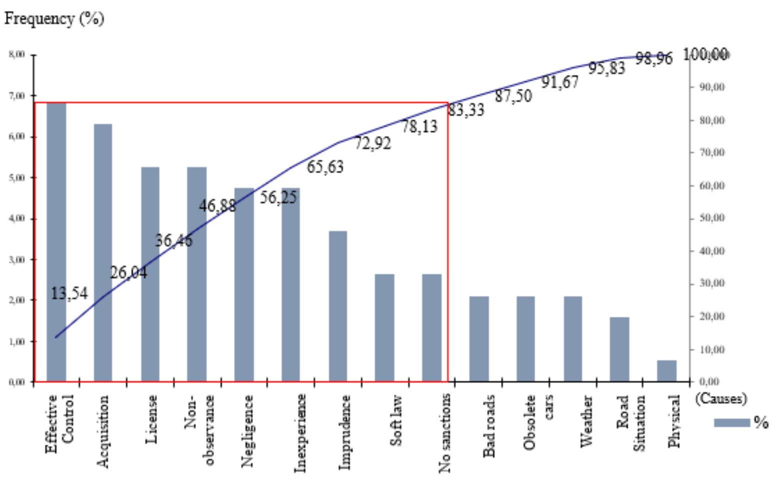

Figure 4: Pareto analysis.

4.3 Neutrosophic Cognitive Map

The causes that lead to 80% of the problems diagnosed through Pareto analysis will be chosen. To simplify its graphical representation, the following coding will be adopted for the nodes:

1. Effective control (EC)
2. Vehicle acquisition (VA)
3. Control over license (Lic)
4. Non-observance of the law (NL)
5. Negligence (N)
6. The inexperience (In)
7. Recklessness (Imp)
8. Soft law enforcement (SL)
9. Failure to punish drivers as established for the offense committed (NP)

For the construction of the map, a selection was made from a panel of experts made up of 3 lawyers, 2 traffic policemen, 4 young drivers. For the information processing, the resulting neutrosophic matrix and its centrality analysis were elaborated using equations 1-4. Figure 5 shows the network of nodes and their weights according to the previous calculations.

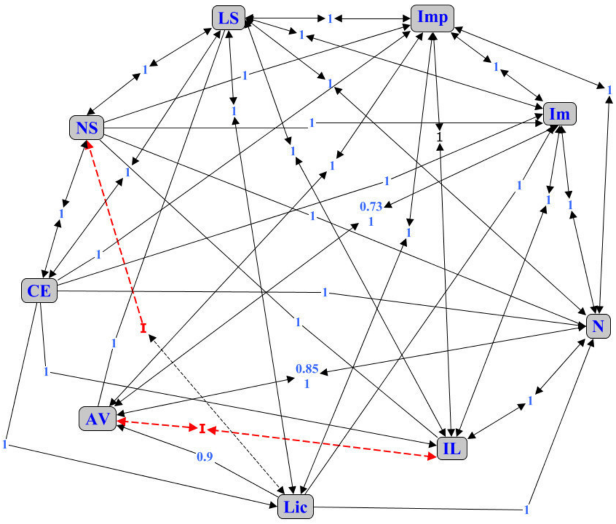

Figure 5: Neutrosophic cognitive map.

	CC	VA	Lic	NL	N	In	Imp	SL	NP
CC	0	0	1	1	1	1	1	1	1
VA	0	0	0	I	0.85	0.73	1	0	0
Lic	1	0.9	0	0	1	1	1	1	I
NL	0	I	0	0	1	1	1	1	0
N	0	1	0	1	0	1	1	1	0
In	0	1	0	1	1	0	1	1	0
Imp	0	1	1	1	1	1	0	1	0
SL	1	1	1	1	1	1	1	0	1
NP	1	1	1	1	1	1	1	1	0

Table 1: Neutrosophic adjacency matrix.

Equation 4 is used for de-neutrosophication and calculation of centrality.

Nodes	*od*	*id*	*td*	*Ranking*
EC	7	3	10	5
VA	2.58 + I	5.9 + I	5.24	9
Lic	5.9 + I	4	7.45	7
NL	4 + I	6 + I	6	8
N	5	7.85	12.85	3
In	5	7.73	12.73	4
Imp	6	8	14	2
SL	8	7	15	1
NP	8	2 + I	9.5	6

Table 2: Centrality analysis.

From the centrality analysis it can be observed that id = od ≠ 0; therefore it can be said that the nodes are all ordinary, that is, they are cause and effect at the same time. In such a way that they transmit information when they are activated as well as when they receive it. Which implies a causal phenomenon.

5 Legal causal reasoning of the case study

The type of traffic offense requires that the vehicle's driver has put the life or physical integrity of the people in concrete danger. Therefore, taking into consideration the information processed, it can be said that the imposition of severe penalties would mitigate the situation but should not be taken as the solution to the problem, since other causes are not related. The legislation should consider that for a person to obtain a driver's license they should have experience since it is not always a requirement. For prevention, a training system must be adopted from educational centers, in the future these students would-be drivers with sufficient basic knowledge.

Conclusion

- ✓ Causal reasoning is implicit in all areas of human life, which is why it is strongly applied within the legal framework. Due to its characteristics, it is very useful in decision-making.
- ✓ For the construction of legal causal models, moral reasoning and understanding of the subject are required. It is a process that implies subjectivity and neutrality. Therefore, it is convenient to study it using cause-effect analysis techniques in a neutrosophic environment. The usefulness of the tools is denoted.
- ✓ Traffic accident rates are high, especially in young people, and their causes are variable.
- ✓ Of the 14 causes determined as probable, according to the statistics consulted we determined that 9 of them are vital (83%) and 5 trivial (17%).
- ✓ The main causes determined by the experts and the legislation are the following: negligence, recklessness, inexperience, and casuistry. By their nature, the first three constitute a non-observance of the legislation. From them, in consideration of the criteria set forth and the processing using the neutrosophic technique, it can be said that there is the following hierarchical order:
    1. Soft law enforcement (SL)
    2. Imprudence (Imp)
    3. Negligence (N)
    4. The inexperience (In)
    5. Effective control (EC)
    6. Failure to punish drivers as established for the offense committed (NP)
    7. Control over license (Lic)
    8. Non-observance of the law (NL)
    9. Vehicle acquisition (VA)

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Neutrosophic K-means for the analysis of earthquake data in Ecuador

Jesús Estupiñán Ricardo [1], Jorge Juan Domínguez Menéndez [2], Ignacio Fernando Barcos Arias[3] , Jorge Manuel Macías Bermúdez[4] and Noel Moreno Lemus[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.c.investigacion@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: direccionbabahoyo@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.ignaciobarcos@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.jorgemacias@uniandes.edu.ec
[5]Procter & Gamble International Operations S.A. Panamá. Email: nmlemus@gmail.com

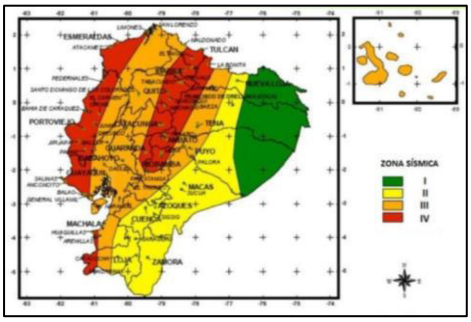
Abstract. The occurrence of earthquakes may have catastrophic and devastating consequences for the inhabitants of the place where they occur. Some regions are characterized by the high frequency of this type of natural phenomenon. Such is the case of Ecuador, a country with a high seismic index due to its location in a subduction zone between the Pacific Plate and the South American Plate. Predictions in the behavior of earthquakes are a way of prevention that allows taking measures according to vulnerability. Although it is difficult to accurately predict the occurrence of an earthquake, there are dissimilar types of analysis to observe its behavior and patterns of occurrence. The nature of earthquakes and their monitoring variables usually make up large databases. For its processing and subsequent analysis of the results, it is convenient to use statistical techniques of Data Mining such as K-Means. In this work, the classic K-Means method is combined with Neutrosophy to improve the results obtained by taking into account the indeterminacy of such complex data sets and including the diversity of the data and its fluctuation, due to the proximity among the boundaries and their membership clusters.

Keywords: K-means clustering, Neutrosophy, earthquakes, prediction, vulnerability

1 Introduction

Due to the devastating effects of earthquakes, society has needed to predict their behavior as a way of prevention [1]. Such is the case of Ecuador, which has a high seismic index due to its location in a subduction zone between the Pacific Plate and the South American Plate, known as the Pacific Ring of Fire. Statistics show that there is a high probability of a major earthquake every 40 years. In other words, if a person lives permanently in the country, he has a high possibility of experiencing at least two major earthquakes during his life, as illustrated in Figure 1[1-3]. This situation, linked to the unfavorable economic indicators that this country has, enhances the negative effects of the phenomenon.

The ability of a disadvantaged population to recover from an earthquake is affected by limited economic and political capital [4]. Numerous studies examining social vulnerability use quantitative indices often modeled with census data to illustrate to governments the need for predictive studies and improvement of quality of life. The imminence of suffering the consequences of a big natural disaster prompts researchers to improve the living conditions of residents in the country by studying their behavior [2, 4-15]. That is why an infrastructure of equipment has been installed to achieve the best possible follow-up of the events.[16] (Figure 1).



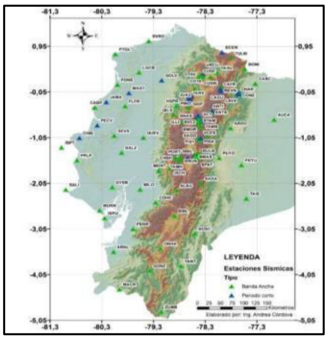
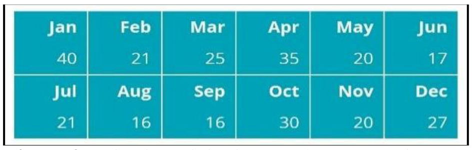


Figure 1. Seismic risk in Ecuador [3] and network of seismic stations [16].

Predictions in the behavior of earthquakes are a form of prevention that contributes to the right to life as part of the human rights of Ecuadorians. Although it is known that it is difficult to accurately predict the occurrence of an earthquake, there are dissimilar types of analysis that range from the behavior of variables and their patterns to the identification of vulnerabilities as illustrated in Figures 2 and 3 [1-3, 13, 14, 17]. Due to its heterogeneous nature, analyzing earthquakes combines statistics and probabilistic with decision-making methods that integrate multiple data sets [2, 11, 13, 18]. The choice of evaluation criteria has been different since the multicriteria evaluation was adopted as a problem-solving and decision-support tool[15, 19].



Jan	Feb	Mar	Apr	May	Jun
40	21	25	35	20	17
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
21	16	16	30	20	27

Figure 2. Seismic activity in Ecuador 2020 [16].

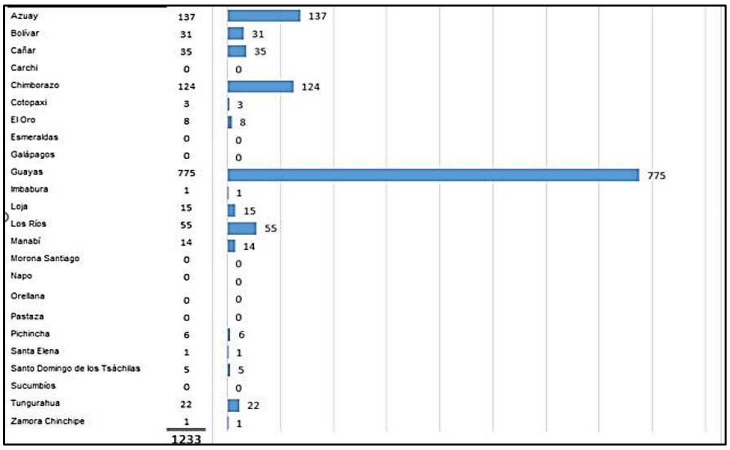


Figure 3. Histogram of earthquake occurrences in 2021 by province [17].

There are studies focused on geophysical factors[20-22]; some other have integrated social vulnerability [23, 24]; but all converge on the need to provide strategies for action. In general, they facilitate simple unit comparisons that can be used to illustrate the complexity of dynamic environments in wide-ranging fields. Despite their heterogeneity, they all expose the possibility of predicting behavior to predict actions by combining criteria of different natures and requires a series of steps in which decisions must be made.[25-27]. This enables preparation and response programs to reduce the negative impacts of these natural disasters.[3, 15, 17].

These phenomena are variable, but within their unpredictability, patterns are sought that achieve proactivity and fulfill the right to life of residents in Ecuador. [1]. Therefore, the objective is focused on applying data segmentation methods (clustering) to a dataset with information on earthquakes in Ecuador to analyze common characteristics in the resulting clusters and to be able to use these results for predictive purposes. From now on, to comply with the aforementioned, the following specific objectives are formulated:

1. Analyze the data contained in the dataset.
2. Apply the neutrosophic K-means clustering technique.
3. State detected patterns

This study is intended to contribute to the early detection of earthquakes that enables adequate preparation and mitigates their adverse effects on the lives of Ecuador's residents and therefore their quality of life, after the disaster.

2 Methods

The nature of earthquakes and their monitoring variables usually make up a large database (big data or dataset) that constitutes a source of knowledge to be used by researchers. For its processing and subsequent analysis of the results, it is convenient to use statistical techniques of Data Mining such as K-Means. Currently, due to the spatial variations of its components, it is significant to include the treatment of uncertainty [2, 11, 13, 14, 18, 20-24]. Therefore, the analysis is made up of the K-Means statistical technique in its Neutrosophic version, because it will take into account the uncertainties and the uncertainty environment inherent to the predictions. The use of a Neutrosophic K-Means based on the classical algorithm is appropriate due to the efficiency demonstrated for the decision-making process based on interpretation of the linguistic terms provided by Neutrosophy and its ability to deal with uncertainty.

2.1 Classic K-Means

According to what was stated by [15, 28-38], the K-Means technique is frequently used in Data Mining, due to its ease in handling and classifying large amounts of data through clustering or grouping. According to [39], clustering means grouping things that are similar or have features in common, and so is the purpose of k-means clustering. K-means clustering is an unsupervised machine learning algorithm for clustering 'n' observations into 'k's clusters where k is a predefined or user-defined constant. The main idea is to define k centroids, one for each cluster. The K-Means algorithm involves:

1. Choosing the number of clusters "k".
2. Randomly assign each point to a cluster.
3. Until clusters stop changing, repeat the following:
   - For each cluster, compute the cluster centroid by taking the mean vector of points in the cluster.
   - Assign each data point to the cluster for which the centroid is the closest.

Two things are very important in K-means, the first is to scale the variables before clustering the data, and the second is to look at a scatter plot or a data table to estimate the number of cluster centers to set for the k parameter in the model.

2.2 Notions of Neutrosophy

Neutrosophy is a new branch of philosophy that studies the origin, nature, and scope of neutralities created by Professor Florentin Smarandache. Its incorporation guarantees that the uncertainty of decision-making is taken into account, including indeterminacies where experts will issue their criteria evaluating linguistic and non-numerical terms, which constitutes the most natural form of measurement in human beings.[33, 40-64]. Logic and neutrosophic sets, for their part, constitute a generalization of Zadeh's fuzzy logic and sets, and especially of Atanassov's intuitionist logic, with multiple applications in the field of decision-making, image segmentation, and machine learning.[40, 42, 65, 66].

Definition 1 [42, 67, 68]: Be X a universe of discourse, a Neutrosophic Set (CN) is characterized by three membership functions,$\mathrm{u_A(x)}:, \mathrm{r_A(x)}:, \mathrm{v_A(x)}:: \mathrm{X} \rightarrow]^{-}0, 1^{+}[$, which satisfy the condition -0 ≤ $\inf \mathrm{u_A(x)} + \inf \mathrm{r_A(x)} + \inf \mathrm{v_A(x)} \leq \sup \mathrm{u_A(x)} + \sup \mathrm{r_A(x)} + \sup \mathrm{v_A(x)} \leq 3$ + x⊂X $\forall \mathrm{u_A(x)}, \mathrm{r_A(x)}$ Y $\mathrm{v_A(x)}$: denote the membership functions of true, indeterminate, and false of x in A, respectively, and their images are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

2.2 Neutrosophic K-means

According to the bibliography consulted [33, 35, 69-71], the Neutrosophic K-Means is an extension of the classic K-Means, as a neutrosophic data mining technique for clustering. This variant is useful to automatically manipulate databases provided by the Ecuador earthquake network in the prediction process. The algorithm allows exploring, organizing, and segmenting large amounts of data, detecting consistent behavior patterns or relationships between the different variables to apply them to new data sets.

This analysis includes the diversity of the data and its fluctuation since due to the proximity of the limits between them and the clusters they belong to, it is difficult to identify them, resulting in false conclusions and the existence of contradictions due to the uncertainty that this may generate. Based on what was stated by [72] the method consists of assigning to each data a value or degree of membership within each cluster (in this way the limits are smoothed and it is possible for a specific data to partially belong to more than one cluster). The above are exposed as:

- **Definition 2**: Let X be the data set and xi an element, such that x_i ∈X.
- **Definition 3:** It is said that a partition $P = \{C_1, C_2, \ldots, C_c\}$is a soft partition of data set X, if and only if it is true that: $(\forall x_i \in X, \forall C_j \in P) \leq \mu C_j(x_i) \leq 1$ y $\left(\forall x_i \in X, \exists C_j \in P\right)$ such that $\mu C_j(x_i) > 0$. Where $\mu C_c(x_i) xi$ denotes the degree to which x_i belongs to cluster Cj
- **Definition 4:** A special soft partition is said when the sum of the degrees of membership of a specific point in all clusters is equal to 1 as shown in equation 1.

$$\sum_j \mu C_j(x_i) = 1, (\forall x_i \in X) \quad (1)$$

- **Definition 5:** A constrained soft partition is a partition that meets this additional condition. The Neutrosophic K-Means algorithm produces a constrained smooth partition and to do this the objective function J is extended in two ways:
  - $\forall x_i \in X, \exists C_j \in P$ such that $\mu C_j(x_i) > 0$ where the degrees of neutrosophic membership of each data in each cluster are incorporated or;

- introducing an additional parameter that serves as exponent weight in the membership function, thus the extended objective function *Jm* is as shown in 2.

$$\mu c_1(x_1) = \frac{1}{\sum_{j=1}^{2} \left[\frac{\|x_1 - v_1\|^2}{\|x_1 - v_j\|^2}\right]^2} \quad (2)$$

Where P is a fuzzy partition of the data set X formed by $\{C_1, C_2, \dots, C_k\}$ and the parameter m is a weight that determines the degree to which the partial members of a cluster affect the result.

This refers to a similarity between the classical method and its neutrosophic extension since the latter also tries to find a good partition by searching for the prototypes vi in such a way that they minimize the objective function Jm and that in the same way, it must also look for the functions of membership μC_1that minimize Jm.

In addition to the method, equation 3 is established to calculate the initial membership functions of both clusters:

$$J_m(P,V) = \sum_{j=1}^{k} \sum_{j_k \in X} (\mu c_j(x_k))^m \|x_k - v_j\|^2 \quad (3)$$

The calculations are subsequently updated according to equation 4.

$$v_1 = \frac{\sum_{k=1}^{n} (\mu C_1(x_k))^2 x_k}{\sum_{k=1}^{n} (\mu C_1(x_k))^2} \quad (4)$$

3 Results

The method described above was applied to a dataset that contains information on the earthquakes that occurred in Ecuador in approximately one year. The dataset collects information on the date and time of occurrence, magnitude, latitude, longitude, closest city, area or region, and depth in kilometers. The classical K-means method was combined with the application of neutrosophic techniques to obtain neutrosophic K-means.

For the execution of the methods, the Orange data mining software (Version 3.27.1) was used, which offers many benefits since it allows experimenting with different workflows and applying a wide variety of available widgets until obtaining the desired result. For the application of neutrosophic K-means, the applied workflow was the one shown in the following figure:

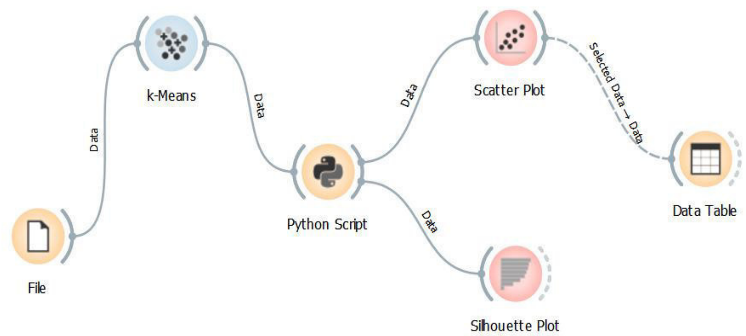


Figure 4. Workflow for Neutrosophic K-means (Orange software).

The dataset is initially loaded through a File widget, then it is processed with the k-Means widget, then Neutrosophy is applied through a Python Script and the results are plotted in a Scatter Plot, as well as a Silhouette Plot, to see in detail the Silhouette values in each cluster. And at the end of the process, a Data Table was placed to better analyze the results: apply filters, count, order, etc.

To define the number of clusters (k), the method offered by Orange's k-Means widget was used, which allows executing several iterations by changing the number of clusters and thus finding the best clustering settings based on the Silhouette Scoring values. The optimal value is the one with the highest Silhouette score, in this case, 0.768, which corresponds to the option of k = 2 clusters.

To include the Neutrosophic part, it was necessary to program a Python script in which formula 3 is applied to calculate the initial membership functions of both clusters, and formula 4 is used to adjust the calculations, iterating the process until the extended objective function is minimized, as expressed in equation 2.

Figure 5 shows the Silhouette plot for the analyzed dataset. As can be seen, two clusters were obtained: one containing 800 and the other 200 data rows where the Silhouette value was calculated based on the Euclidean distance. It can be noted that in cluster 2 (red in figure 5) there is a large amount of data with high Silhouette score values, which indicates that their degree of membership to the cluster in which they are located is remarkably high.

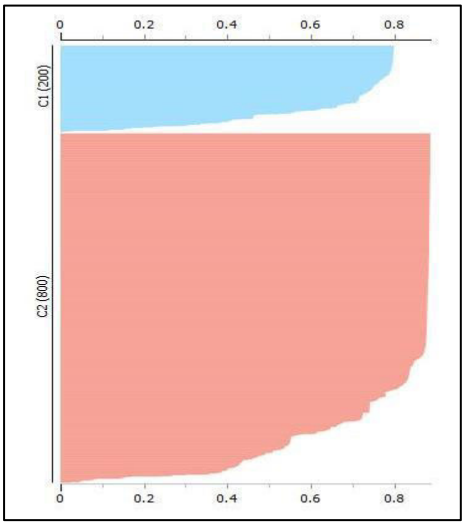


Figure 5. Silhouette Plot based on Euclidean distance.

If we analyze the following image where a graph of Silhouette vs. local time is shown, we can see how the clustering process has segmented the total sample into two sets whose borders are close in the central area of the graph, approximately in August, where we find the group of data with a lower Silhouette value, but the rest of the data is quite well concentrated in their respective clusters. The largest number of points belong to April and May, which indicates that these are probably the dates with the highest level of the propensity for earthquakes.

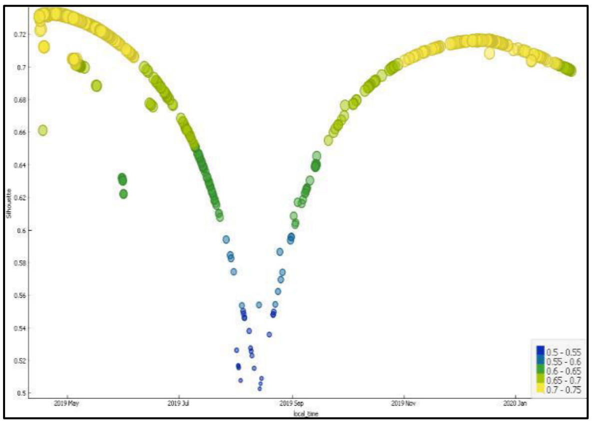


Figure 6. Scatter Plot of Silhouette Scoring vs Local Time.

Another interesting graph we can analyze is the one shown in figure 7, where the y axis displays the magnitudes of the earthquakes, the x-axis shows the local time and the size of the points is defined by the depth (in kilometers). It's harder to find a pattern for the occurrence of the deepest ones, but it is obvious that most of the earthquakes have occurred in the first months of the year, especially in March and April.

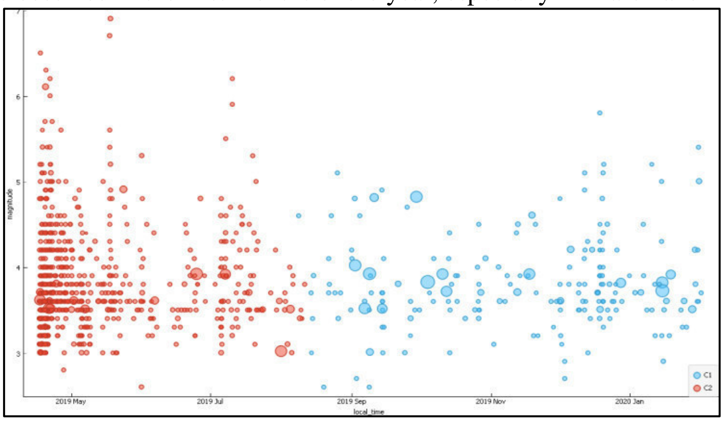


Figure 7. Scatter Plot of magnitude vs local time

Conclusions

In the present work, a data mining analysis was carried out using the K-means neutrosophic clustering method on a dataset with information from earthquakes that occurred in Ecuador, to determine patterns in the data of the sets of clusters obtained to use this information as a possible prediction of future behavior of these phenomena, as well as to take preventive actions and minimize their negative impact.

As a conclusion we can state that the results obtained showed that when applying Neutrosophic K-Means as a Neutrosophic extension of the classical method, it is more advantageous since it can better deal with data that partially belong to more than one cluster; in addition to calculating the prototypes of the cluster, it also calculates the membership functions of the data within each cluster. Neutrosophic K-Means produces a restricted smooth partition of the data set and is therefore useful in situations where the data have characteristics of different groups. This methodology can be applied in many fields such as data classification, medicine, bioinformatics, and economics, among others.

From the processed data, we can conclude that the months most prone to the occurrence of earthquakes are the first months of the year, especially March, April, and May. Therefore, they are denoted as the period of greatest vulnerability. In addition, the highest concentration of earthquakes is located in the first half of the year. In July, August and September, there are not many earthquakes, and if they do occur, they are usually not very intense or are located at a considerable depth.

Based on the data analyzed in the period, it is recommended as a Strategy that government authorities pay special attention to the availability of services in these months with the highest probability of occurrence. Similarly, simulations should be held in schools and places of high concentration of people to achieve greater preparation for emergencies. The season turns out to be of tourist movement so it is important to keep a complete update and preferentially inform the inexperienced and foreign public about the behavior in these situations.

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Selection of Investment Projects in a Plithogenic Environment

Ariel Romero Fernández[1], Gustavo Álvarez Gómez[2], Sary del Rocío Álvarez Hernández[3], William Roberto Álvarez Arboleda and Adonis Ricardo Rosales García[5]

[1]Director of research. Regional Autonomous University of the Andes (UNIANDES). Km 5 ½ road to Baños. Ambato. Tungurahua. Ecuador. Email: dir.investigacion@uniandes.edu.ec
[2]Vice Chancellor General. Regional Autonomous University of the Andes (UNIANDES). Km 5 ½ road to Baños. Ambato. Tungurahua. Ecuador. Email: vicerrectorado@uniandes.edu.ec
[3]Professor of the Business Administration program. Regional Autonomous University of the Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.saryalvarez@uniandes.edu.ec
[4]Professor of the Business Administration program. Regional Autonomous University of the Andes (UNIANDES). Teniente Hugo Ortiz Street, Puyo. Pastaza. Ecuador Email: up.williamalvarez@uniandes.edu.ec
[5] Asociación Iberoamericana de Scrum (AIBES), Quebec , Canada Email: adonis.rosales@aibes.org

Abstract. Nowadays, the economic crisis affecting the countries makes more important the selection process of investment projects. Such is the case of Ecuador where the Multi-annual Public Investment Plan 2017-2021 establishes indicative amounts of public investment that are projected to be executed annually to achieve each of the nine strategic objectives of the National Development Plan that pay tribute to the Sustainable Development Goals of the UN. This plan has certain weaknesses that may not allow an effective and efficient choice at the same time. Which entails a scenario of uncertainty for the Ecuadorian investment process. So we dare to say that a classic selection of investment projects is not suitable. Therefore, there is a need for a decision-making support tool that allows the most effective and optimal selection of the projects of greater importance and scope based on multiple, specifically defined criteria. Thus, the main objective of this research is to develop a selection process for investment projects based on multicriteria decision methods in a plithogenic environment. If an adequate method is determined for the selection of an investment project in an environment of uncertainty based on Plithogeny, it will be possible to provide an effective tool that optimizes the decision-making process. For this, the plithogenic versions of the AHP and TOPSIS methods will be adopted.

Keywords: uncertainty, investment projects, selection, Plithogeny, evaluation, decision making

1 Introduction

Decision-makers often face problems of choosing alternatives with complicated, intangible, and conflicting criteria. To choose the best alternative, they generally rely on multicriteria decision-making methods where priorities of contradictory tangible and intangible criteria are managed based on experts to define and assess potential courses of action. Decision-making consists of the choice by one or more individuals of the best alternative among a set of possible solutions. A traditional approach suggests the existence of a certain group of restrictions generated by resource limitations, where the value of the decision variables that satisfy these restrictions constitutes what is called the feasible or achievable set that may or may not be finite [1].

Usually, to determine the best alternative, a criterion function is defined that adequately reflects the preferences or desires of each of the decision-makers which requires a process [2]. The first step is dedicated to the search for specific technical information and the second step to the preferential judgments of the group of decision-makers. Which is usually optimized by mathematical techniques [1]. This process acquires great connotation on the subject of investments, where resources are used to achieve benefits or profits, which constitutes its main objective for the formation of fixed social capital, technical capital, and technical staff [3].

It is well known that to invest people must have financial, material, and human resources, so the decision to execute them or not imposes a challenge of conscience [2]. Investments increase through interest, dividends, shares, appreciation of assets (increase in value) when you have savings, the portion and duration of those savings must be visualized, before deciding to invest and define where to use those resources [3]. Therefore, it is said that carrying out investments implies the acceptance of risks that must be analyzed, hence the importance of using strategic projection tools and techniques.[2]. So that they deal with the current situation in the market, social inequality, environmental problems, and the global economic crisis that is on the rise, as well as the appearance of Covid-19, has paralyzed the economy on the planet [2].

There are several types of investment [3]:
1. In the financial or capital field
2. In the real estate, business, or production and project field.
3. In the field of personal education and, in projection, education for when people have sons and daughters and provisions for retirement.
4. In goods that increase in value over time

However, regardless of the type of investment involved, it needs to be previously evaluated, since implementing a project without this step could generate a significant loss of resources, which could even lead to bankruptcy due to debt or financial inability to sustain it with own resources [4-6]. Therefore, the decision-making process, in general, adopts the following flow of activities, where it can be seen that the investment idea is materialized in an investment project.

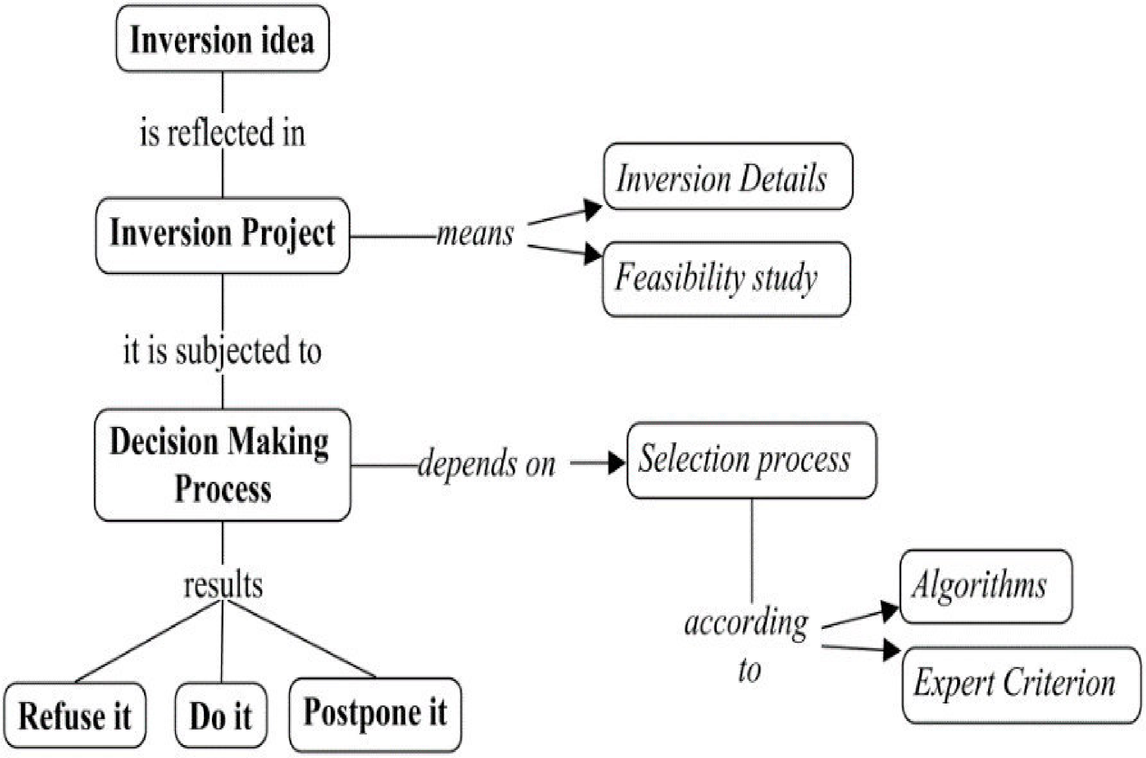

Figure 1. Concept map of the decision-making process for investment projects. Source: Own elaboration (CmapTools software output).

Investment projects are nothing more than documents that include everything related to the execution of the investment idea. The details must be presented in a systemic, qualitative, and quantitative way that allows evaluating investment feasibility from all dimensions. It includes all the elements that allow qualitative and quantitative judging of the advantages and disadvantages of allocating resources to a specific initiative. From the content capable of being exposed, the decision-making capacity is developed, and alternative scenarios are designed to complement the decision-makers opinion when evaluating the investment. The correct design of this document depends on the skills of the person who will execute it and the characteristics of the investment.

On the side of the person who prepares this investment project, it is said that he must have preparation in the techniques of investment projects to collect, create, and systematically analyze a set of economic antecedents that allow judging by experts or algorithms its feasibility for the start-up just as people must design projects with ethical criteria so that the studies base their feasibility in practicealways considering the perspective from the project design and evaluation process to develop decision-making capacity and design alternative scenarios. All this so that the investment project resulting from their work can translate responsibility when assuming a project development contract.

On the document side, it is said that this study should determine all the elements that make it possible to evaluate exhaustively:

- The market feasibility to place the product or service that would be developed in the project based on the analysis of the sub-markets and the commercial strategy and the investments and expenses involved. A strategy in pessimistic environments, where the life cycle of a project is contemplated: idea, pre-investment, investment, and a study of supply and demand (consumer, market, competition)

- The capacity and location of the investment project, as well as the investments and related costs. The financial viability of the project is based on projected financial statements with a financial-economic study where its source of financing (modalities, types) is exposed. As well as costs and expenses: analysis of the cost of capital, determination of the project income budget, expenditure budget, breakeven point.
- Execute an organizational and legal study of the investment project and determine the corresponding investments and expenses Basic engineering (Technical study, description of the project and its purposes, Dimensioning and location, technological alternatives, Description of the production process, Determination of the project equipment, and machinery), as well as its structure and schedule and impact.

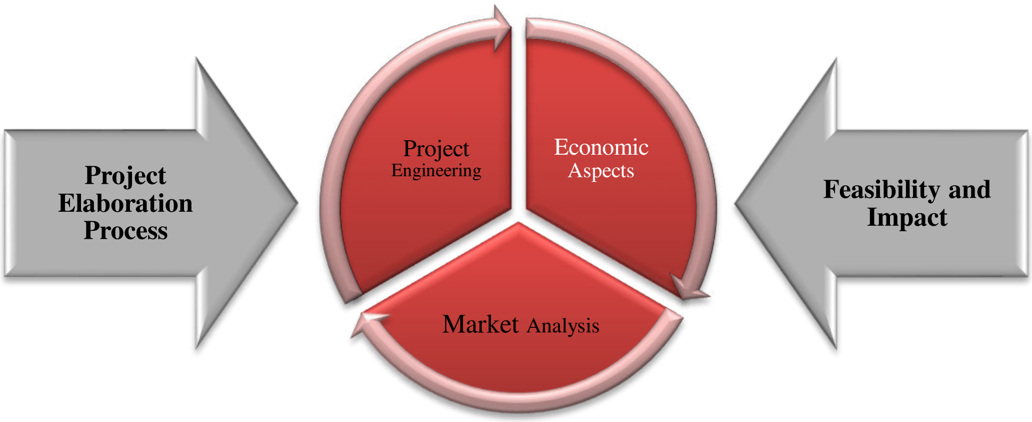

Figure 2. Aspects for the development of investment projects.

According to those above, the idea of an investment project can lead to three possible scenarios after evaluation through the selection process [4]:

- Do the project: The economic, social, environmental, legal, and market feasibility is confirmed, that is, the project is viable, profitable, so it is decided to do it within the planned deadlines.
- Do not do it: Situations are observed where there is infeasibility for the project (it may be its non-profitability, non-compliance with regulations, due to its negative impact on the environment, or the reluctance of the community).
- Postpone it: It is observed that the project meets the conditions to carry it out, however, it is not pertinent to execute it within the planned period (it may be due to the economic, social, political environment, among others). The project is good, but for contingency reasons, it is better to postpone it for a while until the conditions are feasible for its development.

At present, the economic crisis that affects the countries makes even more important this process of selecting the investment projects to be carried out. Mainly due to the need to allocate human, material, financial resources, even time, in an feasible investment that provides a positive impact on society [2]. That is why the Republic of Ecuador has implemented a Multi-annual Public Investment Plan 2017-2021, which is part of the National Development Plan "A whole lifetime" for the medium term [7]. The 2017-2021 Multi-annual Public Investment Plan establishes indicative amounts of public investment that are projected to be executed annually to achieve each of the nine strategic objectives of the National Development Plan that contribute to the UN Sustainable Development Goals [7, 8] and the criteria for prioritizing investment projects are established:

- Poverty reduction
- Closing territorial gaps
- Employment generation
- Generation of complementarity with private initiatives
- Increase in systemic productivity that contributes to the strengthening of non-traditional exports
- The intensity in national inputs: majority use of raw material of national production, without encouraging increased imports

This plan has certain weaknesses since the Investment Plan does not include a list of projects, nor the costing of individual projects, it only considers indicative estimates of investment amounts added by a strategic axis of the National Development Plan. Similarly, it does not detail the localization of public investment nor does it include product and/or results in indicators. Just as it does not include a list of projects in order of priority and/or prioritization criteria. What does not allow an effective and efficient choice at the same time.

A situation that, along with the current shortage where the resources of this plan must be consciously allocated according to the economic crisis caused by the Covid-19 pandemic in the country, is a problem to analyze. This turns into an unprecedented scenario for the Ecuadorian investment process, which provokes an environment of uncertainty. As a result, it can be said that a classic selection of investment projects is not convenient, which denotes the need to have a decision-making support tool to make the most effective and optimal selection of projects of greater importance and scope based on multiple, specifically defined criteria. Thus, the following problem is proposed:

Multi-criteria decision methods are used to assess decision alternatives in a context with different conflicting objectives and an uncertain environment. The use of these methods allows both objective and subjective knowledge, defined in terms of quantitative and qualitative variables, to be integrated into decision-making [1]. As a complement to these methods, neutrosophic logic is used in its plithogenic version that studies the origin, nature, and scope of neutralities, environments of uncertainty, and their interactions. This part, Plithogeny, advocates for the connections and unification of theories and ideas in varied fields of science [9]. Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and mergers of multiple contradictory and/or neutral and/or non-contradictory previous entities. Plithogeny advocates for the connections and unification of theories and ideas in varied fields of science. The "Knowledge" is taken as “Entities” in various fields, such as social sciences, technical sciences, theories of arts and letters[10-12].

Which is convenient according to the environment in which the problem is developed. Therefore, it leads to establishing as the main objective of this research: the development of a selection process for investment projects based on multicriteria decision methods in a plithogenic environment. The hypothesis supports this that if an adequate method is determined for the selection of an investment project in an environment of uncertainty based on Plithogeny, it will be possible to provide an effective tool that optimizes the decision-making process. To achieve this objective, the following activities must be carried out:

1. Establish a case study for the selection of a multicriteria method for expert-based decision making
2. Create an algorithm merging the chosen multicriteria method with the plithogenic sets to guarantee the effective choice of a selection project according to the 2017-2021 Multi-annual Public Investment Plan.

2. Case study

2.1 Decision-making process

Decision-making is the study of the identification and choice of alternatives based on the values and preferences of the decision-maker. Making a decision implies that there are alternatives to consider and it is convenient to choose the one that best suits the goals, objectives, desires, values , and all this in a short time according to the characteristics of the decision-maker [1].

2.2 Multi-criteria decision methods

According to [2, 13] multicriteria methods are especially used to make decisions in the face of problems made up of intangible aspects. These methods do not consider the possibility of finding an optimal solution to a problem, but based on preferences and predefined objectives, the central problem of multicriteria methods consists of selecting the best alternatives, accepting alternatives that seem “good” and reject those that seem "bad" and generate a ranking of the alternatives (from the best to the "worst"). When the objective functions take an infinite number of different values that lead to an infinite number of possible alternatives of the problem, it is called Multiobjective Decision, while those problems in which the decision alternatives are finite are called Discrete Multicriteria Decision problems [13]. Discrete Multicriteria Decision problems are the most common in reality and are used to carry out an evaluation and decision regarding problems that, by nature, admit a finite number of solution alternatives, and is going through [13]:

- A stable, generally finite set of alternatives
- A family of evaluation criteria that allow evaluating the alternatives
- A decision matrix that summarizes the evaluation of each alternative
- A methodology or model of aggregation of preferences in a global synthesis
- A decision-making process

There is a great heterogeneity of the methods, so it is advisable to determine a priori before executing the exercise, which of these are appropriate for the fulfillment of the main objective raised at the beginning of the investigation. A bibliographic analysis is then applied through the UCINET software where the presence of these methods in similar investigations was studied. The results are shown below [2, 13-29]:

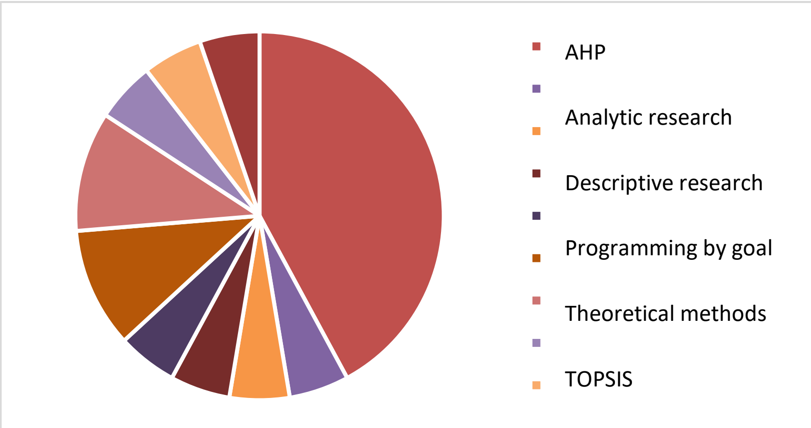

Figure 3. Bibliometric analysis on the multicriteria methods used for the selection and prioritization of investment projects.

As we can see, the Analytic Hierarchy Process (AHP) is the multicriteria decision method with the highest level of presence within the bibliographic references analyzed. Being rated by [15] as a mixed and complex method, which reaffirms the need for application in this case since the variables to be handled: selection criteria, are subjective and qualitative. It is then decided to develop the project selection method based on the AHP. Which taking into account the uncertain environment discussed will be executed in its plithogenic extension for the convenience of the analysis provided by the latter.

3. Methods

After studying the case, it is convenient to define the methods used for this research.

- Analysis and synthesis: to establish the case study and the elaboration of the conclusions.
- Method of Abstraction: for the elaboration of the investigation procedure.
- Hypothetical - Deductive: for the formulation of hypotheses.
- Scientific Observation Method: for the diagnosis of the problem and in the design of the investigation.
- Interviews and questionnaires: to obtain information for the execution of specific objectives.
- Document review
- Brainstorming
- Bibliometric analysis: for the analysis of the consulted bibliography.

3.1 Basic notions of Neutrosophy and Plithogeny

[12, 30-46] Let U be a universe of discourse, and P a non-empty set of elements, $P \subseteq U$. Let A be a non-empty set of *uni-dimensional* attributes $A = \{\alpha_1, \alpha_2, \dots, \alpha_m\}$, $m \geq 1$, and $\alpha \in A$ is a given attribute whose spectrum of all the possible values (or states) is the non-empty set S, where S can be a set of finite discrete, $S = \{s_1, s_2, \dots, s_l\}$, $1 \leq l < \infty$, or infinitely numerable set $S = \{s_1, s_2, \dots, s_\infty\}$, or an infinitely uncountable set (continuous), $S =]a, b[$, $a < b$, where $]\dots[$ is any open, semi-open, or a closed interval set of real numbers or another set.

Let V be a non-empty subset of S, where V is the range of all attribute values needed by experts for the application. Each element $x \in P$ is characterized by the values of all attributes in $V = \{v_1, v_2, \dots, v_n\}$, for $n \geq 1$.

In the set of attribute values, V in general, there is a dominant attribute value determined by experts in its application. Calling an attribute value *dominant* means that it is the most important attribute value that experts are interested in.

Each attribute value $v \in V$ has a corresponding *degree of membership* $d(x, v)$ of the element x, to the set P, concerning some given criteria.

The degree of membership can be a fuzzy degree of membership, a fuzzy intuitionist degree of membership, or a neutrosophic degree of membership to the plithogenic set.

Therefore, the membership degree function of the attribute value is:

$$\forall x \in P, d: P \times V \to \mathcal{P}([0,1]^z), \quad (1)$$

Such that $d(x, v)$ is a subset of $[0,1]^z$, where $\mathcal{P}([0,1]^z)$ is the power set of $[0,1]^z$, where z = 1 (fuzzy degree of membership), z = 2 (intuitionistic fuzzy degree of membership), or z = 3 (neutrosophic degree of membership).

Let $|V| \geq 1$ be the cardinality. Let $c: V \times V \to [0,1]$ be the *attribute value contradiction degree function* between any two attribute values v_1 and v_2, denoted by $c(v_1, v_2)$, and satisfying the following axioms:

$c(v_1, v_1) = 0$, the degree of contradiction between the same attribute values is zero;

$c(v_1, v_2) = c(v_2, v_1)$, commutativity.

We can define a fuzzy attribute value contradiction degree function (c as before, we denote by c_F to distinguish it from the following two), an intuitionistic fuzzy attribute value contradiction degree function ($c_{IF}: V \times V \rightarrow [0,1]^2$), or more generally, a neutrosophic attribute value contradiction degree function ($c_N: V \times V \rightarrow [0,1]^3$), the latter one can be used to increase the complexity of the calculation, but also to increase the accuracy.

The degree of contradiction between the values of the one-dimensional attributes is mainly calculated. For multidimensional attribute values, we can divide them into their corresponding one-dimensional attribute values.

The attribute value contradiction degree function helps the plithogenic aggregation and plithogenic inclusion (partial order) operators to obtain a more accurate result.

The attribute value contradiction degree function is designed in each field where a plithogenic set is used according to the application to be solved. If ignored, the aggregations still work, but the result may lose precision.

So, (P, a, V, d, c) is called a plithogenic set

1. Where "P" is a set, "a" is an attribute (multi-dimensional in general), "V" is the range of values of the attribute, "d" is the degree of appurtenance of the attribute value of each element x to the set P for some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy appurtenance, an intuitionistic fuzzy appurtenance, or a degree of neutrosophic appurtenance, respectively, of an element x to the plithogenic set P;
2. "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.

Functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that experts need to solve.

Then, the following notation is used:

$x(d(x, V))$, where $d(x, V) = \{d(x, v), \text{for every } v \in V\}, \forall x \in P$

The attribute value contradiction degree function is calculated between each attribute value concerning the dominant attribute value (denoted by v_D) in particular, and for other attribute values as well.

The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Longrightarrow$), equivalence ($\Longleftrightarrow$), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of attribute values based on a t-norm and a t-conorm.

Most plithogenic aggregation operators are linear combinations of one fuzzy t-norm (denoted by $\wedge_F$) with one fuzzy t-conorm (denoted by $\vee_F$), but nonlinear combinations can also be constructed.

If the t-norm is applied over the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then v_2 is applied over the attribute value as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2), \tag{2}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \tag{3}$$

Similarly, if the t-conorm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2), \tag{4}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2), \tag{5}$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right), \tag{6}$$

The plithogenic neutrosophic junction is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right), \tag{7}$$

In other words, concerning what applies to membership, the opposite applies to non-membership, while in indeterminacy the average between them applies.

Plithogenic neutrosophic inclusion is defined as follows:

Since the degrees of contradiction is $c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5$, it applies $a_2 \geq [1 - c(a_1, a_2)]b_2$ or $a_2 \geq (1 - 0.5)b_2$ or $a_2 \geq 0.5b_2$, while $c(a_1, a_3) = c(b_1, b_3) = 1$.

Having $a_1 \leq b_1$ the opposite is fulfilled for $a_3 \geq b_3$, hence $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only if $a_1 \leq b_1$, $a_2 \geq 0.5b_2$, and $a_3 \geq b_3$.

3.2 AHP and TOPSIS method in its plithogenic version

AHP: Hierarchical Analysis Process (AHP) [1, 2, 13, 14, 16, 18, 19, 21, 47-56]

a) Make a pairwise plithogenic comparison matrix as defined in equation 7 according to the linguistic terms.

$$\widetilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{8}$$

Where the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$ established for the investment operator is satisfied:

Language expression	Plithogenic number
Low significance	(0.10, 0.70, 0.80)
Equal importance	(0.30, 0.40, 0.80)
Robust importance	(0.50, 0.40, 0.60)
Very robust significance	(0.70, 0.30, 0.10)
Absolute significance	(0.90, 0.10, 0.10)

Table 1. Saaty scale translated to a plithogenic triangular scale

If more than one expert makes the evaluation, then w1, w2,…, wn are replaced by $\overline{w}_1, \overline{w}_2, \cdots, \overline{w}_n w_1', w_2', \cdots, w_n' \overline{w}_1', \overline{w}_2', \cdots$, which are their corresponding weighted geometric mean values, see Eq. 1. and Eq. 2. The weights obtained are not necessarily expressed in normal form, therefore, we have the option of calculating equivalent normalized weights or, such that $\overline{w}_n' \sum_{i=1}^{n} w_i' = 1$ or $\sum_{i=1}^{n} \overline{w}_i' = 1$.

a) For each line of the pairwise comparison matrix, determine a weighted sum based on the sum of the product of each cell by the priority of each alternative or corresponding criterion. For each line, divide its weighted sum by the priority of its corresponding alternative or criterion.

b) Determine the mean ʎmax of the result of the previous stage

c) Calculate the consistency index (CI) for each alternative or criterion

$$CI = \frac{ʎ_{max} - m}{m - 1} \tag{9}$$

Where m is the number of alternatives

d) Determine the Random Index (RI)

Number of alternatives for decision n	Random index	Number of alternatives for decision n	Random index
3	0.58	7	1.32
4	0.9	8	1.41
5	1.12	10	1.49
6	1.24		

Table 2. Random index for the calculation of the consistency coefficient

The TOPSIS method for plithogenic numbers consists of the following, assuming it is a set of alternatives and it is a set of criteria, where the following steps will be carried out: $A = \{\rho_1, \rho_2, \ldots, \rho_m\} G = \{\beta_1, \beta_2, \ldots, \beta_n\}$

Linguistic term	SVNN
Very Important (MI)	(0.9, 0.1, 0.1)

Important (I)	(0.75, 0.25, 0.20)
Media (M)	(0.50,0.50,0.50)
Not Important (NI)	(0.35, 0.75, 0.80)
Very Not Important (MNI)	(0.10,0.90,0.90)

Table 3. Linguistic terms represent the evaluation of the criteria in the alternatives.

a) Construction of the plithogenic decision matrix
Each dij is calculated as the aggregation of the evaluations given by each expert using the weights of the AHP Saaty of each criterion with the help of equations 7 and 8 and tables 1 and 2. In this way, a matrix D = (dij) is obtained ij, where each dij is: (i = 1,2, .., m; j = 1,2,…, n).$(u_{ij}^{t}, r_{ij}^{t}, v_{ij}^{t})$

b) Normalize the decision matrix
Suppose that the weight of each criterion is given by W = (w1, w2,…, wn), where wj denotes the relative importance of the criterion wj. If it is the evaluation of criterion wj by the t-th expert. Then Equation 10 is used to add those with the weights. The construction of the normalized matrix will be as follows:$w_j^t = (a_j^t, b_j^t, c_j^t)w_j^t$

$$w_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \tag{10}$$

Where: wij is the normalized value for the qualification of alternative i against criterion j and fij is the indicator of each alternative i against each indicator j.

c) Construction of the plithogenic decision matrix of the weighted average of unique values concerning the criteria.

D * = D*W, where $d_{ij}^{*} = w_j * d_{ij} = (a_{ij}, b_{ij}, c_{ij})$ (11)

d) Determine the ideal positive and negative solutions.

$$s^{+} = (x_1^{+}, x_2^{+}, \dots x_{j+1}^{+}) \text{ it implies, } s_i^{+} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{+}\right)^2 + \left(b_{ij} - b_j^{+}\right)^2 + \left(c_{ij} - c_j^{+}\right)^2\right\}\right)^{\frac{1}{2}} \tag{12}$$

$$s^{-} = (x_1^{-}, x_2^{-}, \dots x_{j+1}^{-}) \text{ namely, } s_i^{-} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{-}\right)^2 + \left(b_{ij} - b_j^{-}\right)^2 + \left(c_{ij} - c_j^{-}\right)^2\right\}\right)^{\frac{1}{2}} \tag{13}$$

e) To calculate the Relative Proximity Index (Ri), it is done as follows. The proximity coefficient of each alternative is calculated concerning the positive and negative ideal solutions.

$$Ri(A^k, A^i) = \frac{s^{-}}{s^{-} + s^{+}} \tag{14}$$

f) The alternatives are ordered from highest to lowest, under the condition that Ri is the optimal solution.→

For the conversion of plithogenic numbers into sharp, the following equation will be continued:

$$\mathcal{S}([\mathrm{T}, \mathrm{I}, \mathrm{F}]) = \frac{2 + \mathrm{T} - \mathrm{I} - \mathrm{F}}{3}, \tag{15}$$

3.3 Algorithm developed for the selection of investment projects in a plithogenic environment

Objective: to offer an efficient choice of investment projects that pay tribute to the National Multi-year Investment Plan by prioritizing them. This level of prioritization will be obtained through the following processes:

Establishment of criteria and sub-criteria for project evaluation:

a) Selection of criteria: according to questionnaires, documentary review, and bibliometric analysis.
b) Apply the plithogenic AHP technique to determine the level of importance (weights) between subcriteria (single)
c) Apply the plithogenic AHP technique to determine the level of importance (weights) between criteria (single)
d) Multiply the matrices of each of the sub-criteria by one of the criterion to which it belongs to determine an overall level of importance (weights).

Evaluation of investment projects: First, decision maker must declare the criteria and their respective weights (results of the previous step), the alternatives (number of projects to be selected through the evaluation = and the experts to participate. Then execute the plithogenic TOPSIS analysis and expose the ranking of the evaluated projects to carry out selection.

4 Application of the model

The criteria are the relevant dimensions that significantly affect the objectives and express those involved in decision-making [13]. According to the bibliometric analysis performed [2, 13-23]. In section 2.2 of this document, it was observed that there is a tendency to evaluate projects based on the following criteria and aspects:

Criteria	Sub-criteria
Socio-environmental	Objective 3- Good health: Guarantee a healthy life and promote well-being for all of all ages.
	Objective 6- Clean water and sanitation: Guarantee the availability of water and its sustainable management and sanitation for all.
	Goal 7- Affordable and sustainable energy: Guarantee access to affordable, safe, sustainable, and modern energy for all.
	Objective 12- Responsible consumption and production: Guarantee sustainable consumption and production patterns.
	Goal 13- Climate Action: Adopt urgent measures to combat climate change and its effects.
	Impact on quality of life (poverty, health, employment, education, etc.)
	The number of people who benefited
Economic-Financial	Economic-financial indicators (Net Social Value, Internal Rate of Return, Cost/Benefit, Investment Payback Period, among others)
	Budget
	Financing sources
Technicians	Equipment-Technology
	Execution time
	Necessary resources (human, material)
	Location (micro and macro location)
	Project Type
Market study	Position before the competition
	Commercial benefits (prestige, brand consolidation, innovation)
	Customer satisfaction

Table 4. Criteria and subcriteria for the selection of investment projects

According to the above, the degree of cardinality is calculated: 7x3x5x3 = 315

The AHP method will be applied for each of the criteria set forth. The result of the process is shown below:

Criteria	Socio-environmental	Economic-Financial	Technicians	Market study	Weights
Socio-environmental	Equal importance	Absolute significance	Absolute significance	Absolute significance	**0.18**
Economic-Financial	$\frac{1}{(0{,}90;\ 0{,}10;\ 0{,}10)}$	Equal importance	Very robust significance	Very robust significance	**0.19**
Technicians	$\frac{1}{(0{,}90;\ 0{,}10;\ 0{,}10)}$	$\frac{1}{(0{,}70, 0{,}30, 0{,}10)}$	Equal importance	Absolute significance	0.15
Market study	$\frac{1}{(0{,}90;\ 0{,}10;\ 0{,}10)}$	$\frac{1}{(0{,}70, 0{,}30, 0{,}10)}$	$\frac{1}{(0{,}90;\ 0{,}10;\ 0{,}10)}$	Equal importance	0.15

Table 5. Application of the AHP to the criteria

In the same way, the weights were calculated for each of the sub-criteria, the final results of the process are shown below:

Partner-environmental	WEIGHT
Objective 3	0.10
Goal 6	0.15
Goal 7	0.15
Goal 12	0.15
Quality of life impact	**0.21**
Goal 13	0.20
Benefited	**0.21**

Economic-Financial	WEIGHT
Economic-financial indicators	0.12
Budget	**0.19**
Financing sources	**0.19**

Technicians	WEIGHT
Equipment-Technology	0.12
Execution time	0.16
Resources	0.14
Location	**0.19**
Project Type	**0.22**

Market study	WEIGHT
Position before the competition	0.16
Business benefits	0.17
Customer satisfaction	**0.18**

Table 6. Results of the application of the AHP technique in the sub-criteria

To confirm the validity of the procedure in each of the binary comparisons, its consistency was analyzed, obtaining the following values respectively: (0.07; 0.09; 0.08; 0.065; 0.059) <0.10, therefore it is accepted.

Then we proceed to the multiplication of matrices between the criteria and sub-criteria and then to the weighting of them to obtain the global input weights to the TOPSIS technique that will be used for the evaluation and selection of investment projects.

Not.	Sub-criteria	Weights
1	Objective 3- Good health: Guarantee a healthy life and promote well-being for all of all ages.	0.036642444
2	Objective 6- Clean water and sanitation: Guarantee water availability and its sustainable management and sanitation for all.	0.05411483
3	Goal 7- Affordable and sustainable energy: Guarantee access to affordable, safe, sustainable, and modern energy for all.	0.051868009
4	Objective 12- Responsible consumption and production: Guarantee sustainable consumption and production patterns.	0.053992697
5	Goal 13- Climate Action: Adopt urgent measures to combat climate change and its effects.	0.070404688
6	Impact on quality of life (poverty, health, employment, education, etc.)	0.072981582
7	Number of people benefited	0.075290383
8	Economic-financial indicators (Net Social Value, Internal Rate of Return, Cost / Benefit, Investment Payback Period, among others)	0.043197325
9	Budget	0.071653038
10	Financing sources	0.068875919
11	Equipment-Technology	0.035920985
12	Execution time	0.05050696
13	Necessary resources (human, material)	0.043482424
14	Location (micro and macro location)	0.057575976

15	Project Type	0.06803746
16	Position before the competition	0.045358783
17	Commercial benefits (prestige, brand consolidation, innovation)	0.048425688
18	Customer satisfaction	0.051670808

Table 7. Result of the calculation of the overall weighted weights for each sub-criterion for the evaluation of the projects

To better illustrate the method, we proceed to take as an example four projects called A, B, C, and D. Then, to start the application of the plithogenic TOPSIS, the variables are declared:

- Criteria: 18
- Alternatives: 4
- Experts: 10

Weighted Criteria	Weights	Alternatives to evaluate			
		Project A	**Project B**	**Project C**	**Project D**
Objective 3	0.036642444	(0.10,0.90,0.90)	(0,9; 0,1; 0,1)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)
Objective 6	0.05411483	(0,35; 0,75; 0,80)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
Objective 7	0.051868009	(0.10,0.90,0.90)	(0,75, 0,25, 0,20)	(0,75, 0,25, 0,20)	(0,75, 0,25, 0,20)
Objective 12	0.053992697	(0,35; 0,75; 0,80)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)	(0,75, 0,25, 0,20)
Impact on Quality of life	**0.070404688**	(0,35; 0,75; 0,80)	(0,9; 0,1; 0,1)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)
Objective 13	**0.072981582**	(0.10,0.90,0.90)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)	(0,75, 0,25, 0,20)
Benefitted	**0.075290383**	(0.10,0.90,0.90)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
Economic-financial indicators	0.043197325	(0.10,0.90,0.90)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)	(0.10,0.90,0.90)
Budget	**0.071653038**	(0.10,0.90,0.90)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)	(0.10,0.90,0.90)
Funding sources	0.068875919	(0.50,0.50,0.50)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.10,0.90,0.90)
Equipment-technology	0.035920985	(0.50,0.50,0.50)	(0,75, 0,25, 0,20)	(0,75, 0,25, 0,20)	(0,75, 0,25, 0,20)
Execution time	0.05050696	(0.50,0.50,0.50)	(0,9; 0,1; 0,1)	(0,75, 0,25, 0,20)	(0,75, 0,25, 0,20)
Resources	0.043482424	(0,35; 0,75; 0,80)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
Localization	0.057575976	(0.10,0.90,0.90)	(0,75, 0,25, 0,20)	(0.50,0.50,0.50)	(0,9; 0,1; 0,1)
Type of project	0.06803746	(0,35; 0,75; 0,80)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.10,0.90,0.90)
Position in front of competence	0.045358783	(0,35; 0,75; 0,80)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)

Business benefits	0.048425688	(0.10,0.90,0.90)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
Client satisfaction	0.051670808	(0.10,0.90,0.90)	(0,9; 0,1; 0,1)	(0.50,0.50,0.50)	(0.50,0.50,0.50)

Table 8. Step 1. Experts' assessment (median)

Weighted criteria	SIP	SIN
Objective 3	0.025576794	0.005683732
Objective 6	0.040591761	0.016236704
Objective 7	0.029606243	0.007791117
Objective 12	0.03312247	0.015689591
Impact on Quality of life	0.04766518	0.019066072
Objective 13	0.047603727	0.012527296
Benefitted	0.05831968	0.012959929
Economic-financial indicators	0.034460629	0.009068587
Budget	0.05716115	0.015042408
Funding sources	0.053351058	0.011855791
Equipment-Technology	0.019387525	0.012754951
Execution time	0.030541282	0.016967379
Resources	0.032616348	0.013046539
Localization	0.040007334	0.008890519
Type of project	0.055221561	0.012271458
Position in front or competence	0.034023813	0.013609525
Business benefits	0.037510376	0.008335639
Client satisfaction	0.040024036	0.00889423

Table 9. Steps 2-6 of the TOPSIS

TOPSIS	Proj A	Proj B	Proj C	Proj D
s+	0.031446823	0	0.01853756	0.02132344
s-	0	0.03144682	0.0168575	0.01060924
Ri	0	1	0.47626692	0.33223761
Level of prioritization and ranking of the projects selection	**4**	**1**	**2**	**3**

Conclusion

At present, the economic crisis affecting the countries makes the selection process of investment projects to be carried out more critical. Such is the case of Ecuador, where the Multi-annual Public Investment Plan 2017-2021 establishes indicative amounts of public investment that are projected to be executed annually to achieve each of the nine strategic objectives of the National Development Plan that pay tribute to the Sustainable Development Goals of the UN. However, this plan has certain weaknesses that may not allow an effective and efficient choice at the same time. Which entails a scenario of uncertainty for the Ecuadorian investment process. It can be said that the objective of this research was met by responding to the problem, developing a three-step model for the selection of investment projects in a plithogenic environment using discrete multicriteria decision methods. From its application we may conclude that:

1. In the case of comparison of criteria, for experts, it is more important to choose a project that shows favorable economic-financial indicators and in turn, is compatible with the Socio-environmental indicators that contribute to the implementation of the Sustainable Development Goals.
2. In the case of the separate analysis, it is evident that the experts consulted give greater importance to the budget, financing sources, client satisfaction, location, type of project, impact on quality of life and the number of people benefited.
3. During the TOPSIS, as an example, it was confirmed that, in a weighted way, the experts give greater importance to the impact quality of life, the fulfillment of objective 13 of Sustainable Development "Climate Action" which means adopting urgent measures to fight climate change and its effects, the

number of people benefited and the budget.

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University of New Mexico

Digital Transformation of Marketing in Small and Medium Enterprises Through Social Networks: Plitogenic Decision-Making

Carlos Roberto Sampedro Guaman[1], Diego Paul Palma Rivera[2], Silvio Amable Machuca Vivar[3] and Estalin Vladimir Arrobo Lapo[4]

[1] us.carlossampedro@uniandes.edu.ec. Teacher. Regional Autonomous University of the Andes, Santo Domingo, Ecuador
[2] us.diegopalma@uniandes.edu.ec. Professor, Regional Autonomous University of the Andes, Santo Domingo, Ecuador
[3] us.silviomachuca@uniandes.edu.ec. Professor, Regional Autonomous University of the Andes, Santo Domingo, Ecuador
[4] us.estalinarrobo@uniandes.edu.ec. Teacher. Regional Autonomous University of the Andes, Santo Domingo, Ecuador

Abstract. How companies relate to customers and the global society has changed over time; those who do not use internet marketing and social networks have reduced their recognition. The archaic ways businesses handled their marketing have caused a considerable lag in their online sales and the many benefits they can offer. The revolution in the use of technology is currently fundamental for business; practitioners can find several areas to apply this resource, such as decision-making, teleworking, and sales, among others. This allows adapting business operations and services efficiently. Companies leverage a combination of cutting-edge technologies to modernize legacy business operations and recognize and implement new opportunities from current models. This research aims to analyze aspects related to the implication that social networks have in marketing in small and medium-sized companies in the city of Santo Domingo. Te research was developed based on the analytical-synthetic and inductive-deductive research modality and mathematical modeling for decision-making through neutrosophic logic and plithogenic logic. It was determined that the most relevant economic activity is commerce and that the tertiary sector was one of the most affected by the quarantine. Likewise, it was determined that social communities helped increase sales and that the most used company is Facebook and its complementary networks.

Keywords: Social networks, digital transformation, electronic commerce, internet sales, neutrosophic logic, plithogenic logic.

1 Introduction

Reinventing oneself is the term used by medium, small, and micro-enterprises (MSMEs) to take a step towards the digital transformation of their activities in the face of the situation produced by the quarantine. Due to the COVID-19 pandemic, there was no alternative but to enhance electronic commerce (e-commerce)[1]. Those who already had digital platforms adapted easier and are taking better advantage of the situation. The first option for MSMEs that did not have an e-commerce platform was selling their products through their social media profiles or well-known buying and selling applications in Ecuador: "Mercado libre" and OLX. Below are some essential concepts:

Marketing a product: The commercialization of a product or service focuses on commercializing, which consists of putting a product on sale, giving it the necessary commercial conditions for its sale and providing it with the distribution channels that allow it to reach the final public. It is based on all the techniques and decisions focused on selling a product in the market to achieve the best possible results [2].

Social marketing: It is the use of social networks (Facebook, Instagram, Twitter, YouTube, Pinterest, etc.) to communicate information that is interesting to the thousands and millions of users who use the network. It is not a miracle solution for any business, but it can be very effective to add new potential clients, expand the network of suppliers, generate alliances, among others [3]. Social networks can be a fantastic tool to get these contacts to visit the profile, establish a communication channel with them, position the brand, get new customers, and continue buying and recommending other people. To achieve these objectives, a practitioner must know very well how these networks work, their terms and conditions, analyze how to achieve the sale of products and services and the most important thing is to establish a strategy, follow an action plan and use the correct tools to optimize maximum time and resources [3].

Ecuador - Digital Users: Society has been driven towards accelerated digitization due to confinement, motivating proposals from organizations and institutions that, along with creativity and innovation, have activated various digital services that were previously only found in plans. This has provoked a growth both in the number of users and in time spent on platforms, transactions, use of digital services, relevant content, and unfortunately also, false, incomplete content and news that users should be aware of and alert to, verifying and validating information before sharing or publishing it [4].

Social media	Users
Facebook	13.1 million
Instagram	4.7 million
Linkedin	2.7 Million
TikTok	2.6 Million
Twitter Ads	1.3 Million
Pinterest	1.1 million

Table 1 Audience on Social Networks. Source: [4]. Facebook Ads, Twitter Ads, SemRush, Linkedin Ads, Snapchat Ads, Statista, InternetWorldStats & CIA Worldfact book. Twitter and Spotify information according to the latest available statistics. Figures Spotify and Pinterest.

Ecuador users who employ the different messaging services to carry out communication processes in different activities.

Instant messaging	Users
Messenger	8,400,000
Telegram	300,000
WhatsApp	9,100,000

Table 2 Use of Instant Messaging in Ecuador. Source: [4]. Facebook Ads July 14, 2020.

Digitization has brought along the adaptation of people to a more agile, convenient, and connected world. It has enabled organizations to obtain real-time information, evaluate data and follow the customer throughout the entire value chain to keep it authentic and secure. At the same time, it facilitates the coordination of decisions for the best operation of a company.

In the business landscape, digital transformation fluctuates between two variables. First, measure the revenue each share brings according to competitors. Furthermore, second, add value to customers through the use of technology. Both make the customer experience accessible and control the entire supply chain [5].

Implementing a digital transformation project can be challenging due to budget constraints, or you may find that users are resistant to changes. If this happens, having a plan is essential to get the project back on track. Forbes Technology Council advises on managing digital transformation and correcting courses if the project deviates. Here are the best strategies for tech teams to follow [6]:

- ✓ Identify the goal
- ✓ Remember the reasons to transform
- ✓ Prioritize for an early and easy impact
- ✓ Reboot with a new goal
- ✓ Incorporate smaller profits
- ✓ Design an overlay solution in the cloud
- ✓ Focus on the customer
- ✓ Set recognizable milestones
- ✓ Take a look at organizational change
- ✓ Build consensus across the organization
- ✓ Train employees to experiment and learn
- ✓ Develop a measurable message about the value of the project
- ✓ Handle expectations with care
- ✓ Do not try to do too much at once
- ✓ Remember why it started

Social networks for SMEs

Networks are used to sell on the internet, but launching without a plan does not guarantee business. Facebook, Twitter, Instagram, LinkedIn, Google Plus, Snapchat, or YouTube cannot increase sales by themselves. Social platforms are essential in a digital marketing strategy to increase the sales of SMEs. The dissemination of content and "advertising" of social platforms are one of the most powerful tools to generate new sales opportunities [7]

Segmentation in social networks

Allows gathering specific content with a specific audience. It allows gathering the appropriate message with the appropriate person. It is something very useful when selling, although it does not offer all the solutions:

- ✓ It is helpful because business owners can send people with certain specific characteristics (such as age, purchasing power, geographical area of residence, etc.) specific messages of interest to them about a product you sell.
- ✓ Insufficient because not all the data allows identifying if they are ready to buy. No social network can do that on its own because [8]

Main objectives of SMEs in social networks

The main goals that social media marketing professionals have are:

- ✓ Increase brand awareness.
- ✓ Increase community engagement.
- ✓ Increase website clicks.

Making sure businesses have them is one of the biggest bets because the conditions for talking to the community would have improved [9]

Digitization of MSMEs

Electronic commerce has been an ally for customers and merchants during the pandemic, with which physical contact has been avoided. Small businesses have looked for a way to ride this "digital wave", which has more impact on sales every day. To help micro, small and medium-sized enterprises (MSMEs) take their first steps in the world of electronic commerce, the Government recently launched a digitization plan, with the support of the Organization of American States (OAS) Kolau technology company. It is a regional initiative, which has been taken to 11 countries in Latin America, whose objective is to promote that MSMEs can create their web pages, to offer and sell their products and services. In Ecuador, the idea is coordinated by the Ministry of Tourism [10]

In Ecuador, 780,000 households make their purchases through electronic commerce. This was reported in the webinar of the consulting firm Kantar called "A vision of the new shopper for the growth of Latin America". The company explained that online purchases are all those processes that are made through applications, Internet sites, or WhatsApp [11]

What motivates people to buy?

There are several interests and motivations of people to buy and make use of electronic commerce, and that is where companies must put their efforts. Customers are looking for a good product, at a good price, with secure payment and timely delivery [12]

- ✓ Have a guarantee of return and/or exchange of product and/or service
- ✓ Guarantee of confidentiality of customer information
- ✓ More information on how to buy the product or service
- ✓ Customer service during the purchase [12]

Online businesses have to work with more responsibility and seriousness because it will be one of the channels of preference for all consumers. If it does not end up being the most important sales channel, it will at least be among the top five most important inside the company. There are *more expert* users, much more constant users, and new users who must be served in the best possible way. The future of electronic commerce is very great and positive and it must be taken with great responsibility [13].

Electronic commerce, also known as e-commerce, is buying and selling products or services, mainly through computer networks and the internet. Thanks to the mass use of the internet, which in Ecuador covers more than half the population. This type of trade proliferated in the world, moving millions of dollars [14].

Ecuador has increased the demand for internet

According to the Association of Telecommunications Companies of Ecuador (Asetel) and the Association of Internet Providers, Added Value, Carriers and Information Technologies (Aeprovi), Ecuador experienced a 30% growth in the demand for internet services during the last months [15]. Likewise, according to statistics from the report "Digital State Ecuador 2020" presented in January, the country has 80% of users with internet access, 33% are concentrated in Quito and Guayaquil, and 63% of the total are older than 24 years old, who register 92% of income and interaction in social networks, of which Facebook, Instagram, WhatsApp and Messenger maintain the leadership with 13 million integrated users [15].

Objectives, policies, and projects of the 2016-2021 national plan

In the National Plan for Telecommunications and Information Technologies of Ecuador 2016-2021, international trends in the ICT sector show in recent years a greater penetration of portable devices with high storage capacity, development of free transmission products (for example, Netflix, Whatsapp), an exponential increase in storage capacity and the expansion in the supply and demand of cloud computing services. In the future, the abundance of data is expected to multiply more and more through the Internet of Things, social networks, and Big Data analytics, and processing capacity will continue to increase along with greater ease of use of these technologies by the population [16].

For the development of this study, mathematical modeling for decision-making was applied using neutrosophic logic and plithogenic logic. Neutrosophic sets are a part of Neutrosophy, which studies the origin, nature, and scope of neutralities and their interactions with different ideational spectra. Neutrosophic sets are relatively new extensions of fuzzy intuitionist sets, while Plithogeny advocates for the connections and unification of theories and ideas in varied fields of science, as it is an extension of the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set [17].

2 Methods

To determine the impact that the use of social networks as a marketing strategy for their products or services has on businesses during the quarantine period due to the COVID-19 pandemic, a survey was applied to business owners who are doing this activity. As well as the observation of the offer in the Marketplace and the groups on Facebook: purchase sale Santo Domingo and OLX Santo Domingo de Los Tsáchilas.

Analytical-Synthetic: It facilitates the processes and the unification of said study based on its constituents, allowing information to be obtained on each of the aspects required in the survey carried out with entrepreneurs.

Inductive-Deductive: With this method, the conclusions are reached from the premises obtained [18].

Techniques

Mathematical modeling through neutrosophic logic and plithogenic logic

Documentary research to obtain data related to Small and Medium-sized companies that are marketing through social networks.

Neutrosophic sets were introduced in the literature by F. Smarandache since fuzzy intuitionistic sets could only handle incomplete information, but not the indeterminate and inconsistent information, which commonly exists in fuzzy systems. Thus, the term neutrosophic means knowledge of neutral thought and this neutrality represents the main distinction between fuzzy logic and fuzzy intuitionist [19-27].

In neutrosophic sets, the indeterminacy is explicitly quantified through a new parameter I. True membership (T), indeterminate membership (I), and false membership (F) are independent of each other and the sum among them satisfies the inequalities $0 \leq T + I + F \leq 3$. In fuzzy intuitionistic sets, the uncertainty depends on the degree of membership and the degree of non-membership [28]. In neutrosophic sets, the indeterminacy factor (I) is independent of the true and false values. There are no restrictions between the degree of truth, the degree of indeterminacy, and the degree of falsehood [19, 28-31].

If U is a universe of discourse, a Neutrosophic Set (NS) is characterized by three membership functions, uA (x), rA (x), vA (x) $:X \rightarrow]\,0^-, 1^+\,[$, which satisfy the condition $0 \leq -\inf uA(x) + \inf rA(x) + \inf vA(x) \leq \sup uA(x) + \sup rA(x) + \sup vA(x) \leq 3^+$ for all $x \in X$. uA (x), rA (x) and vA (x) are the membership functions of the trueness, indeterminacy and falsehood of x in A, respectively and their images are standard or non-standard subsets of $]\,0^-, 1^+\,[$.

When approaching the perspective of indeterminacy and contradiction, as is the case with Gödel's incompleteness theorem, it states that any proposition in a mathematical axiom system will present a degree of truth (T), falsehood (F), and indeterminacy (I). Neutrosophy, therefore, establishes a unique solution for the existence of paradoxes in philosophy.

Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and mergers of multiple contradictory and/or neutral and/or non-contradictory previous entities. Plithogeny advocates for the connections and unification of theories and ideas in varied fields of science. "Knowledge" is taken as "entities" in various fields, such as social sciences, technical sciences, theories of arts, and so on [31].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a type of opposites: <A> and <antiA>), Neutrosophy (dynamics of a type of opposites and their neutrals: <A> and <antiA> and <neutA>), since Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites (<A> and <antiA> and <neutA>, <B> and <antiB> and <neutB>, etc.), and many non-opposites (<C>, <D>, etc.) all together. As an application and particular case derived from Plithogeny, the plithogenic set extends the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set, and has multiple scientific applications [31].

So, (P, a, V, d, c) is called a plitogenic set

1. Where "P" is a set, "a" is an attribute (multidimensional in general), "V" is the range of attribute values, "d" is the degree of membership of the attribute value of each element x to the set P for some given criteria (), and "d" means "" or "" or "", when it is a fuzzy degree of membership, an intuitionistic fuzzy membership or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P; $x \in P d_F d_{IF} d_N$
2. "c" means "" or "" or "", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value degree of contradiction function, respectively. $c_F c_{IF} c_N$

The functions are defined according to the applications that the experts need to solve. $d(\cdot,\cdot) c(\cdot,\cdot)$
So, the following notation is used:
$x(d(x, V))$, where $d(x, V) = (d(x, v), \text{for every } v \in V), \forall x \in P$
The attribute value contradiction degree function is calculated between each attribute value concerning the dominant attribute value (denoted by) in particular and other attribute values.v_D
The function of the degree of contradiction of attribute value c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (Y), union (OR), implication (⟹), equivalence (⟺), inclusion (order partial) and other plithogenic aggregation operators that combine two or more degrees of attribute values based on a t-norm and a t-conorm

Most of the plithogenic aggregation operators are linear combinations of a fuzzy t-norm (indicated by $\wedge_F$) with a fuzzy t-conorm (indicated by $\vee_F$), but non-linear combinations can also be constructed.
If the t-norm is applied on the value of the dominant attribute denoted by, and the contradiction between and is, then it is applied on the value of the attribute as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2), \quad (1)$$

Or, using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \quad (2)$$

Similarly, if the t-conorm applies to the value of the dominant attribute denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2) v_2$, then it applies to the value of the attribute:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2), \quad (3)$$

Or, using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2), \quad (4)$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right), \quad (5)$$

The plithogenic neutrosophic junction is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right), \quad (6)$$

In other words, if something applies to membership, the opposite applies to non-membership, while in indeterminacy it is the average what applies. Plithogenic neutrosophic inclusion is defined as follows:
Since the degrees of contradiction is:
$c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5,$
|Applying $a_2 \geq [1 - c(a_1, a_2)] b_2$ $a_2 \geq (1 - 0.5) b_2$ o $a_2 \geq 0.5 b_2$, while $c(a_1, a_3) = c(b_1, b_3) = 1$
Having the opposite is true for $a_1 \leq b_1$ if and only if $a_3 \geq b_3$ therefore $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only $a_1 \leq b_1$, $a_2 \geq 0.5 b_2$, and $a_3 \geq b_3$

Next, an algorithm for the resolution of this research is presented where Plithogeny will be merged with the algorithm of Neutrosophy.
From this moment on, expressions 2 to 8 must be applied to execute the operations of the classical algorithm with plithogenic numbers.
To elaborate a single decision matrix, the median of the plithogenic numbers is calculated for each combination for all specialists. The median is calculated using the following formula:

$$\mathrm{median}_{i=1}^{m}\{PN_i\} = (\mathrm{median}_{i=1}^{m}\{T(PN_i)\}, \mathrm{median}_{i=1}^{m}\{I(PN_i)\}, \mathrm{median}_{i=1}^{m}\{F(PN_i)\}), \quad (7)$$

Where PN_i, are plithogenic numbers, $T(PN_i)$ are their true components, $I(PN_i)$ are their indeterminate components and $F(PN_i)$ are their false components. In other words, Equation 7 means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components:

To compare the relationships between the quadrants, the following formula is used to blur a neutrosophic number [32]:

$$\mathcal{S}([T, I, F]) = \frac{2+T-I-F}{3}, \quad (8)$$

- Determine for each line of the pairwise comparison matrix, a weighted sum based on the sum of the product of each cell by the priority of each alternative or corresponding criterion.
- For each line, divide its weighted sum by the priority of its corresponding alternative or criterion
- Determine the mean λ_{max} of the result of the previous stage.
- Calculate the consistency index (CI) for each alternative or criterion

  $$CI = \frac{\lambda_{max} - m}{m-1} \quad (9)$$

  Where m is the number of alternatives
- Determine the Random Index (RI) from table 2
- Determine the consistency ratio index (the ratio between the consistency index and the random index.

3 Results

The investigation resulted as follows:

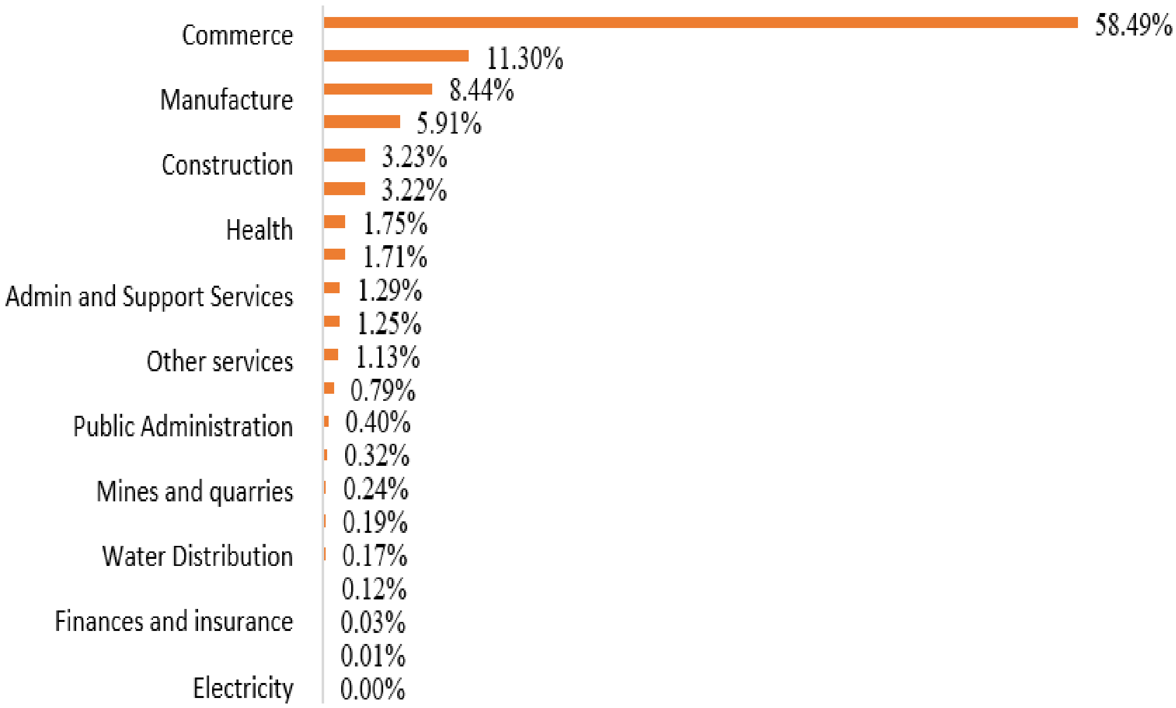

Figure 1. Average distribution of registered sales by type of economic activity in the province of Santo Domingo de Los Tsáchilas, in percentages, period 2011-2016. **Source**: Internal Revenue Service, September 2017.

The productive activities of the province of Santo Domingo de Los Tsáchilas have been influenced by its strategic geographical location, fostering commercial exchange between the coast and the mountains. Thus the main economic activity of the territory is trade, representing 58.49 %, agriculture contributes with 11.30%, manufacturing with 8.44%, transportation, and storage with 5.91%, among others.

The results of the survey are set out below

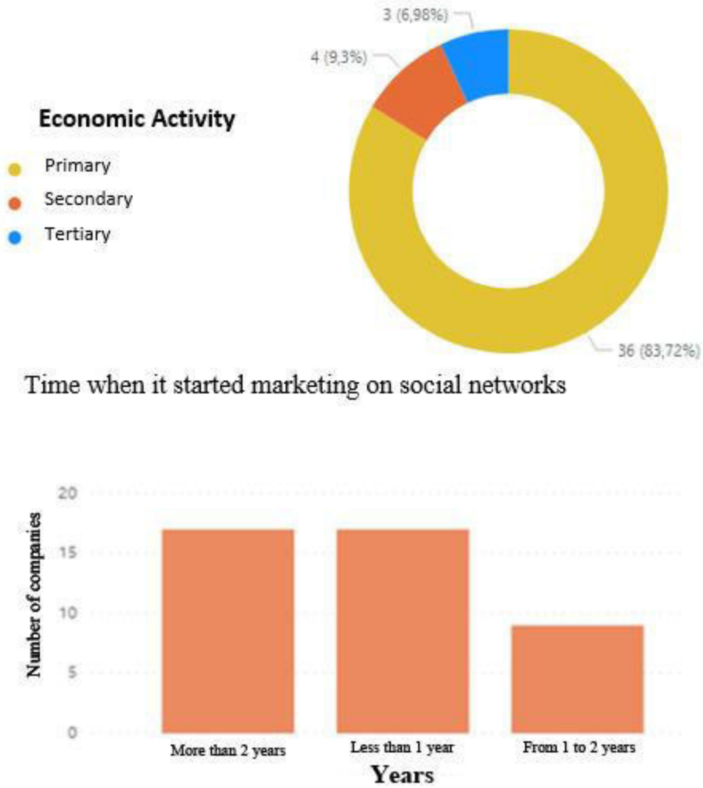

Figure 2. Results by type of economic activity of the companies.

One of the sectors most affected by the quarantine was the tertiary sector of trade in products and services, which in turn constitute the majority of economic activity in Santo Domingo (84% in the survey), followed by secondary activities (9.3% manufacturing and production of goods or services) and primary (6.98% livestock, agriculture and other tasks related to the treatment of raw materials). 60% of those surveyed were already doing social media marketing (40% are positioned in the market and 20% in the growth stage) before the pandemic, and the remaining 40% started social media activity during the pandemic.

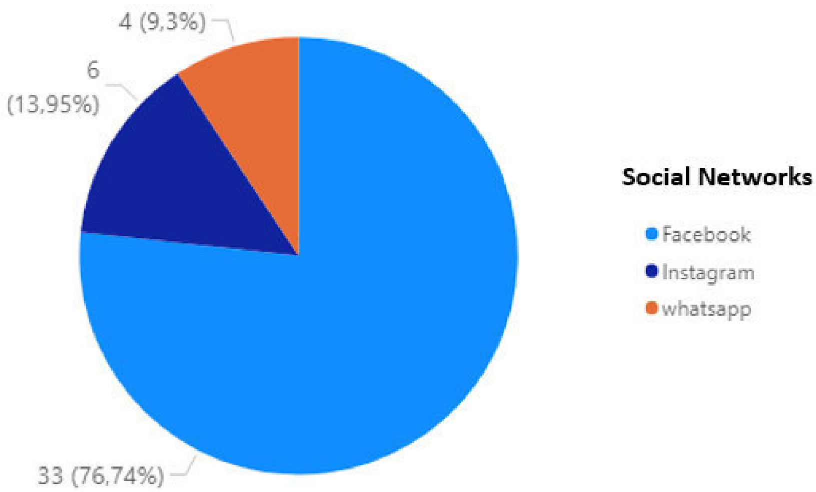

Figure 3. Social networks are used to promote the business or service.

Most entrepreneurs use Facebook as a social network to market their products, Instagram is followed in a lower percentage, and others pointed to WhatsApp (Although it is not a social network), they did not point out as social networks used: LinkedIn, Twitter, and Pinterest, which were among the response options.

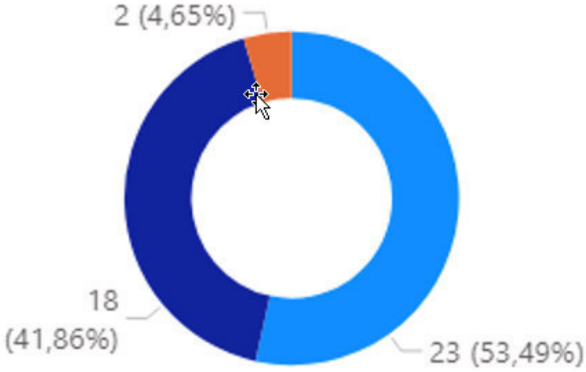

Figure 4. Impact of social networks on marketing and sales.

53% of companies that carried out marketing through social networks have experienced an increase in their sales, 42% indicate that sales remained the same, and only 5% saw their sales reduced.

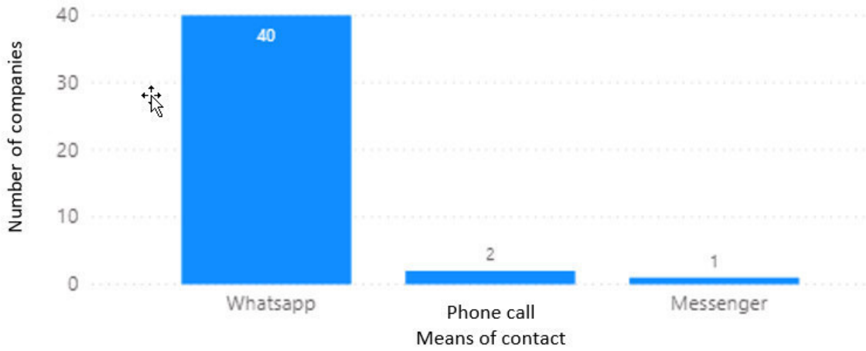

Figure 5. Means of contact to make sales.

The most used means of contact to make sales was WhatsApp, with a minimum percentage of telephone calls and Messenger, they did not consider email, telegram, or any other means of contact.

4 Discussion

4.1 Development of mathematical modeling for decision making with plithogenic logic in the digital transformation of marketing

Plithogenic Set: Digital Transformation of Marketing

That is why a plithogenic set is defined that consists of 4 attributes, each of these attributes contain possible V values that appear between parentheses.

The attributes are defined as follows and the possible values appear in parentheses:

V1	Reputation and ranking in the market	v11	Advertising
		v12	Perception of the brand image in the client
V2	Marketing and sales	v21	Natural resources, livestock, agriculture, and other related tasks
		v22	Manufacture and production of the goods or services
		v23	Trade in products and services
V3	Quality of customer service	v31	Provision of the service
		v32	Customer acquisition
V4	Social networks and platforms	v41	Increase in web traffic

The multi-attribute of dimension 5 has cardinality 2x3x2x1 = 12.

The degrees of contradiction between the values for each attribute are defined below:
cN (v11, v12) = 0.2
cN (v21, v22) = cN (v22, v23) = cN (v22, v23) = 0.5
cN (v31, v32) = 0.3
cN (v41, v41) = 0

As you can see, the dominant values for each attribute are: v12, v23, v32, and v41

Linguistic Expression	Plithogenic number (T, I, F)	$S([T,I,F]) = \frac{2+T-I-F}{3}$
Very Weak (MMD)	(0.10, 0.75, 0.85)	0.16
Weak (D)	(0.25, 0.60, 0.80)	0.28
Medium Weak (MD)	(0.40, 0.70, 0.50)	0.40
Medium (M)	(0.50, 0.40, 0.60)	0.50
Medium Strong (MF)	(0.65, 0.30, 0.45)	0.63
Strong (F)	(0.80, 0.10, 0.30)	0.80
Very Strong (MMF)	(0.95, 0.05, 0.05)	0.95

Table 3 Plitogenic numbers

$$N(E) = \begin{pmatrix}
\mathbf{(0,50; 0,40; 0,60)} ; & (0,95; 0,05; 0,05) ; & (0,65; 0,30; 0,45) ; & (0,80; 0,10; 0,30) ; & (0,80; 0,10; 0,30) ; & (0,80; 0,10; 0,30) ; & (0,25; 0,60; 0,80) ; & (0,80; 0,10; 0,30) ; & (0,65; 0,30; 0,45) \\
(0,65; 0,30; 0,45) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) ; & (0.10, 0.75, 0.85) ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) \\
(0,65; 0,30; 0,45) ; & (0,65; 0,30; 0,45) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,50; 0,40; 0,60) ; & (0,50; 0,40; 0,60) ; & (0,50; 0,40; 0,60) ; & (0.10, 0.75, 0.85) ; & (0,65; 0,30; 0,45) ; & (0,40; 0,70; 0,50) \\
(0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) ; & (0.10, 0.75, 0.85) \\
(0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) ; & (0,40; 0,70; 0,50) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) \\
(0,80; 0,10; 0,30) ; & (0,65; 0,30; 0,45) ; & (0,40; 0,70; 0,50) ; & (0,40; 0,70; 0,50) ; & (0,40; 0,70; 0,50) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) ; & (0,25; 0,60; 0,80) \\
(0.10, 0.75, 0.85) ; & (0,25; 0,60; 0,80) ; & (0.10, 0.75, 0.85) ; & (0,25; 0,60; 0,80) ; & (0,40; 0,70; 0,50) ; & (0,65; 0,30; 0,45) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,40; 0,70; 0,50) ; & (0,40; 0,70; 0,50) \\
(0,95; 0,05; 0,05) ; & (0,40; 0,70; 0,50) ; & (0,65; 0,30; 0,45) ; & (0.10, 0.75, 0.85) ; & (0,25; 0,60; 0,80) ; & (0,80; 0,10; 0,30) ; & (0,40; 0,70; 0,50) ; & \mathbf{(0,50; 0,40; 0,60)} ; & (0,65; 0,30; 0,45) \\
(0,65; 0,30; 0,45) ; & (0,95; 0,05; 0,05) ; & (0,80; 0,10; 0,30) ; & (0,40; 0,70; 0,50) ; & (0,65; 0,30; 0,45) ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) ; & (0,95; 0,05; 0,05) ; & \mathbf{(0,50; 0,40; 0,60)}
\end{pmatrix}$$

Figure 6. Neutrosophic matrix under the neutrosophic logic

$$E = \begin{pmatrix}
\mathbf{0.50} ; & 0.95 ; & 0.63 ; & 0.80 ; & 0.80 ; & 0.80 ; & 0.28 ; & 0.80 ; & 0.63 \\
0.63 ; & \mathbf{0.50} ; & 0.95 ; & 0.95 ; & 0.95 ; & 0.95 ; & 0.16 ; & 0.95 ; & 0.95 \\
0.63 ; & 0.63 ; & \mathbf{0.50} ; & 0.50 ; & 0.50 ; & 0.50 ; & 0.16 ; & 0.63 ; & 0.40 \\
0.16 ; & 0.16 ; & 0.16 ; & \mathbf{0.50} ; & 0.16 ; & 0.16 ; & 0.16 ; & 0.16 ; & 0.16 \\
0.28 ; & 0.28 ; & 0.28 ; & 0.40 ; & \mathbf{0.50} ; & 0.28 ; & 0.28 ; & 0.28 ; & 0.28 \\
0.80 ; & 0.63 ; & 0.40 ; & 0.40 ; & 0.40 ; & \mathbf{0.50} ; & 0.28 ; & 0.28 ; & 0.28 \\
0.16 ; & 0.28 ; & 0.16 ; & 0.28 ; & 0.40 ; & 0.63 ; & \mathbf{0.50} ; & 0.40 ; & 0.40 \\
0.95 ; & 0.40 ; & 0.63 ; & 0.16 ; & 0.28 ; & 0.80 ; & 0.40 ; & \mathbf{0.50} ; & 0.63 \\
0.63 ; & 0.95 ; & 0.80 ; & 0.40 ; & 0.63 ; & 0.95 ; & 0.95 ; & 0.95 ; & \mathbf{0.50}
\end{pmatrix}$$

	td
v12	1.6838
v41	1.5722
v11	1.5637
v32	1.3877
v23	1.3648
v13	1.2818
v22	1.0701
v31	0.9127
v21	0.8827

Figure 7. De-neutrosophic adjacent matrix and the values of the extremes of the MCN under the neutrosophic logic

When v12 is activated, all other nodes are activated, which means that the value of the *brand image perception* on the client in the subset of the reputation and ranking in the market will cause a positive influence by projecting as the dominant value within the plithogenic set.
The evaluation of the digital transformation of marketing in the subset *reputation and ranking in the market* is determined by the results obtained

v11	v12
F (0.95, 0.05, 0.05)	**MF** (0.65, 0.30, 0.45)

Table 3: Subset evaluations reputation and ranking in the market

The plithogenic conjunction of these values gives the following results, taking into account that the degree of contradiction is 0.5; first, it is calculated

(v1) Reputation and ranking in the market

Plitogenic Neutrosophic Intersection	$S([T,I,F]) = \frac{2+T-I-F}{3}$	Evaluation
$(a1, a2, a3) \wedge_p (b1, b2, b3) = (a1 \wedge_D b1, \frac{1}{2}[(a2 \wedge_D b2) + (a2 \vee_D b2)], a3 \vee_D b3)$ $(a1, a2, a3) \wedge_p (b1, b2, b3) = (0.617, 0.175, 0.4775)$	0.65	It is located on a sublevel between MF and F

The Reputation and market ranking subset is classified between medium strong and strong within the plithogenic set using the Plithogenic Neutrosophic Intersection operator. Similarly, evaluations can be carried out for the rest of the subsystems, even between the different subsystems.

Conclusion

The study determines the projection of social networks for marketing based on the attributes analyzed. The use of mathematical modeling for decision making through neutrosophic logic and plithogenic logic establishes the order and relationship between resulting criteria based on:

- ✓ Social networks for marketing are widely used to improve economic activity in companies of different types of activity, but an adequate way to manage them is not determined.
- ✓ The group of companies that belong to Facebook is the most used in companies in Santo Domingo, with Facebook and Instagram being the most used social networks for marketing and WhatsApp as a means of communication and contact.
- ✓ All companies have presented promising results based on SMEs and their digitization process in social networks, but they must have an official website to present greater confidence and credibility of their corporate image.

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University of New Mexico

Neutrosophic Statistic for Exploratory Analysis of the Data Provided by the Publications in the Social Sciences

Merck Milko Benavides Benalcázar[1], Bolívar David Narváez Montenegro[2], María José Calderón Velásquez[3], and Jaime Rodrigo Cadena Morillo[4]

[1] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.merckbenavides@uniandes.edu.ec
[2] Director de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.bolivarnarvaez@uniandes.edu.ec
[3] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.mariacalderon@uniandes.edu.ec
[4] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.jaimecadena@uniandes.edu.ec

Abstract. In the 21st century, several investigations related to society have focused on studies of the Social Sciences. The problems that affect the population are reflected in issues of the rights of women, children, and adolescents. Several authors have reflected their support against domestic violence, femicide, labor exploitation, the evaluation and modification of laws. The present study with the use of exploratory analysis and neutrosophic statistics seeks to define the most debated issues in the Social Sciences and each person's life with society. It should be noted that segments of society such as indigenous people and mestizos are aggravated by discrimination in each element analyzed, which journalists and authors refer to in their publications. For the visualization of the study, three groups comprised of society were analyzed. The analysis is developed in the visualization of the increase of publications disaggregated in neutrosophic subsets.

Keywords: publications, social sciences, exploratory analysis, neutrosophic statistics

1 Introduction

Among the topics debated by the authors in research and studies in the Social Sciences we may find:

Modifications of rules and regulations

The modifications of norms and regulations have played an important role for the state and the governing bodies to direct the processes in each country. Among those references is public procurement. For example, article 9 of the Organic Law of the National Public Procurement System seeks to guarantee the full execution of contracts, the effective application of contractual regulations, and ensuring and demanding compliance with the priority objectives of the National Public Procurement System [1].

Public purchases such as all those operations for the contracting and acquisition of products and services carried out by public entities fulfill the objectives that the company has entrusted to it [2]. These operations tend to be regulated by specific laws to guarantee the public sector's proper functioning, especially transparency and accountability to society [3] [4].

Among international organizations, we have the world health organization (WHO), which in 2020 declared COVID-19 a pandemic. The health mechanisms in each country were modified in pursuit of the health situation by approving rules and regulations. Several authors and journalists have set their sights on this critical issue facing society [5].

Studies against discrimination

The authors and magazines offer an overview of the situation of indigenous communities [6]. Indigenous communities have been affected by climate change[7], [8],[9],[8], [10],[11], [12]. Indigenous peoples and nations today turn out to be the most affected as a result of discrimination. Jobs in the public or private sector lack indigenous people who hold positions in these entities. Indigenous people who have lower-skilled jobs and greater instability bear the worst consequences in the face of economic shocks [13].

Criminal proceedings against crimes in society

Violence

Research and studies against violence have encouraged the struggle and concern of the governments in favor of the victims. For example, violence against women is a social problem that affects the family and that each year leaves thousands of victims in the world according to the results of the census of the National Institute of Statistics and Censuses 2010 [14].

The world health organization (WHO) declares that physical violence causes physical and psychological damage at the body level, it leaves scratches, internal wounds, cuts, burns, fractures, even death. The immediate effect that occurs is pain; children who have suffered violence are exposed to persistent neurological problems and manifest themselves in irritability, lethargy, tremors, and vomiting. In addition, frequent shaking syndrome in young children predisposes them to permanent deafness or blindness, paralysis, and coma, to death. Concerning psychological effects, after a certain amount of time, these become catastrophic since they induce the risk of addictive behaviors to psychoactive substances [15-17].

Women's studies

Femicide

From the published papers, the authors describe that femicide, from a social and cultural point of view, is derived from the patriarchal system, where authority in the primitive social organization was exercised by a male, who was the head of each family at least. that it is analyzed that femicide is a gender problem closely linked to the patriarchal system, which predisposes women to a greater or lesser extent to be murdered[18], [19] [15] [20], [21].

Childhood and adolescent studies

Childhood and adolescence

UNICEF, organizations in support of children and adolescents, and various authors defend the rights of children and their development at every stage of life. Several articles refer that children living in distress are victims of abandonment [22].

Abandonment is the action and effect of abandoning or abandoning oneself; lack of dedication or effort to act. It is considered a severe scourge [23] because it is about helpless human beings left to their luck, without anyone's attention. It is a true crime against the life and safety of a defenseless person [24]. It is the minor's family ties breakdown, leaving him to his fate [25-27].

From the exploratory analysis provided by the data of the analyzed publications, the most published topics can be determined through exploratory research and the application of neutrosophic statistical modeling. That is why this study focuses on:

- Problem situation: increase in publications of the Social Sciences and its reflection in society
- The main objective: define which are the most debated topics in the Social Sciences
- Specific objectives:
    - Determine the studies with the greatest contribution of data to society
    - Carry out the measurement and modeling of the neutrosophic variable
    - Analyze the effect of the data provided in the publications on society

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. For example, the Neutrosophic Probability of an event E is the probability that event E will occur [28-34], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics analyzes neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [35], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal underlying patterns [36].

In short, the Neutrosophic Logic [37] [38], Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development.

The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [39].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers [40], while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$.

Following the neutrosophic mean of the variable $(\bar{x}_N)$when formulating:

$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u]$ (1)

Where $\bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}, \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu}, n_N \in [n_l, n_u]$ (2)

is a neutrosophic random sample. However, the calculation of neutral squares (NNS) can be done as follows

$$\sum_{i=1}^{nN}(\bar{X}-\bar{X}_{iN})^2 = \sum_{i=1}^{nN}\begin{bmatrix} min\begin{pmatrix}(a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U)\\(a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U)\end{pmatrix}\\ max\begin{pmatrix}(a_i+b_iI_L)(\bar{a}+\bar{b}I_L),(a_i+b_iI_L)(\bar{a}+\bar{b}I_U)\\(a_i+b_iI_U)(\bar{a}+\bar{b}I_L),(a_i+b_iI_U)(\bar{a}+\bar{b}I_U)\end{pmatrix}\end{bmatrix}, I \in [I_L, I_U] \quad (3)$$

Where $a_i = X_l b_i = X_u$

The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{nN}(X_i - \bar{X}_{iN})^2}{{}^{n}N}; S_N^2 \in [S_L^2, S_U^2] \quad (4)$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [41].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} X100;\ CV_N \in [CV_L, CV_U]$$

To achieve a scale of measurement of the variables, it is associated with the linguistic terms with their neutrosophic evaluation and a score value.

Linguistic term	NNVU	Score
Very Weak (VW)	(0.10, 0.75, 0.85)	0
Weak (W)	(0.25, 0.60, 0.80)	1
Medium Weak (MW)	(0.40, 0.70, 0.50)	2
Medium (M)	(0.50, 0.40, 0.60)	3
Medium Strong (MS)	(0.65, 0.30, 0.45)	4
Strong (S)	(0.80, 0.10, 0.30)	5
Very Strong (VS)	(0.95, 0.05, 0.05)	6

Table 1. The evaluation system for experts according to the weight of the factor with the neutrosophic subset

3 Results

3.1 Data collection

To identify the possible relationships or integrations, three groups studied in the social sciences are established to analyze segments of the neutrosophic group based on exploratory data analysis provided by surveys, interviews, and exploratory analysis of the most common themes in society (Table 1). The sample for each neutrosophic subset is 120 social issues that have a greater interest in society with an intercept versus groups (F_n) (table 2).

For the modeling of the neutrosophic statistics, it is suggested to code the variable and its representation in charts and tables (Table 2).

3.2 Development of the method

Variable	Coding	Group	Sample	Ethnic groups
Topics with greater representation in the Social Sciences	ESC	A	120	Indigenous
		B	120	Mixed race
		C	120	general

Table 2. Characteristics of the DML variable

By modeling the variable with the use of neutrosophic statistics, the relative frequencies are obtained to determine the level of representativeness of the subjects, $F_n = \{F_1, F_2, F_3, F_4, F_5\}$ of the factors in the ESC (table 3), in a sample of 360 people subdivided into groups A, B, and C.

COD	Studies	Topics	Scale	Group	Ethnic groups
F1	Modifications of rules and regulations	• Work code • Penal Code • Laws	[0; 6]	A	Indigenous
F2	Studies against discrimination	• Gender			

F3	Criminal proceedings against crimes in society	• Labor • Assaults • Crimes • Violence		
F4	Women's studies	• Femicide • Women's rights • Domestic violence	B	Mixed race
F5	Childhood and adolescent studies	• Children's rights • Abandonment in childhood and adolescence • Adoption and guardianships • Education • Child labor	C	general

Table 3. Most published social studies are segmented into groups (ESC).

To obtain the weight of each factor that influences the ESC in each group, as the measure of indeterminacy for each study on a scale of $0 \leq ESC \geq 1$, it is decided to analyze the variable from the linguistic terms with its neutrosophic evaluation for $F_n = \{F_1, F_2, F_3, F_4, F_5\}$ (table 1).

Days	Neutrosophic frequencies				
	F1	**F2**	**F3**	**F4**	**F5**
1	[4 ; 5]	[4 ; 6]	[2 ; 2]	[1 ; 1]	[4 ; 5]
2	[1 ; 3]	[3 ; 4]	[1 ; 3]	[4 ; 4]	[0; 2]
3	[1 ; 2]	[0; 2]	[1 ; 2]	[1 ; 3]	[4 ; 5]
4	[1 ; 1]	[0; 1]	[2 ; 3]	[1 ; 1]	[4 ; 6]
5	[3 ; 4]	[4 ; 5]	[2 ; 4]	[1 ; 2]	[3 ; 5]
6	[0; 1]	[1 ; 2]	[2 ; 3]	[4 ; 4]	[0; 1]
7	[3 ; 4]	[2 ; 3]	[3 ; 3]	[3 ; 5]	[3 ; 5]
8	[4 ; 5]	[2 ; 3]	[4 ; 6]	[4 ; 5]	[0; 2]
9	[0; 1]	[4 ; 6]	[0; 0]	[4 ; 4]	[4 ; 4]
10	[2 ; 2]	[0; 0]	[0; 2]	[1 ; 1]	[3 ; 3]
11	[2 ; 4]	[3 ; 3]	[0; 0]	[2 ; 2]	[4 ; 5]
12	[2 ; 2]	[1 ; 2]	[2 ; 3]	[0; 0]	[0; 0]
13	[1 ; 1]	[3 ; 3]	[0; 1]	[3 ; 3]	[0; 1]
14	[0; 2]	[3 ; 4]	[2 ; 2]	[2 ; 3]	[3 ; 3]
15	[1 ; 1]	[0; 0]	[3 ; 4]	[3 ; 5]	[4 ; 6]
16	[4 ; 5]	[3 ; 4]	[1 ; 1]	[0; 1]	[0; 2]
17	[2 ; 2]	[3 ; 5]	[1 ; 3]	[0; 2]	[4 ; 6]
18	[2 ; 4]	[1 ; 3]	[4 ; 6]	[4 ; 5]	[1 ; 2]
19	[0; 0]	[0; 0]	[3 ; 3]	[0; 2]	[0; 0]
20	[2 ; 3]	[2 ; 2]	[0; 2]	[1 ; 3]	[2 ; 3]
0-120	[265; 383]	[252; 374]	[225; 347]	[245; 354]	[253; 383]

Table 4. Neutrosophic frequencies.

Of the neutrosophic relative frequencies observed for ESC, for 120 studies analyzed, the results showed that there is a level of total indeterminacy of $F_1 = 118, F_2 = 122, F_3 = 122, F_4 = 109, F_5 = 130$, with a level of representativeness [37.5%; 65%], in subjects with a weight greater than 3, with a higher incidence of 42% for studies F4 and F5.

Days	Neutrosophic frequencies				
	F1	F2	F3	F4	F5
1	[2 ; 6]	[2 ; 5]	[2 ; 2]	[1 ; 2]	[1 ; 1]
2	[2 ; 5]	[2 ; 6]	[1 ; 3]	[1 ; 2]	[2 ; 5]
3	[1 ; 1]	[1 ; 4]	[2 ; 4]	[2 ; 4]	[2 ; 3]
4	[1 ; 1]	[2 ; 3]	[1 ; 4]	[1 ; 5]	[1 ; 5]
5	[1 ; 4]	[1 ; 5]	[1 ; 5]	[1 ; 2]	[1 ; 4]
6	[2 ; 5]	[1 ; 1]	[1 ; 5]	[2 ; 6]	[1 ; 3]
7	[1 ; 5]	[1 ; 3]	[2 ; 5]	[1 ; 4]	[1 ; 5]
8	[1 ; 3]	[2 ; 4]	[1 ; 5]	[2 ; 3]	[2 ; 5]
9	[1 ; 5]	[1 ; 3]	[1 ; 1]	[1 ; 5]	[1 ; 2]
10	[1 ; 4]	[2 ; 4]	[1 ; 2]	[2 ; 6]	[1 ; 4]
11	[1 ; 3]	[1 ; 1]	[2 ; 2]	[2 ; 3]	[1 ; 3]
12	[1 ; 1]	[1 ; 4]	[2 ; 5]	[1 ; 3]	[1 ; 2]
13	[1 ; 4]	[1 ; 1]	[2 ; 4]	[1 ; 5]	[2 ; 5]
14	[1 ; 3]	[2 ; 3]	[1 ; 5]	[1 ; 3]	[1 ; 4]
15	[1 ; 3]	[2 ; 5]	[1 ; 5]	[1 ; 5]	[1 ; 1]
16	[1 ; 5]	[2 ; 2]	[1 ; 2]	[2 ; 4]	[2 ; 2]
17	[1 ; 4]	[2 ; 3]	[1 ; 2]	[2 ; 6]	[1 ; 5]
18	[2 ; 4]	[2 ; 3]	[1 ; 2]	[2 ; 2]	[2 ; 6]
19	[1 ; 2]	[1 ; 1]	[1 ; 5]	[2 ; 4]	[1 ; 3]
20	[2 ; 6]	[2 ; 6]	[1 ; 1]	[2 ; 4]	[1 ; 1]
0-120	[182; 419]	[180; 430]	[174; 412]	[179; 454]	[179; 427]

Table 5. Relative neutrosophic frequency of the level of ESC in Group B

Of the neutrosophic relative frequencies observed for the ESC, for 120 studies analyzed, the results showed that there is a level of total indetermination of $F_1 = 237, F_2 = 250, F_3 = 238, F_4 = 275, F_5 = 248$, with a level of representativeness [68.3%; 75.8%], in subjects with a weight greater than 3, with a higher incidence of 72% for studies F4 and F5.

Days	Neutrosophic frequencies				
	F1	F2	F3	F4	F5
1	[0; 1]	[0; 2]	[3 ; 5]	[0; 0]	[3 ; 4]
2	[3 ; 5]	[2 ; 4]	[2 ; 4]	[2 ; 2]	[2 ; 5]
3	[3 ; 4]	[2 ; 5]	[3 ; 3]	[3 ; 5]	[3 ; 4]
4	[0; 0]	[3 ; 3]	[2 ; 4]	[1 ; 3]	[2 ; 4]
5	[3 ; 4]	[0; 0]	[2 ; 4]	[3 ; 5]	[3 ; 4]
6	[3 ; 4]	[0; 2]	[0; 0]	[2 ; 3]	[1 ; 4]
7	[3 ; 5]	[0; 0]	[2 ; 4]	[3 ; 4]	[0; 1]
8	[0; 1]	[2 ; 4]	[3 ; 6]	[3 ; 4]	[2 ; 5]
9	[3 ; 4]	[0; 1]	[1 ; 4]	[1 ; 2]	[2 ; 4]
10	[2 ; 4]	[0; 3]	[3 ; 3]	[2 ; 2]	[0; 3]
11	[2 ; 5]	[2 ; 2]	[0; 1]	[0; 3]	[2 ; 2]
12	[0; 1]	[0; 0]	[1 ; 3]	[1 ; 2]	[2 ; 5]
13	[0; 0]	[2 ; 5]	[3 ; 3]	[1 ; 4]	[3 ; 3]
14	[2 ; 4]	[2 ; 3]	[1 ; 4]	[1 ; 4]	[0; 1]
15	[0; 3]	[0; 3]	[2 ; 4]	[2 ; 5]	[3 ; 5]
16	[1 ; 2]	[3 ; 6]	[3 ; 3]	[1 ; 4]	[1 ; 2]
17	[0; 0]	[0; 3]	[0; 0]	[0; 2]	[1 ; 4]

18	[2 ; 4]	[3 ; 6]	[0; 0]	[0; 2]	[3 ; 5]
19	[1 ; 2]	[2 ; 3]	[2 ; 5]	[2 ; 3]	[1 ; 1]
20	[1 ; 3]	[3 ; 6]	[2 ; 3]	[3 ; 6]	[3 ; 5]
0-120	[170; 352]	[183; 368]	[179; 377]	[177; 366]	[198; 381]

Table 6. Relative neutrosophic frequency of ESC level in Group C

Of the neutrosophic relative frequencies observed for ESC, for 120 studies analyzed, the results showed that there is a level of total indeterminacy of $F_1 = 182, F_2 = 185, F_3 = 198, F_4 = 189, F_5 = 183$, with a level of representativeness $[41.6\%;\ 69.1\%]$, in subjects with a weight greater than 3, with a higher incidence of 60 % for studies F3 and F5.

3.3 Neutrosophic statistical analysis

In the first stage, for the results in the modeling, the ESC is observed in the population, they are interrelated between the studies of women and childhood and adolescence. These determine that writers, reporters, and journalists have reported in their publications the current situation of women in society and the physical and psychological state of children and adolescents in the population. Among other groups with a completed level of studies, are the rights of the child, abandonment, adoption and guardianship, and education.

For the analysis of the representative mean as a function of $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated and for each study in interrelation with each neutrosophic subset, determined by the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$, to determine in which study there is a greater coherence and incidence of ESC in society $CV_N \in [CV_L ;\ CV_U]$.

The graphic modeling represents that the result provided implies by the groups analyzed that there is a greater incidence in the F5 studies. The development of childhood and adolescence for F5 is present in several publications that defend the rights of boys and girls in society. The average level of the problems with the highest frequency is represented in the mean of indeterminacy of F5 with group C. The interrelation F5 - Group C defines that the studies are not only directed to a segment of society but the general sphere, to cause that the problems affect each sector within the neutrosophic group analyzed in society (Figure 1).

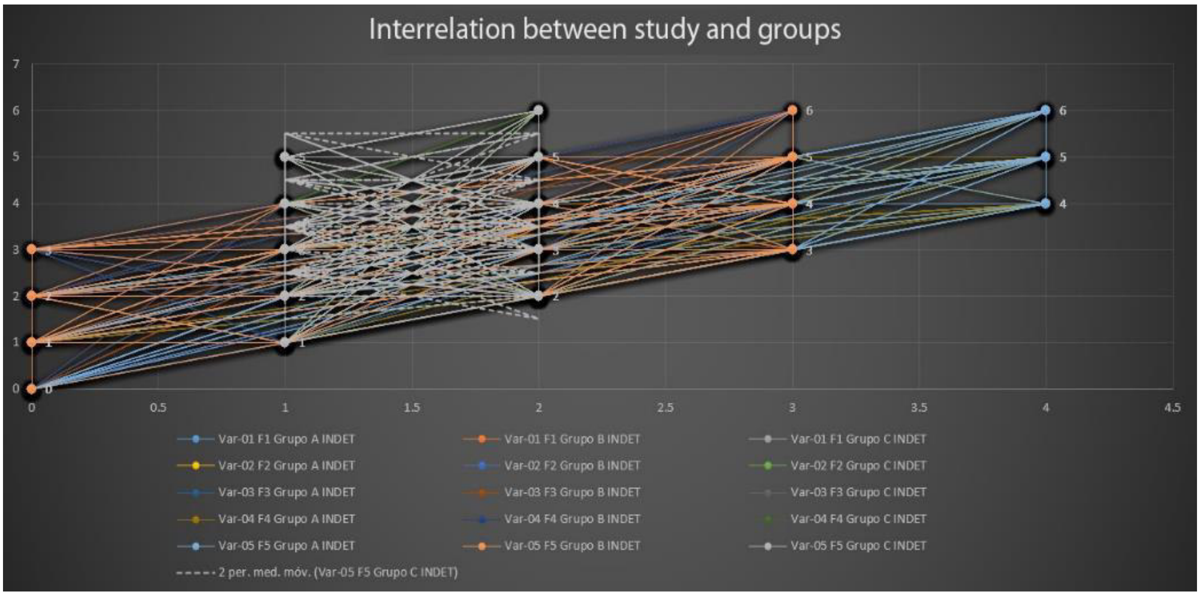

Figure 1. Neutrosophic interrelation between ESC research topics and groups. Own elaboration

3.4 Comparative analysis

To determine the associated referent indeterminacy measure $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ y $CV_N \in [CV_L ;\ CV_U]$ for the form of neutrosophic numbers (Table 5). In the results obtained for Group A, it is observed that for the values CV_N go from 0.58 to 0.695 with the indeterminacy measure of 20.9%, the effect brings with it an increase in studies that advocate for women's rights and the full development of childhood and adolescence and from 23.4% to women's studies, as corresponding to the weakest links among the indigenous group.

Factors	$\bar{x}_N$	*YN*	*CVN*
Modifications of rules and regulations	2,208 + 3,192 I; I $\in [0; 30.8]$	1.28 + 2.523 I; I $\in [0; 49.3]$	0.58 + 0.79I;I $\in [0; 26.6]$
Studies against discrimination	2.1 + 3.117 I; I $\in [0; 32.6]$	1,268 + 2,507 I; I $\in [0; 49.4]$	0.604 + 0.804 I; I $\in [0; 24.9]$
Criminal proceedings against crimes in society	1,875 + 2,892 I; I $\in [0; 35.2]$	1,304 + 2,624 I; I $\in [0; 50.3]$	0.695 + 0.907 I; I $\in [0; 24.2]$
Women's studies	2,042 + 2.95 I; I $\in [0; 30.8]$	1,234 + 2,351 I; I $\in [0; 47.5]$	0.695 + 0.907 I; I $\in [0; 23.4]$
Childhood and adolescent studies	2,108 + 3,192 I; I $\in [0; 34.0]$	1,407 + 2.69 I; I $\in [0; 47.7]$	0.667 + 0.843 I; I $\in [0; 20.9]$

Table 7. Neutrosophic forms with indeterminacy measure for Group A

In the results of Group B, it is observed that for the values CV_N go from 0.082 CV_N to 0.087 with the indeterminacy measure of 83% and 83.3%. It shows a strong interrelation between the studies aimed at the fight against femicide and child labor in childhood and adolescence. Group B characterized by mestizo people, suffers the harmful effects of society. A complicated stage where the burden of the family falls on single women. It is noteworthy that this group is discriminated against, issues that are addressed in social research (table 6).

Factors	$\bar{x}_N$	*YN*	*CVN*
Modifications of rules and regulations	1,517 + 3,492 I; I $\in [0; 56.6]$	0.125 + 1.978 I; I $\in [0; 93.7]$	0.082 + 0.566 I; I $\in [0; 85.5]$
Studies against discrimination	1.5 + 3,583 I; I $\in [0; 58.1]$	0.125 + 1.937 I; I $\in [0; 93.5]$	0.083 + 0.541 I; I $\in [0; 84.7]$
Criminal proceedings against crimes in society	1.45 + 3.433 I; I $\in [0; 57.8]$	0.126 + 1.843 I; I $\in [0; 93.2]$	0.087 + 0.537 I; I $\in [0; 83.8]$
Women's studies	1,492 + 3,783 I; I $\in [0; 60.6]$	0.125 + 1.868 I; I $\in [0; 93.3]$	0.084 + 0.494 I; I $\in [0; 83.0]$
Childhood and adolescent studies	1,492 + 3,558 I; I $\in [0; 58.1]$	0.125 + 1.792 I; I $\in [0; 93.0]$	0.084 + 0.504 I; I $\in [0; 83.3]$

Table 8. Neutrosophic forms with indeterminacy measure for Group B

In the results obtained from Group C, it is observed that for the values CV_N go from 0.465 to 0.568 with the indeterminacy measure of 26.3% and 27.9%. It shows a strong interrelation between studies directed at women and children and adolescents. Group C is characterized by people throughout the neutrosophic group that studies the problems of society. Changes in the development of society are characterized by problems that negatively affect the weakest links in society. Women and children and adolescents are present in more than 80% of the investigations with existing levels of indeterminacy in the reference topic (table 7).

Factors	$\bar{x}_N$	*YN*	*CVN*
Modifications of rules and regulations	1,417 + 2,933 I;I $\in [0; 51.7]$	0.805 + 2.354 I; I $\in [0; 65.8]$	0.568 + 0.803 I; I $\in [0; 29.3]$
Studies against discrimination	1,525 + 3,067 I;I $\in [0; 50.3]$	0.819 + 2.536 I; I $\in [0; 67.7]$	0.537 + 0.827 I; I $\in [0; 35.1]$
Criminal proceedings against crimes in society	1,492 + 3,142 I; I $\in [0; 0; 52.5]$	0.832 + 2.378 I; I $\in [0; 0; 65.0]$	0.558 + 0.757 I; I $\in [0; 0; 26.3]$

Women's studies	$1.475 + 3.05\,I;\ I \in [0; 51.6]$	$0.795 + 2.34\,I;\ I \in [0; 66.0]$	$0.539 + 0.767\,I;\ I \in [0; 29.7]$
Childhood and adolescent studies	$1.65 + 3.175\,I;\ I \in [0; 48.0]$	$0.767 + 2.049\,I;\ I \in [0; 62.6]$	$0.465 + 0.645\,I;\ I \in [0; 27.9]$

Table 9. Neutrosophic forms with a measure of indeterminacy for Group C

Conclusions

- Currently, authors, reporters, researchers, and journalists have debated in their publications the issues that have generated controversy in society. Several are in favor of the rights of children and adolescents, the rights of women, and ethnic groups regarding indigenous people and mestizos. On the other hand, other publications refer to the fight of women against domestic violence and the abandonment of children and adolescents.
- The exploratory analysis of data carried out through the information obtained and the modeling of the neutrosophic statistics have shown that the subsets A, B, C show a lower value of CV in the Studies on women and childhood and adolescence. Furthermore, the modeling determined that studies, in general, are more related to defending the rights of women, especially and with a higher level of growth in publications in favor of children and adolescents.
- Neutrosophic statistics and exploratory analysis determined the neutrosophic components of the analyzed variable. Each alternative responds to each neutrosophic subset or subgroup in the neutrosophic group that represents society. Therefore, it is required to determine the possible variables that influence a certain degree of indeterminacy in the subgroups studied. As a result, we can see that the culture of good living and the right to all citizens emerges from the laws' modifications and those people who in their publications defend and record the facts and current situation in each era. The increase in publications about childhood and adolescence shows a reflection of current problems in the world.

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Evaluation of the Effectiveness in the National Social Rehabilitation System using Neutrosophy and Compensatory Operators

Rosa Leonor Maldonado Manzano[1], Jessica Jazmín Cellán Palacios[2], and Federico Miguel Estrella Gómez[3]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.c.derecho@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.jessicamora@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.federicoestrella@uniandes.edu.ec

Abstract. Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants. Having a transparent, equitable, and egalitarian administration of justice is essential when a person violates peace and harmony. The effectiveness of this system lies in need to synergistically achieve efficiency and effectiveness in both the bureaucracy and the actions inherent to it. Failures today affect the remarkable work in the Social Rehabilitation Centers, which violates the inherent rights of adults in conflict. The situation was modeled with compensatory fuzzy logic using the single value neutrosophic numbers to deal with uncertainty, which led to the analysis of the results and strategies to mitigate the situation. The main problems lie at the management level of the system that does not achieve the execution of concrete actions in the Rehabilitation Centers, so it is not effective or efficient. It is suggested as main strategies of action: exhaustive training of the personnel and modifying the legislation that propitiates the imperative mode for this problem.

Keywords: Fuzzy Compensatory Logic, Neutrosophy, National Social Rehabilitation System, Rehabilitation Centers**.**

1 Prior Knowledge

Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants. Similarly, having a transparent, equitable, and egalitarian administration of justice is essential when a person violates peace and harmony. However, this imperatively guarantees the initiation of a criminal process that will culminate in a sanction for committing a typical, unlawful and guilty action classified as a criminal offense [1].

This implies a probability of a custodial sanction towards the convicted person. To serve this sanction, there are Social Rehabilitation Centers under the provisions of Art. 772 numeral 12. It indicates that the Ecuadorian National Social Rehabilitation System in these centers will rule custody. This is why it is considered the initial cell of the rehabilitation process to achieve complete reintegration into society and family, thus embodying the purpose of the mentioned system contained in Art. 2013 of our fundamental regulation [1-12].

Social Rehabilitation Centers have been classified as places with an unsafe future where intimidation and corruption converge under the protection of the law of the strongest. A situation that has changed over the years with the progressive application of the Treatment Axes. Currently, people who have been convicted, while serving their sentence, have the opportunity to be beneficiaries of different treatment axes contemplated in the Integral Organic Penal Code (IOPC) that expressly classifies as the procedures given to the persons deprived of liberty to rehabilitate and reintegrate them socially. The development of each of these treatments is determined in the regulations of the National Social Rehabilitation System, which are shown in Figures 1 and 2.

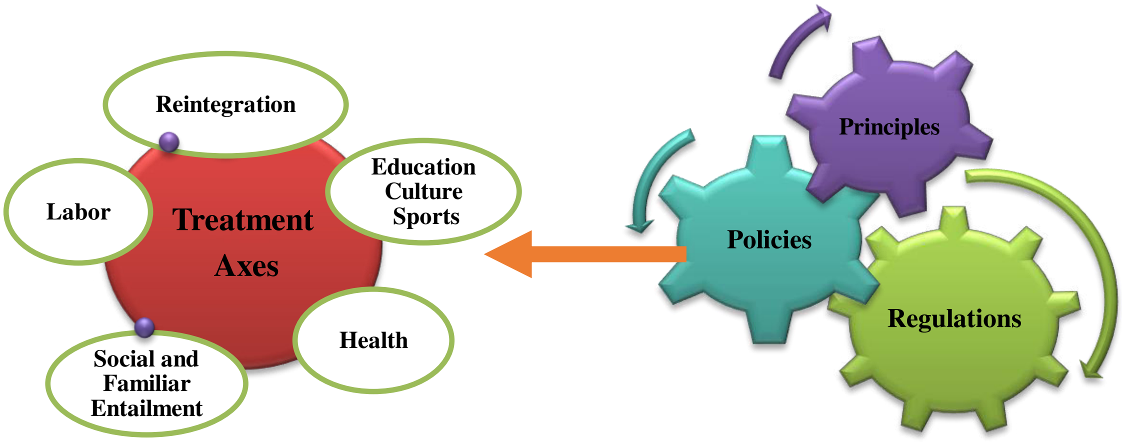

Figure 1: National Social Rehabilitation System. **Source**: own elaboration

The above stated ideally ensures that the convicted person:

- ✓ Learn or improve activities that will be useful later in his life in freedom.
- ✓ Maybe a beneficiary of the progressivity system contemplated in Article 695 of the Integral Organic Penal Code

The effectiveness of this system lies in the need to achieve synergistically the efficiency and effectiveness in both the bureaucracy and the actions inherent to it as illustrated in figure 2. Failures that exist today affect the remarkable work in the Social Rehabilitation Centers.

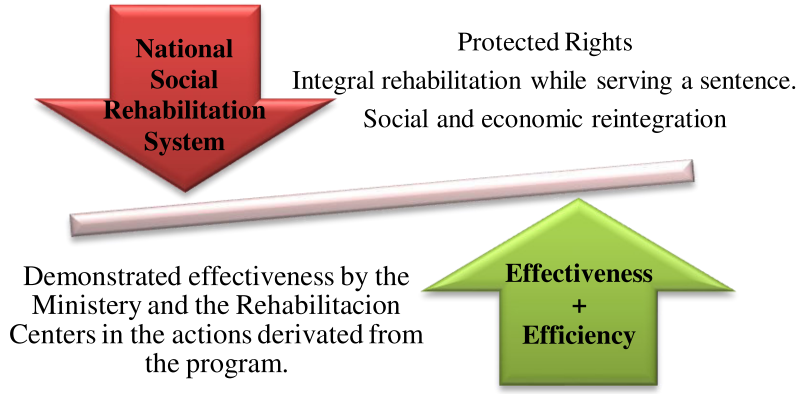

Figure 2: Guarantees for the correct application of the National Social Rehabilitation System. Source: own elaboration

The lack of application of the provisions of Article 701 of the IOPC [4, 13-15] violates the inherent rights of adults in conflict. This is mainly caused because the system is created on the idea that it is optional and not imperative. It is then considered that, to guarantee the effectiveness and efficiency of the system:

- ✓ For the effectiveness of its regulations, principles, policies, and axes, it does not comply with the results for which they were designed.
- ✓ The treatment axes by the Ministry of Justice, Human Rights, and Worship must be effectively complied with. This Ministry is the only State entity having the administrative and political force necessary to exercise imperative control in all the Social Rehabilitation centers of the country, places where the social reintegration of people deprived of liberty is put into practice. Those are the administrative and judicial errors that concur in the processing of penitentiary guarantees cases, but mainly the voluntary nature of the application of treatment axes in an integral rehabilitation system.

Hence the importance of a study of this matter and above all to understand the methods and their impact on the change of the social rehabilitation regime in Ecuador. That is why the previously mentioned is proposed as the objective of this work. To achieve it, we will take advantage of the benefits of mathematical modeling offered by

Compensatory Fuzzy Logic and Neutrosophy [16]. In the following section, we will expose the essential notions for the achievement of the objective.

2. Materials and methods

2.1 Compensatory Fuzzy Logic (CFL)

It is a branch of Fuzzy Logic created by the multidisciplinary scientific group Business Management in Uncertainty: Research and Services (GEMINIS) of the José Antonio Echeverría Higher Polytechnic Institute (ISPJAE), in Havana, Cuba. Dr. Rafael Espín Andrade, professor of the ISPJAE, is one of its most representative researchers. In general, it can be said that it is a new multivalent system that breaks with the traditional axiomatic to achieve semantically better behavior than the classic ones [17-29]. According to the bibliography consulted, we may highlight the precepts listed below:

- ✓ In the processes that require decision making, it involves compound predicates [20]. The truth-values obtained on these compound predicates must have sensitivity to changes in the truth-values of the basic predicates. A predicate is a function of the universe X in the interval [0,1], and the operations of conjunction, disjunction, negation, and implication are defined in such a way that when they are restricted to the domain [30-35] the Boolean Logic is obtained [19].
- ✓ It discards compliance with the classical properties of conjunction and disjunction. This notion makes the FCL a sensible logic [17].
- ✓ It is flexible and tolerant of imprecision, making it possible to model natural language expressions, promoting the use of complete sentences rather than simple linguistic variables to take advantage of the knowledge accumulated by experts following the notion of Knowledge Engineering [21]. It is compatible with the branches of mathematics related to decision-making by taking human language, formed by interrogative, imperative, and declarative phrases, which in many cases present a degree of truthfulness. Vagueness and uncertainty are the objects of its modeling.
- ✓ It uses mathematical operators that guarantee the effective combination of intangible elements assessed by experts, considering categorical scales of veracity, with quantitative information, which provides truth values through conveniently defined predicates based on such information:

Operators	Predicate logic
Conjunction	(And), c, $\wedge$
Disjunction	(or), d, $\vee$
Fuzzy strict order	(o)
Denial	(not)

Table 1. Presentation of the mathematical operators in FCL predicate logic.

It goes from [0,1] n to [0,1], or go from [0,1] 2 to [0,1] and n to [0,1][20]. Which satisfies the following axioms:

1. $\min \{x_1, x_2, \cdots, x_n\} \leq d\ (x_1, x_2, \cdots, x_n) \leq \max \{x_1, x_2, \cdots, x_n\}$ (Compensation Property).
2. $d\ (x_1, x_2, \cdots, xi, \cdots, x_j, \cdots, x_n) = d\ (x1, x_2, \cdots, x_j, \cdots, x_i, \cdots, x_n)$ (Property of Commutativity or Symmetry).
3. If $x_1 = y_1, x_2 = y_2, \cdots, x_i - 1 = y_i - 1, x_i + 1 = y_i + 1, \cdots, x_n = y_n$, such that neither is zero, $x_i > y_i$, then $d\ (x_1, x_2, \cdots, x_n) > d\ (y_1, y_2, \cdots, y_n)$ (Strict Growth Property)
4. If $x_i = 1$ for some i, then $d\ (x_1, x_2, \cdots, x_n) = 1$ (Veto Property)
5. $c\ (x_1, x_2, \cdots, x_n) = d\ (x_1, x_2, \cdots, x_n) = x$ (Idempotency Property).

According to [21], the use of sigmoidal membership functions for increasing or decreasing functions is recommended for modeling vagueness. This is also achieved through linguistic variables, which makes it possible to take advantage of the knowledge of the experts. These linguistic variables are based on scales such as the one shown in table 2 [17].

2.2 Neutrosophy

The theory of Neutrosophy proposed by Florentin Smarandache, for the treatment of neutralities, generalizes clear and fuzzy set theories, where indeterminacies have support. It is a useful theory that is increasing the number of its applications in many fields. In this case, the inclusion of this theory enriches the possibilities of the analysis by complementing the values shown in table 2 [31]. This is mainly due to two issues: first, the addition of the notion of indeterminacy and, secondly, the possibility of calculating using linguistic terms [30-36]. For this reason, it was decided to opt for a fusion of both techniques and carry out the study using the neutrosophic CFL. Firstly, let us formally expose neutrosophic logic's original definition as shown in [34, 37-40].

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$[41]be a neutrosophic set of evaluation. $v: P \rightarrow N$ is a mapping of a group of propositional formulas into N, ie, each sentence p∈ is associated to a value in N, as it is exposed in Equation 1, meaning that p is T true, I indeterminate, and F false.

$$v(p) = (T, I, F) \quad (1)$$

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of Neutrosophy according to [31, 42].

Definition 2. Be X a universe of discourse. Three membership functions characterize a Neutrosophic Set (NS), $u_A(x), r_A(x), v_A(x) : X \rightarrow]^{-}0, 1^{+}[$ that satisfy the condition -0 $\leq$ $\inf u_A(x) + \inf r_A(x) + \inf v_A(x)$ $\sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq$ 3+ for all x∈X. $u_A(x), r_A(x)$ Y $v_A(x)$ denote the membership functions of true, indeterminate, and false of x in A, respectively, and their images are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

Definition 3. Be Xa universe of discourse. A Neutrosophic Set of Unique Value (CNVU) A onX is an object of the form: $A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\}$ Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ Y $v_A(x)$ denote the membership functions of true, indeterminate, and false of x in A, respectively. For convenience, a Neutrosophic Unique Value Number (SVNN) will be expressed as A = (a, b, c), where a, b, c [0,1] and satisfies $0 \leq a + b + c \leq 3$.

In this article, linguistic terms will be associated with SVNN so that experts can carry out their assessments in linguistic terms, which is more natural. Therefore, the scales shown in table 2 will be taken into account.[42].

Category	SVNN
False	(0,1,1)
Almost false	(0.10,0.90,0.90)
Quite false	(0.20,0.85,0.80)
Somewhat false	(0.30,0.75,0.70)
More false than true	(0.40,0.65,0.60)
As true as false	(0.50,0.50,0.50)
More true than false	(0.60,0.35,0.40)
Somewhat real	(0.70,0.25,0.30)
Pretty true	(0.8,0,15,0.20)
Almost true	(0.9, 0.1, 0.1)
True	(1,0,0)

Table 2: Evolution of the magnitude of variables from linguistic fuzzy to neutrosophic ones

To convert neutrosophic numbers into crisp numbers, see Equation 2:

$$s(V) = T - F - I \quad (2)$$

2.3 Calculation of statistical coefficients

The concordance (Cc) coefficient is used to determine the degree of consensus of the experts on the subject. For this, equation 3 will be used.

$$Cc = (1 - \frac{Vn}{Vt}) * 100 \quad (3)$$

Where:

Vn: Number of experts against the prevailing criterion.

Vt: Total number of experts.

It is empirically considered that if Cc≥75% then the agreement is acceptable. The components that obtain Cc values <75% are eliminated due to low agreement or little consensus among the experts.[44].

The coefficient of variation (Cv) of the predicates will be calculated using equation 4 applying statistical decision criteria according to the following parameters:

Yes Cv ≥0.20, take the modal value (assessment given by the experts that are repeated the most in the analyzed range)

If Cv <0.20, take the value of the arithmetic mean (average score of the experts)

$$Cv = \frac{S}{X_{med}} \quad (4)$$

S: Standard deviation of the data

Xmed: Average of the data

Summarizing the following is the working algorithm to follow once the experts have been determined.

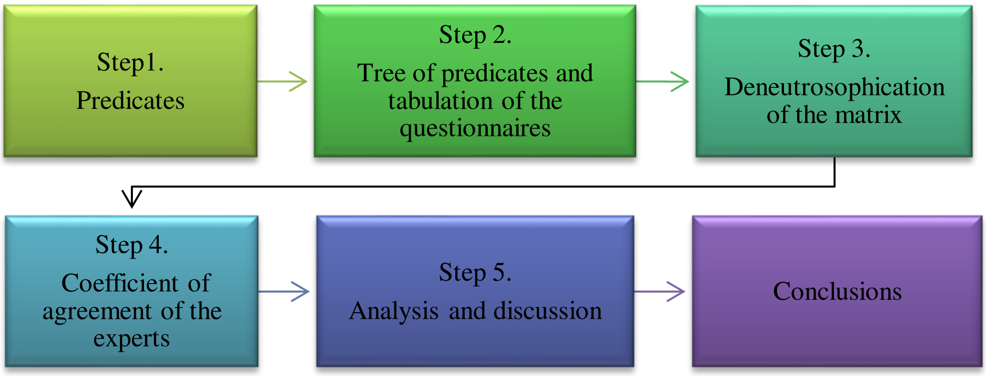

Figure 3: Work algorithm.

For the design and application of the questionnaires, the predicates and their functions were first stated.

3 Results

Experts were selected according to their skills, motivation, and experience required during the exercise of the application of the National Social Rehabilitation System (NSRS) from each of their positions. Then, questionnaires were applied to determine the evaluation of agreement (applying the linguistic scale defined in table 2) to each of the predicates. Finally, seven groups of experts were selected according to the place and profession where the exercise was applied.

Step 1. Predicates

The Prior Knowledge section of this paper was taken into consideration, where we exposed the important notions that characterize the Ecuadorian National Social Rehabilitation System.

Simple predicates:

1. **CL (x):** "The Social Rehabilitation Center effectively complies with the activities inherent to the Labor Treatment Axis"
2. **CR (x):** "The Social Rehabilitation Center effectively fulfills the activities inherent to the Reintegration Treatment Axis"
3. **CECD (x):** "The Social Rehabilitation Center effectively fulfills the activities inherent to the Education, Culture and Sports Treatment Axis"
4. **CVFS (x):** "The Social Rehabilitation Center effectively fulfills the activities inherent to the Family Social Bonding Treatment Axis"
5. **CS (x):** "The Social Rehabilitation Center effectively fulfills the activities inherent to the Health Treatment Axis"
6. **ML (x):** "The Axis of Labor Treatment is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights, and Religion"
7. **MR (x):** "The Reintegration Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights, and Cult"
8. **MECD (x):** "The Education, Culture and Sports Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights and Worship"
9. **MVFS (x):** "The Family Social Entailment Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights"
10. **MS (x):** "The Health Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights and Cults"
11. **MP (x):** "The principles of the National System of Social Rehabilitation are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it effectively comply with it"
12. **MN (x):** "The regulations of the National Social Rehabilitation System are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it is effectively enforced"
13. **MPol (x):** "The policies of the National System of Social Rehabilitation are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it is effectively enforced"

Compound predicates:

1. **NSRS (x):** "The National Social Rehabilitation System demonstrates its effectiveness"
2. **Adm (x):** "The administration of the Ministry of Justice, Human Rights and Worship effectively manages the National System of National Rehabilitation"

3. **ET (x):** "The treatment axes are met effectively"
4. **ETL (x):** "The Axis of Labor Treatment is fulfilled effectively"
5. **ETR (x):** "The Reintegration Treatment Axis is effectively fulfilled"
6. **ETECD (x):** "The Education, Culture and Sports Treatment Axis is effectively fulfilled"
7. **ETVSF (x):** "The Family Social Entailment Treatment Axis is effectively fulfilled"
8. **ETS (x):** "The Health Treatment Axis is effectively fulfilled"

Step 2. Tree of predicates and tabulation of the questionnaires

A logical tree is made where the simple and compound predicates are represented, as well as the linguistic operators and modifiers used. From the tree, we got the calculation expressions that allowed obtaining the result of the evaluation of the activities of the National Social Rehabilitation System.

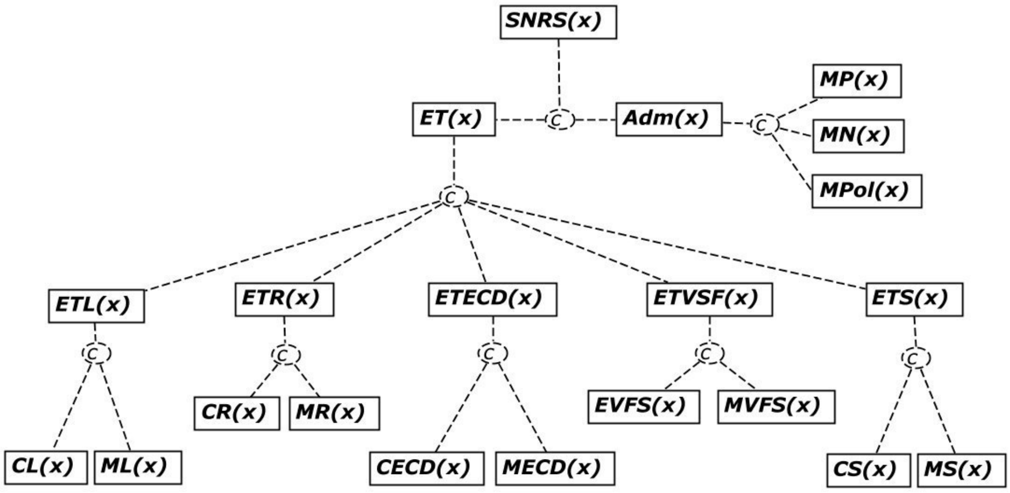

Figure 4: Tree of logical predicates for the effectiveness of the National Social Rehabilitation System.

Expressions:

- ✓ $SNRS(x) = ET(x) \wedge Adm(x)$
- ✓ $ET(x) = ETL(x) \wedge ETR(x) \wedge ETECD(x) \wedge ETVSF(x) \wedge ETS(x)$
- ✓ $ETL(x) = CL(x) \wedge ML(x)$
- ✓ $ETR(x) = CR(x) \wedge MR(x)$
- ✓ $ETECD(x) = CECD(x) \wedge MECD(x)$
- ✓ $ETVSF(x) = CVSF(x) \wedge MVSF(x)$
- ✓ $ETS(x) = CS(x) \wedge MS(x)$
- ✓ $Adm(x) = MP(x) \wedge MN(x) \wedge MPol$

The questionnaires were applied by groups of experts using the neutrosophic scales in Table 2.

Predicate	Expert Group 1	Expert Group 2	Expert Group 3	Expert Group 4	Expert group 5	Expert Group 6	Expert Group 7
CL (x)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.5;0.5;0.5)
CR (x)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.4;0.65;0.6)	(0.4;0.65;0.6)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.4;0.65;0.6)
CECD (x)	(0.4;0.65;0.6)	(0.4;0.65;0.6)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.4;0.65;0.6)	(0.5;0.5;0.5)
CVFS (x)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.4;0.65;0.6)	(0.6;0.35;0.4)	(0.5;0.5;0.5)
CS (x)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.6;0.35;0.4)	(0.6;0.35;0.4)
ML (x)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)
MR (x)	(0.7;0.25;0.3)	(0.7;0.25;0.3)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)
MECD (x)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)
MVFS (x)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)
MS (x)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)
MP (x)	(1;0;0)	(1;0;0)	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)	(1;0;0)
MN (x)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)
MPol (x)	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)

Table 1: Tabulation of the results.

Step 3. Deneutrosophication of the matrix

Then equation 2 was applied for the des-neutrosophication of the results, obtaining tables 2 and 3.

Simple predicates	fashion	Half	S	Cv	Truth value	Category
CL (x)	-0.5	-0.350	0.187	-0.535	-0.350	As true as false
CR (x)	-0.15	-0.500	0.350	-0.700	-0.500	As true as false
CECD (x)	-0.85	-0.550	0.315	-0.573	-0.550	As true as false
CVFS (x)	-0.5	-0.400	0.265	-0.661	-0.400	As true as false
CS (x)	-0.15	-0.250	0.171	-0.683	-0.250	As true as false
ML (x)	0.45	0.407	0.113	0.279	0.450	Pretty True
MR (x)	0.45	0.364	0.146	0.402	0.450	Pretty True
MECD (x)	0.45	0.443	0.159	0.360	0.450	Pretty True
MVFS (x)	0.45	0.443	0.159	0.360	0.450	Pretty True
MS (x)	0.45	0.407	0.113	0.279	0.450	Pretty True
MP (x)	1	0.957	0.113	0.118	0.957	True
MN (x)	0.7	0.743	0.113	0.153	0.743	Almost true
MPol (x)	0.7	0.786	0.146	0.186	0.786	Almost true

Table 2: Calculation of the truth-values of simple predicates

Compound predicate	Truth value	Category
ETL (x)	0.050	Somewhat real
ETR (x)	-0.025	More true than false
ETECD (x)	-0.050	More true than false
ETVSF (x)	0.025	Somewhat real
ETS (x)	0.100	Somewhat real
ET (x)	0.020	Somewhat real
Adm (x)	0.829	Almost true
SNRS (x)	0.424	Pretty true

Table 3: Calculation of compound predicates

Step 4. Coefficient of agreement of the experts

Equation 3, the tabulated outputs of the questionnaires were applied. As a result, we obtained that in all cases the coefficient of agreement among experts is 0.785> 0.75; so it is considered acceptable.

Step 5. Analysis and discussion

Experts agree that the greatest weakness within the National Social Rehabilitation System is found in the Social Rehabilitation Centers. The results show that the system's effectiveness is affected by the low importance of what was agreed by the Ministry for them. We may observe that the fulfillment of the simple predicates related to the Treatment Axes in the Social Rehabilitation Centers are those rated with the lowest score. This means that the Ministry does not enforce the provisions.

The previously mentioned may translate into a system management level qualifying each of the parameters as fulfilled, but it occurs at the operational level. This means that its translation into concrete actions in the Rehabilitation Centers is not effective or efficient. Therefore, it is necessary to draw up concrete action strategies and give it the appropriate follow-up. First, it is suggested, to begin with, an exhaustive training of the personnel who work in them, by the Ministry itself, and then draft a document that eliminates the optional character by making it mandatory.

Conclusions

- ✓ Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants.
- ✓ Having a transparent, equitable, and egalitarian administration of justice is essential when a person violates the peace and harmony of a state.
- ✓ The effectiveness of this system lies in the need to synergistically achieve efficiency and effectiveness in both the bureaucracy and the actions inherent to it.
- ✓ Current existing failures affect the remarkable work in the Social Rehabilitation Centers, which violates the inherent rights of adult people in conflict.
- ✓ The situation was modeled using compensatory fuzzy logic with a neutrosophic fusion. Which led to the analysis of the results and strategies to mitigate the situation.

- ✓ The main problems lie at the management level of the system that does not achieve the execution of concrete actions in the Rehabilitation Centers, so it is not effective or efficient.
- ✓ Suggested main strategies of action: exhaustive training of the personnel and the modification of the legislation so that it propitiates the imperative mode for this problem.

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Neutrosophic Statistics for Project Management. Application to a Computer System Project

Ariel Romero Fernández[1], Lourdes Viviana Moreira Rosales[2], Olga Germania Arciniegas Paspuel[3] , Walter Bolívar Jarrín López[4] and Anthony Rafael Sotolongo León[5]

[1] Director de Investigación. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: dir.investigacion@uniandes.edu.ec

[2] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.lourdesmoreira@uniandes.edu.ec

[3] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.olgaarciniegas@uniandes.edu.ec

[4] Docente de la carrera de Contabilidad y Auditoría. Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.walterjarrin@uniandes.edu.ec

[5]Ongres, Santiago de Chile, Chile. Email: asotolongo@ongres.com

Abstract. This research aims to apply a mathematical procedure of the project evaluation and review technique (PERT) in a neutrosophic environment. For such purpose, the elements of the three PERT estimates are considered neutrosophic elements, more specifically, trapezoidal neutrosophic numbers. The technique used is novel and attractive since it allows to overcome the limitations of the different Fuzzy PERT methods and handle indeterminacy mathematically. On this occasion, the neutrosophic PERT method is applied to managing a computer system development project. The PERT method made it possible to estimate the minimum duration of the project, the beta parameters of the duration of each activity, and the identification and calculation of the critical path, with the help of specialized software.

Keywords: Neutrosophic trapezoidal number, Neutrosophic PERT, IT project, Critical path.

1 Introduction

The complexity, uncertainty, and extreme competition in the economic and industrial environment in which companies of all kinds operate today, and the difficulties in managing their projects are the cause of new challenges and growing problems. Therefore, it is not weird to see projects end up in severe and costly failures, deterioration or questioning of their main objectives (costs, deadlines, and technical performance) and sometimes in their immediate abandonment. For these reasons, project management has become one of the most important topics for many companies in recent years.

The word project comes from the Latin *projectum* of *projacere*, "to launch something forward." The prefix pro means "precedent in time" (by analogy with the Greek) and the root jacere means "to launch". Thus, the word "project" originally meant what is done before the launch (development, manufacture, construction) of something.

According to [2], a project can be defined as a series of works related to achieving a goal or the development of a product and for which time is required. Therefore, project management seeks the planning, direction, and control of resources that are subject to critical activities, dependent activities, slack, and lead time.

In their simplest form, projects are unique in that they have a single goal and a set of individual, definable and measurable objectives. They have a finite shelf life and are generally intended to improve or create some process. On the other hand, they are usually relatively complex and (because they involve the generation of change), they are often relatively risky. Hence the importance of its correct administration.

It can be stated that project management is the planning, direction, and control of resources (people, equipment, materials) to ensure the budget control of the project, the efficient management of available resources and compliance with the agreed deadlines and thus guarantee an execution effective, comprehensive project.

Project management developed from its founding phases in the 1940s and became one of the most important international and interdisciplinary applications. The related professional associations are active throughout the world and in most areas of industry and commerce. Project management practices and procedures are used in various applications, from agricultural projects to complex engineering projects.

Project management is based on the following objectives. The functional performance objective and technical specifications for (reliability, maintainability, ease of use). The respect of a project execution deadline is an important component of the expression of needs since a delay can reduce the interest of the project and, in most cases, lead to additional costs, in the form of a delayed penalty, in particular.

Depending on the project's scope, the economic objective can take different forms (cost, profitability). Among the limitations or restrictions that must be controlled in the project, time limitations must be highlighted. These are the expression of the periods within which the project must be completed.

The increasing complexity of projects worldwide has driven the growth of project management as an international discipline. To structure the implementation of a project, different techniques have been designed that allow addressing some calculations related to the management of its costs, quality, and delivery times, within these techniques the network planning models stand out, one of the best known is the Program Evaluation and Review Technique (PERT).

From a network analysis perspective, project planning methods require the identification of data and the organization and typification of reciprocal relationships between activities to estimate the project execution time and thus carry out planning [2].

These methods have also been used to manage IT projects, which are designed based on a set of tasks that have their associated costs and delivery times. Mainly, the PERT method offers certain advantages when considering probable scenarios for the development of the tasks and, therefore, for fulfilling the deadlines. In addition, some authors consider the usefulness of the PERT method for the management of computer projects for the development of multipurpose software systems [5].

PERT method was developed to include the uncertainty in the estimates of the duration and assumes that the time to carry out each of the activities is a random variable described by a probability distribution.

The original version of PERT takes into account uncertainty by using three different types of estimates of the duration of an activity, to obtain basic information about its probability distribution (Beta). These are the *most probable estimate* (m); *optimistic estimate* (o) and *pessimistic estimate* (p). These estimates can be identified as the estimate of the most probable value of the duration; the estimated duration under the most favorable conditions and the estimated duration under the most unfavorable conditions, respectively [9].

Some authors identified certain limitations in the classic PERT method. This is evidenced by the statements made by [6]:

The common method of analyzing projects, classical PERT, has numerous problems such as the beta distribution and stochastic variables and the estimation of parameters (expected duration and variance). This has led researchers to seek new solutions, eg to integrate fuzzy sets with PERT and created a new approach, namely Fuzzy PERT or FPERT. (p.185)

Likewise, these authors believe that the planning of the project should be carried out with greater precision and the results should be obtained more realistically with the help of fuzzy sets and the inclusion of opinions and experiences of experts [3] [6] [7] [14].

However, other authors believe that the theory of neutrosophic sets is more appropriate than fuzzy sets to model the uncertainty associated with parameters such as the duration of the activity and the availability of resources in PERT. This is mainly because the project manager, to determine the optimistic and pessimistic values of the duration of the activities, often faces uncertain, inconsistent, and incomplete information about the real world [11].

Following the above, a Neutrosophic version of the PERT method was used that allows the treatment of indeterminacy in the possible scenarios, to estimate the duration of the project of a computer system for the control of production in an Ecuadorian company. The following section addresses the theoretical elements of the classical and neutrosophic PERT method applied to the management of a computer project.

For the PERT method, it is assumed that the shape of the probability distribution obtained is a beta distribution with mean [9] [10]:

$$\mu = \frac{o+4m+p}{6} \tag{1}$$

and variance:

$$\sigma^2 = \left(\frac{p-o}{6}\right)^2 \tag{2}$$

In recent years, according to fuzzy set theory for project management, there were different PERT methods. However, the existing fuzzy PERT methods have some drawbacks [2]:

- A critical path cannot be found in a fuzzy project network.
- Increase possible critical paths, which is the riskiest path.
- Indeterminacy, which exists in real-life situations, cannot be determined.

In the case of PERT, time estimates vary considerably. Three-time estimates are used here, which are optimistic

(a), pessimists (b), and most likely (m). In practice, the question often arises as to how to obtain good optimistic or pessimistic estimates. Neutrosophic set theory is more appropriate than fuzzy sets, for modeling the uncertainty associated with parameters, such as activity duration and resource availability in PERT. By using neutrosophic set theory in the PERT technique, we can also overcome the drawbacks of fuzzy PERT methods [11].

Due to those above, we propose applying the neutrosophic sets to the project management of a computer system. The neutrosophic PERT method based on trapezoidal neutrosophic sets, proposed by [12], will be applied. This method will be implemented based on the plan of activities planned to develop a computer system proposed by [5].

2 Materials and methods

In this section, some theoretical elements, formulas, and calculation procedures of the neutrosophic statistics are systematized [15-18], which will be used to estimate the project's duration using the neutrosophic PERT method.

Definition 1. [1] Let X be a space of points (objects) and $x \in X$. A neutrosophic set A in X is defined by a truth-membership function (x), an indeterminacy-membership function $I_A(x)$ and a falsity-membership function $F_A(x)$. (x), (x) and (x), are real standard or real nonstandard subsets of]- 0, 1+[. That is (x): $X\to$]-0,1+[, $I_A(x)$: $X\to$]-0, 1+[and $F_A(x)$:$X\to$]-0, 1+[. There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, so $0- \leq \sup T_A(x)+ \sup I_A(x) + \sup F_A(x) \leq 3+$.

Definition 2. [1] Let X be a universe of discourse. A single valued neutrosophic set A over X is an object having the form $A=\{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in X\}$, where $T_A(x)$:$X\to[0,1]$, $I_A(x)$:$X\to[0,1]$ and $F_A(x)$: $X\to[0,1]$ with $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$ for all $x \in X$. The intervals (x), (x) and (x) denote the truth-membership degree, the indeterminacy-membership degree, and the falsity membership degree of x to A, respectively. For convenience, an SVN number is denoted by $A= (a, \text{b}, \text{c})$, where a, , $c \in [0, 1]$ and $a + b + c \leq 3$.

Definition 3. [6] Let $\boldsymbol{\alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \epsilon [0,1]}$ and $\boldsymbol{a_1, a_2, a_3, a_4 \epsilon R}$ such that $\boldsymbol{a_1 \leq a_2 \leq a_3 \leq a_4}$. Then a single-valued trapezoidal neutrosophic number, $\boldsymbol{\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle}$ is a special neutrosophic set on the real line set R. The truth-membership, indeterminacy-membership, and falsity- membership functions of $\boldsymbol{\tilde{a}}$, are given by [12]:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right) & if\ a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}} & if\ a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_4-x}{a_4-a_3}\right) & if\ a_3 \leq x \leq a_4 \\ 0 & otherwise \end{cases} \tag{3}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\theta_{\tilde{a}}(x-a_1))}{(a_2-a_1)} & if\ a_1 \leq \text{x} \leq a_2 \\ \theta_{\tilde{a}} & if\ a_2 \leq \text{x} \leq a_3 \\ \frac{(x-a_3+\theta_{\tilde{a}}(a_4-x))}{a_4-a_3} & if\ a_3 \leq \text{x} \leq a_4 \\ 1 & otherwise \end{cases} \tag{4}$$

$$\boldsymbol{F_{\tilde{a}}(x)} = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{(a_2-a_1)} & \boldsymbol{if\ a_1 \leq \text{x} \leq a_2} \\ \boldsymbol{\beta_{\tilde{a}}} & \boldsymbol{if\ a_2 \leq \text{x} \leq a_3} \\ \frac{(x-a_3+\beta_{\tilde{a}}(a_4-x))}{a_4-a_3} & \boldsymbol{if\ a_3 \leq \text{x} \leq a_4} \\ \boldsymbol{1} & \boldsymbol{otherwise} \end{cases} \tag{5}$$

where $\boldsymbol{\alpha_{\tilde{a}}, \theta_{\tilde{a}}}$ **and** $\boldsymbol{\beta_{\tilde{a}}}$ denote the maximum truth-membership degree, minimum indeterminacy-membership degree, and minimum falsity-membership degree, respectively. A single-valued trapezoidal neutrosophic number $\tilde{\boldsymbol{a}} = \langle(\boldsymbol{a_1}, \boldsymbol{a_2}, \boldsymbol{a_3}, \boldsymbol{a_4}); \boldsymbol{\alpha_{\tilde{a}}}, \boldsymbol{\theta_{\tilde{a}}}, \boldsymbol{\beta_{\tilde{a}}}\rangle$, according to [11], may express an ill-defined quantity about a, which is approximately equal to [a_2, a_3].

From the theory about the single-valued trapezoidal neutrosophic numbers, [12], they propose the theory of the neutrosophic PERT method, in which, they define the three-time estimates for activity duration as *Optimistic time* ($\tilde{a}$); *Pessimistic time* ($\tilde{b}$) and *Most likely* time, ie Mode ($\tilde{m}$). Where$\tilde{a}$,, $\tilde{m}$ are trapezoidal neutrosophic numbers. Then, based on three-time estimates ($\tilde{a}$, $\tilde{b}$,$\tilde{}$), expected time and standard deviation of each activity should be calculated, and to do this, we should first obtain crisp values of the three-time estimates.

To obtain the crisp values of each estimated time, we use the score function $\left(S(\tilde{a})\right)$ and accuracy function $\left(A(\tilde{a})\right)$, as follows [11]:

$$Score\ function\ \ S(\tilde{a}) = \left(\frac{1}{16}\right)[a_1 + a_2 + a_3 + a_4]x[\alpha_{\tilde{a}} + (1 - \theta_{\tilde{a}}) + (1 - \beta_{\tilde{a}})] \tag{6}$$

$$\boldsymbol{Accuracy\ function}\ \ A(\tilde{\boldsymbol{a}}) = \left(\frac{\boldsymbol{1}}{\boldsymbol{16}}\right)[\boldsymbol{a_1} + \boldsymbol{a_2} + \boldsymbol{a_3} + \boldsymbol{a_4}]x[\boldsymbol{\alpha_{\tilde{a}}} + (\boldsymbol{1} - \boldsymbol{\theta_{\tilde{a}}}) + (\boldsymbol{1} + \boldsymbol{\beta_{\tilde{a}}})] \tag{7}$$

With the crisp values for each time estimated (a, m, and b), by using the score function, the expected time and standard deviation of each activity can be calculated by using (1) and (2), respectively.

For the management of the computer system project, the activities proposed by [5] are shown in table 1.

N.	Task title
1	Beginning of the project implementation
2	Meeting with a customer
3	Investigating the subject area
4	Designing class models and basic algorithms
5	Developing the modules of the software system
6	Module Testing
7	Interface design and development
8	Testing and Debugging
9	Presenting software to a customer
10	Writing software documentation
11	Project Completion

Table 1. Tasks defined for the IT system project

The temporal relationship between the activities in Table 1, represented by the project network, is illustrated in Figure 1.

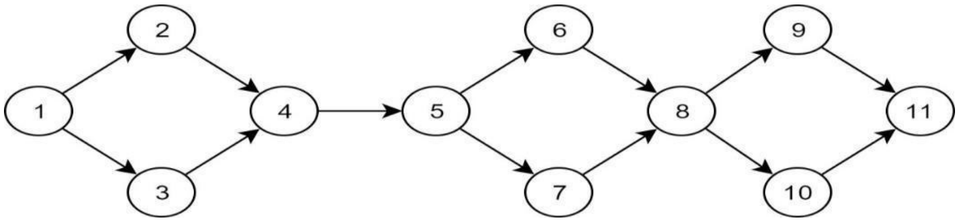

Figure 1. Project network. Source: [5]

On the other hand, the trapezoidal neutrosophic numbers proposed by [12] and which are listed below will be applied.:

$\tilde{1} = \langle(0,2,4,5));\ 0.8,0.6,0.4\rangle$; $\tilde{2} = \langle(1,3,5,6));\ 0.2,0.3,0.5\rangle$;$\tilde{3} = \langle(1,2,5,6));\ 0.2,0.5,0.6\rangle$
$\tilde{4} = \langle(1,2,5,7));\ 0.5,0.4,0.9\rangle$;$\tilde{5} = \langle(2,4,7,10));\ 0.8,0.2,0.4\rangle$; $\tilde{6} = \langle(3,7,9,12));\ 0.7,0.2,0.5\rangle$
$\tilde{7} = \langle(5,8,9,13));\ 0.4,0.6,0.8\rangle$;$\tilde{8} = \langle(1,6,10,13));\ 0.9,0.1,0.3\rangle$;$\tilde{9} = \langle(6,8,10,15));\ 0.6,0.4,0.7\rangle$
$\widetilde{10} = \langle(1,6,11,15));\ 0.7,0.6,0.3\rangle$; $\widetilde{11} = \langle(5,8,15,20));\ 0.8,0.2,0.5\rangle$; $\widetilde{12} = \langle(4,8,17,25));\ 0.3,0.6,0.4\rangle$

The elements exposed up to here were applied in correspondence with the working algorithm proposed by [12]:

- We considered three-time estimates of the PERT technique as a single-valued trapezoidal neutrosophic number to deal with uncertain, inconsistent, and incomplete information about activity time.
- Calculate membership functions of each single-valued trapezoidal neutrosophic number, using equations 1, 2, and 3.
- Obtain the crisp model of PERT three-time estimates using the score function equation as we illustrated previously.
- Use crisp values of three-time estimates to calculate the expected time and standard deviation of each activity.
- Draw a PERT network diagram.
- Determine floats and critical path, which is the longest path in the network, as we illustrated previously with details.
- Calculate the expected time and variance of the critical path.
- Determine expected project completion time.

2 Results

From the application of the trapezoidal neutrosophic numbers listed at the end of the previous section, the duration of the computer system project activities was determined, which are shown in Table 2.

N	Task title	Duration (days) $\tilde{a}$	$\tilde{m}$	$\tilde{b}$
1	Beginning of the project implementation	0	0	0
2	Meeting with a customer	$\langle(0,2,4,5); 0.8,0.6,0.4\rangle$	$\langle(1,3,5,6); 0.2,0.3,0.5\rangle$	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$
3	Investigating the subject area	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$	$\langle(1,2,5,7)); 0.5,0.4,0.9\rangle$	$\langle(2,4,7,10); 0.8,0.2,0.4\rangle$
4	Designing class models and basic algorithms	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$	$\langle(2,4,7,10); 0.8,0.2,0.4\rangle$	$\langle(3,7,9,12); 0.7,0.2,0.5\rangle$
5	Developing the modules of the software system	$\langle(1,6,10,13); 0.9,0.1,0.3\rangle$	$\langle(6,8,10,15)); 0.6,0.4,0.7\rangle$	$\langle(4,8,17,25)\ 0.3,0.6,0.4\rangle$
6	Module Testing	$\langle(2,4,7,10); 0.8,0.2,0.4\rangle$	$\langle(5,8,9,13); 0.4,0.6,0.8\rangle$	$\langle(6,8,10,15); 0.6,0.4,0.7\rangle$
7	Interface design and development	$\langle(1,3,5,6); 0.2,0.3,0.5\rangle$	$\langle(1,2,5,7); 0.5,0.4,0.9\rangle$	$\langle(2,4,7,10); 0.8,0.2,0.4\rangle$
8	Testing and Debugging	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$	$\langle(1,2,5,7)); 0.5,0.4,0.9\rangle$	$\langle(3,7,9,12); 0.7,0.2,0.5\rangle$
9	Presenting software to a customer	$\langle(0,2,4,5); 0.8,0.6,0.4\rangle$	$\langle(1,3,5,6); 0.2,0.3,0.5\rangle$	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$
10	Writing software documentation	$\langle(1,3,5,6); 0.2,0.3,0.5\rangle$	$\langle(1,2,5,6); 0.2,0.5,0.6\rangle$	$\langle(2,4,7,10); 0.8,0.2,0.4\rangle$
11	Project Completion	0	0	0

Table 2. Input data for neutrosophic PERT

Using the scoring function (6), the estimated times for each activity were obtained, shown in Table 3, together with the immediate predecessors of each activity.

N.	Task title	Immediate Predecessors (Activity number)	Duration (days) a	m	b
1	Beginning of the project implementation	-	0	0	0
2	Meeting with a customer	1	1.31	0.96	1.31
3	Investigating the subject area	1	1.12	3.16	1.12
4	Designing class models and basic algorithms	2.3	3.16	3.87	3.16

5	Developing the modules of the software system	4	3.66	4.39	3.66
6	Module Testing	5	2.19	3.66	2.19
7	Interface design and development	5	1.12	3.16	1.12
8	Testing and Debugging	6.7	1.12	3.87	1.12
9	Presenting software to a customer	8	1.31	0.96	1.31
10	Writing software documentation	8	0.96	3.16	0.96
11	Project Completion	9.10	0	0	0

Table 3. Three-time estimated crisp numbers for activities

By applying (1) and (2), the meantime and the variance of the duration of the activities were obtained. In figure 2, the project network is shown with the estimated average times of each activity.

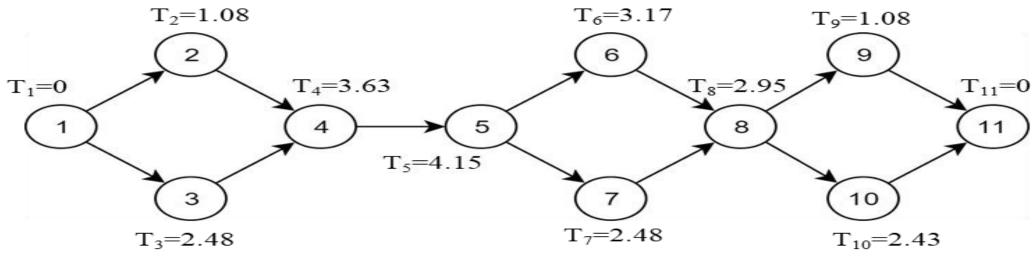

Figure 2. Estimated time network

Applying specialized software for project management, it was possible to estimate a minimum duration for the computer system development project of 19.86 days. Likewise, the critical path shown in figure 3 could be obtained.

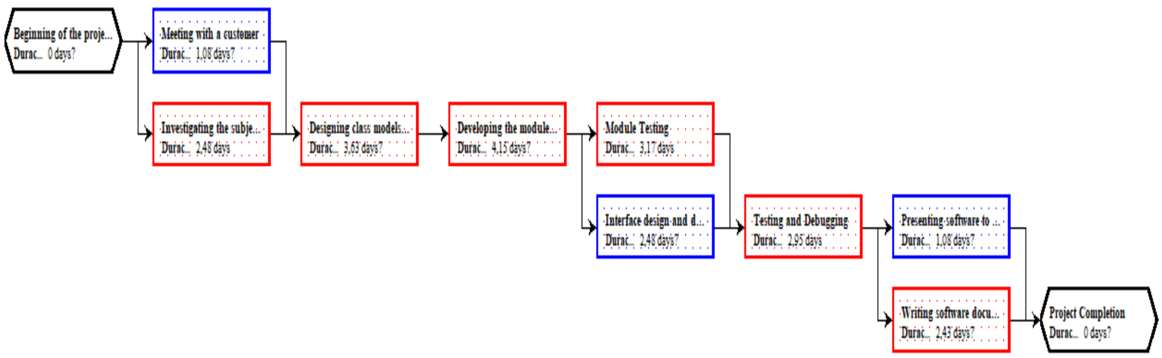

Figure 3. Project Critical path

As can be seen in Figure 3, the critical activities of the project, ie those that significantly affect the completion of this project, are the following: Investigating the subject area; Designing class models and basic algorithms; Developing the modules of the software system; Module Testing; Testing and Debugging and Writing software documentation.

Conclusions

With the application of the neutrosophic PERT method, it was possible to calculate the estimated time of completion of the project (19.81 days), from indeterminate values of the three classical times of the PERT method. This was made possible by applying for trapezoidal neutrosophic numbers. This type of number allows handling 4 components for each time and their respective functions of belonging to the specified sets. Hence it is important for project management, in inconsistent or ambiguous information environments.

The neutrosophic PERT method is a very useful tool, which can be generalized to any type of project that you want to manage or undertake, although it can be stated that it has proven efficiency in the management of computer projects, in which vagueness tends to abound. When estimating the completion of a task, due to the complexities inherent in the art of programming.

Although the problem of software development is widely discussed in academic articles, some specific issues related to the management of software development projects may be of interest for future research.

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Neutrosophy to Enrich Legal Opinion Mining

Wilson Eduardo Castro Núñez[1], Paul Alejandro Centeno Maldonado[2], Diego Xavier Chamorro Valencia[3] , Danilo Santiago Alvarado Ibarra[4], and Anthony Rafael Sotolongo León[5]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador. Email: uq.wilsoncastro@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.lpaulcenteno@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.diegochamorro@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.daniloalvarado@uniandes.edu.ec
[5] OnGres, Santiago de Chile, Chile. Email: asotolongo@ongres.com

Abstract. The main characteristics of legal research lie in its complex operation and the articulation between science, technology, politics, and law. This is why it is claimed that the technology helps experts in processing information resulting from the sources of a legal investigation. Furthermore, the data mining process offers statistical techniques and pattern recognition and trend identification in the stored information. In this way, it facilitates its study and offers a significant contribution to the speed and efficiency required by today's users. Therefore, the main objective of the research is to develop a simple method for mining legal opinions enriched with Neutrosophy that contributes to legal scientific research. This multidisciplinary project allowed obtaining a model that integrates single value neutrosophic numbers to calculate polarity and statistical processing based on data clustering.

Keywords: opinion mining, legal research, SVN, clustering, Orange.

1. Introduction

Legal research is of vital importance for law professionals. In fact, according to what was stated by the authors in [1]:

> The dual system of professional training in the legal sciences is based on the premise of the investigation as an element that reinforces and improves the performance of the student, who incorporates this competence, to his daily performance as a resolution mechanism in the face of any problem situation (p. 3).

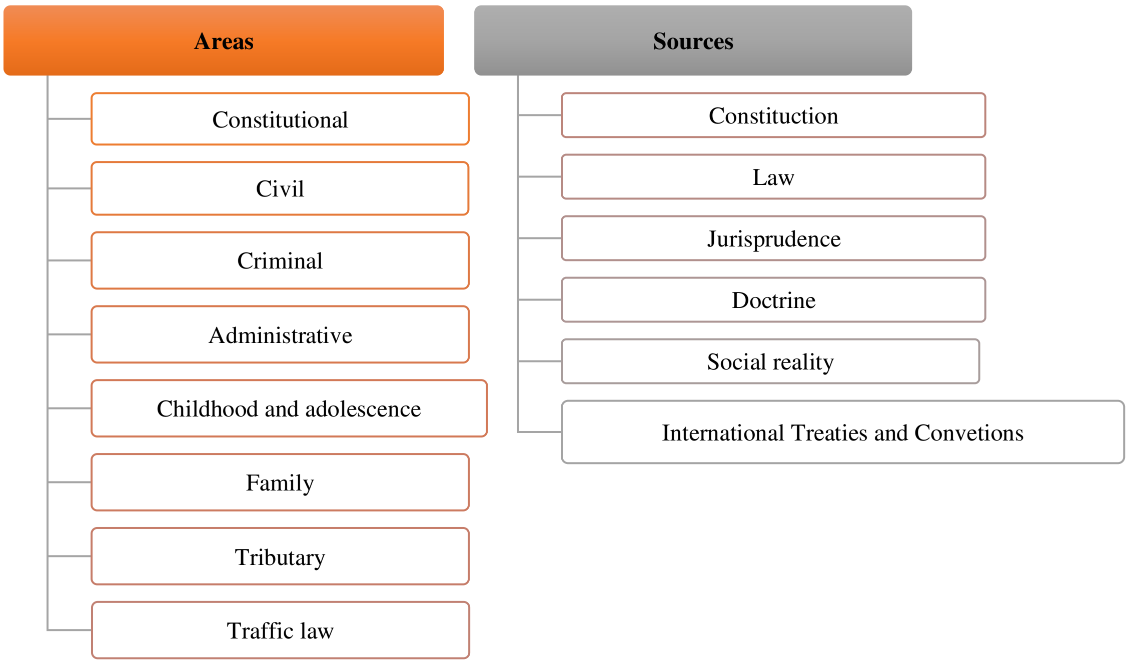

Figure 1: Main areas and sources of legal research.

To establish the theoretical and epistemological foundations of this type of research, the details stated in figure 2 must be taken into account since they are necessary to identify specific problems in law and legal sciences and propose solutions through legal scientific production. These models, methods, and paradigms have qualitative as a fundamental component, one of their primary applications being the analysis of legal texts associated with the sources and areas shown in Figure 1.

Models	General Methods	Paradigms
Historical– legal Legal– comparative Legal– descriptive Legal– exploratory Legal– projective Legal– propositivo Hermeneutical model Legal-dogmatic model Realistic-materialistic model	Quantitative: (historical-logical, hypothetical-deductive, systemic, experimental, inductive-deductive). Qualitative: (phenomenological, grounded theory, action research, ethnographic)	Positivist Post positivist Socio-critical Constructivist Quantitative or explanatory Qualitative or hermeneutical

Figure 2: Models, methods and paradigms for legal scientific research.

According to [1], the main characteristics of legal research lie in its complex behavior and the articulation between science, technology, politics, and law, which leads to an updated view of it. That is why technology currently helps experts in processing scientific evidence [1] in all the areas in which it develops. Nowadays, this issue has been consistently consolidated because Artificial Intelligence has made Opinion Mining and Sentiment Analysis possible. It is worth remarking that in the consulted references, we could observe that the authors are divided regarding establishing the similarities and differences of these terms. Some say that it is not the same since the first focuses on the narrative while the second on pure emotions. However, all agree on the help provided by both techniques for legal scientific work [2-5].

Statistical techniques and techniques for pattern recognition and trend identification are used in the stored information through the data mining process. In this way, it facilitates its study and offers a great contribution to the speed and efficiency required by today's users [4, 6-9]. The foregoing is supported by the fact that opinion mining subtasks have evolved and now include [10]:

1. Subjectivity analysis: implies determining whether one of the topics for the blogging sub-community is text (neutral in feeling) or subjective (expresses a positive or negative sentiment or opinion).
2. Polarity analysis: includes the prediction of whether a text that has been established as subjective is positive or negative in its polarity
3. Degree of polarity: measures positive or negative polarity, in a subjective text.

It should be noted that among the advantages of using data mining is the ease of its implementation and its various applications. But the main difficulty in applying these models lies in the effort required in the evaluative processes of the different algorithms. However, as it was possible to verify in the previous paragraph, the polarity analysis is dichotomous, so applying it to a legal investigation where neutralities exist, is not convenient. Therefore, the authors of the current work agree on the need to incorporate a science such as Neutrosophy [11-20], since it analyzes this type of situation. Then all these criteria will be unified, while still simplifying the process to obtain cost reduction. Thus, this research will be carried out with free software so as not to have to pay excessive licenses [1-5, 10, 21].

According to the need to improve and humanize legal science researchers' work, we will develop a simple method for mining legal opinions enriched with Neutrosophy that contributes to legal scientific research. Which is exposed as the main objective of this article. Since it is established as a hypothesis of whether the text processing is optimized that allows analyzing opinions to obtain knowledge on a certain subject, it will be possible to contribute effectively to legal research. In addition, with the introduction of neutrosophic science, it will be possible to complement the opinion analysis system covering a broader field of variables that enrich the qualitative-quantitative research of any student of the social sciences in the legal field. For the fulfillment of this, in the first place, a theoretical framework will be established with the previous knowledge in section two. Subsequently, the method developed will be presented in section three and its respective application in the Results section. Finally, the conclusions reached and the bibliographic references of the research will be presented.

2 Previous knowledge

For the analysis of this topic within the present research, we start from a common thread of thought as illustrated in figure 3:

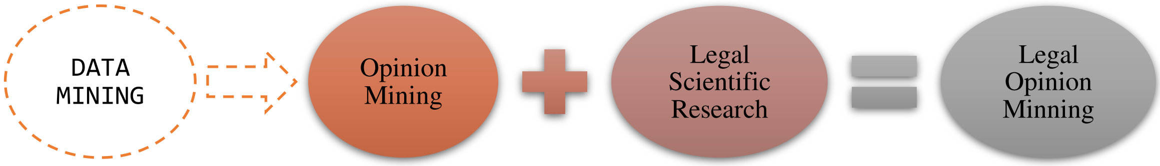

Figure 3: Relationship diagram.

2.1 Data mining

Data mining is based on statistics, database management, and artificial intelligence models and is closely related to computer science. Its purpose is to generate knowledge from databases [2-5, 10].

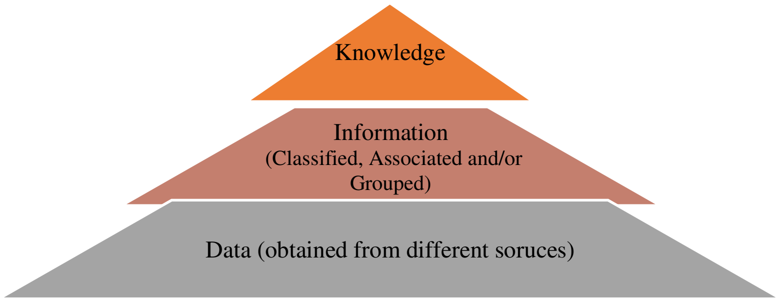

Figure 3: Phases of data mining. Adapted by the authors from [3].

In general, a Database Knowledge process consists of 5 stages[5]: data selection, data preparation or pre-processing, exploratory analysis, Data mining, interpretation of patterns, and evaluation of models. Obtaining the final DM model depends on the last two stages, which requires successive iterations on the exploratory analysis of the input data, and obtaining patterns and interpretation of results.[5].

2.2 Opinion mining

According to [10]:

> Opinion mining identifies the author's point of view on a topic rather than simply identifying the topic itself (…). Analyzing the text for your opinions can be extremely valuable to a legal researcher looking for a perspective on a legal topic or even information on a product or service. Organizations can also benefit from automatic opinion extraction by getting a timely picture of how their customers view their products or services, or more generally their names. The Web is a sprawling environment where customers seek or submit opinions that may be ripe for mining. An increasing number of customer views are posted on blogs (short for Weblogs). The content of these blogs can range from brief product reviews by consumers to elaborate essays on legal issues by law professors (p. 231).

3 Materials and methods

To develop the work method, a Legal-exploratory model will be used, where exploratory research based on the mining of legal options is used to describe the phenomena as they exist. In other words, it will be used to identify and obtain information on the polarities of opinions in the legal field. All this pursuing a quantitative or explanatory paradigm where the researcher describes what he has found based on his condition as an observer. The neutrosophic details on which the method will be based will be explained below.

3.1 Neutrosophy

Neutrosophy is a new branch of philosophy that studies the origin, nature and scope of neutralities created by Professor Florentin Smarandache. Its incorporation guarantees that the uncertainty of decision-making is considered, including indeterminacies where experts will issue their criteria evaluating linguistic and non-numerical terms, which constitutes the most natural form of measurement in human beings [13, 22-26]. Logic and neutrosophic sets, on the other hand, constitute a generalization of Zadeh's logic and fuzzy sets, and especially of Atanassov's intuitionist logic, with multiple applications in the field of decision-making and machine learning [13, 23, 27-29]. The truth value in the neutrosophic set is defined as follows [29-31]**:**

Definition 1 [13, 32, 33]: Be X a universe of discourse, a Neutrosophic Set (NS) is characterized by three membership functions, $u_A(x):, r_A(x):, v_A(x):: X \rightarrow]^-0, 1^+[$ which satisfy the condition $-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ $x \subset X$ $\forall u_A(x), r_A(x)$ and $v_A(x)$: denote the membership functions of true, indeterminate, and false of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$. Let $N = \{(T, I, F): T, I, F \subseteq [0,1]\}n$ be a neutrosophic evaluation of a mapping of a group of formulas propositional to N, and for each sentence p:

$$\boldsymbol{v(p) = (T, I, F)} \quad (1)$$

To facilitate the practical application in real-world problems [7], the use of Single-Value neutrosophic Sets (SVNS) was proposed, through which it is likely to use linguistic terms to obtain greater interpretability of the results [8]. Let X be a universe of discourse, an SVNS A over X has the following form [9]:

$$\boldsymbol{A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}} \quad (2)$$

Where $\boldsymbol{u_a(x): X \rightarrow [0,1], r_a(x): X \rightarrow [0,1]\ y\ v_a(x): X \rightarrow [0,1]}$

With $\boldsymbol{0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \forall x \in X}$ (3)

The intervals $\boldsymbol{u_a(x), r_a(x)\ y\ v_a(x)}$ denote the memberships related to true, indeterminate and false from x in A, respectively[10]. For convenience reasons, a Single Value Neutrosophic Number (SVNN) is expressed as A = (a, b, c), where a, b, c∈ [0.1] and $0 \leq a + b + c \leq 3$.

Linguistic terms	SVNN numbers
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0,15,0.20)
Good (G)	(0.70,0.25,0.30)
Medium good (MDG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Moderately bad (MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 1: Linguistic terms used. Source: [34].

Let A = (a, b, c) be a single-valued neutrosophic number, a score function S related to a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and false membership degree is defined [35]:

$$\boldsymbol{s(V_i) = 2 + T_i - F_i - I_j} \quad (4)$$

3.2 Designed method

For the development of the model, we based on what was exposed by the investigations of [2-10, 14-21, 30, 36-41] and obtained the following:

1. Define the subject area of interest
2. Identify external or internal sources of information
3. Data collection from identified sources
4. Formation of the corpus: the extracted data will be filtered and ordered to form the dataset destined for legal research (corpus), whether they are complete writings of an author, laws, among others. That is, an analysis of the extracted data is made to verify that they comply with the study standards.
5. Algorithms:
   5.1. Data transformation: a series of rules are applied to convert it to a specific format desired by the unit of analysis.
   5.2. Opinion classification: the previously identified words are taken to assign a polarity, that is, to define the associated sentiment according to the SVNN. To determine the polarity and therefore identify feelings or opinions, each word will be assigned its respective grammatical category (verb, adjective, adverb, name, etc.). Once done, the system will search the corpus and process only the polarity of the information collected.
6. Results display:
   For the output, visualization, and discussion of the results, the data will be clustered. This technique starts from a measure of proximity between individuals and, from there, they look for the groups of individuals most similar to each other, according to a series of measured variables [12, 42-49]. According to what was consulted, the K-mean method is very favorable for this, so its application is decided in this step.

However, to manage neutrality within the entire process, we added to this technique, a neutrosophic version according to [22, 42-45, 47-54]:

Definition 2: A partition $P = \{C_1, C_2, \dots, C_c\}$ is said to be a soft partition of data set X, if and only if it is true that: $(\forall x_i \in X, \forall C_j \in P) \leq \mu C_j(x_i) \leq 1$ and $(\forall x_i \in X, \exists C_j \in P)$such that $\mu C_j(x_i) > 0$. Where $\mu C_c(x_i)$ denotes the degree to which xi belongs to the cluster *Cj*

Definition 3: A Partition is a special soft partition when the sum of the degrees of membership of a specific point in all the clusters is equal to 1 as shown in equation 5.

$$\sum_j \quad \mu C_j(x_i) = 1, (\forall x_i \in X \tag{5}$$

Definition 4: A constrained soft partition is a partition that meets this additional condition. The Neutrosophic K-Means algorithm produces a constrained smooth partition and to do this the objective function J is extended in two ways: $\forall x_i \in X, \exists C_j \in P$ such that $\mu C_j(x_i) > 0$ where the degrees of neutrosophic membership of each data in each cluster are incorporated or; introducing an additional parameter that serves as exponent weight in the membership function, thus the extended objective function *Jm* is as shown in 6.

$$\mu c_1(x_1) = \frac{1}{\sum_{j=1}^{2} \quad \left[\frac{\|x_1 - v_1\|^2}{\|x_1 - v_j\|^2}\right]^2} \tag{6}$$

Where P is a fuzzy partition of the data set X formed by $\{C_1, C_2, \dots, C_k\}$ and the parameter m is a weight that determines the degree to which the partial members of a cluster affect the result. This refers to a similarity between the classical method and its neutrosophic extension since the latter also tries to find a good partition by searching for the prototypes vi in such a way that they minimize the objective function Jm and that in the same way, it must also search for the functions of membership μC_1 that minimize Jm. In addition to the method, equation 7 is established for the calculation of the initial membership functions of both clusters:

$$J_m(P, V) = \sum_{j=1}^{k} \sum_{j_k \in X} \quad (\mu c_j(x_k))^m \|x_k - v_j\|^2 \tag{7}$$

The calculations are subsequently updated according to equation 8.

$$v_1 = \frac{\sum_{k=1}^{n} \quad (\mu C_1(x_k))^2 x_k}{\sum_{k=1}^{n} \quad (\mu C_1(x_k))^2} \tag{8}$$

3.3 Software for the processing of the method

Due to the benefits it offers, we chose Orange Software, which is a free software application for data mining and predictive analysis, under the GPL license. It is a powerful tool, but at the same time, it is friendly and intuitive and allows visual, fast and versatile programming for an exploratory data analysis. Developed in C ++, the Orange application is multiplatform, as Windows, Linux and Mac support it. It allows predictive modeling through classification trees, regression, logistics, Bayes classification, and association rules. In addition to data description methods, self-organizing maps, and clustering. Lastly, you have model validation and cross-validation techniques. It also has an easy, powerful, fast, and versatile visual programming component [4, 36].

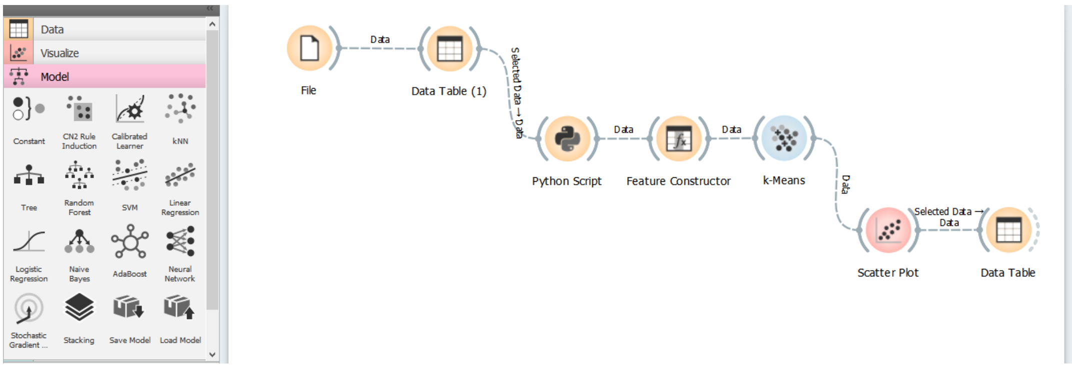

Figure 4: Workflow in Orange.

To start the process, the corpus is loaded through a file widget, then its polarity is processed by applying the SVNNs and the neutrosophic K-means. In the end, the results are shown in a Scatter Plot and a Data Table to better analyze the results: apply filters, count, sort, etc. Equation 4 is incorporated into the Feature Constructor for the deneutrosophication of SVNNs and equations 6, 7, and 8 through a Python Script.

4 Results

To illustrate the operation of the proposed model, a test experiment is carried out. Where it is proposed as a thematic field of interest to determine the legal opinions expressed by the students in a blog about the sentence in a judicial process of a femicide case. The data entry for the formation of the corpus was based on the comments made by said students on this particular topic. For the data transformation, words were chosen to form a dictionary where the neutrosophic numbers are assigned based on the polarity shown. Here is an example:

Corpus-polarity	Neutrosophic linguistic term	SVNN
Indication of total acceptance with the verdict: totally agree, very fair, exemplary	Extremely positive (EP)	(1,0,0)
Indication of an agreement but without showing empathy: Fair	Average (M)	(0.50,0.50,0.50)
Indication of revulsion with the verdict: appeal, unworthy, unfair	Extremely negative (EN)	(0,1,1)

Table 2: Association of the SVNN to the polarity of opinion.

Then the data is entered according to the flow that was programmed in Orange, obtaining the following:

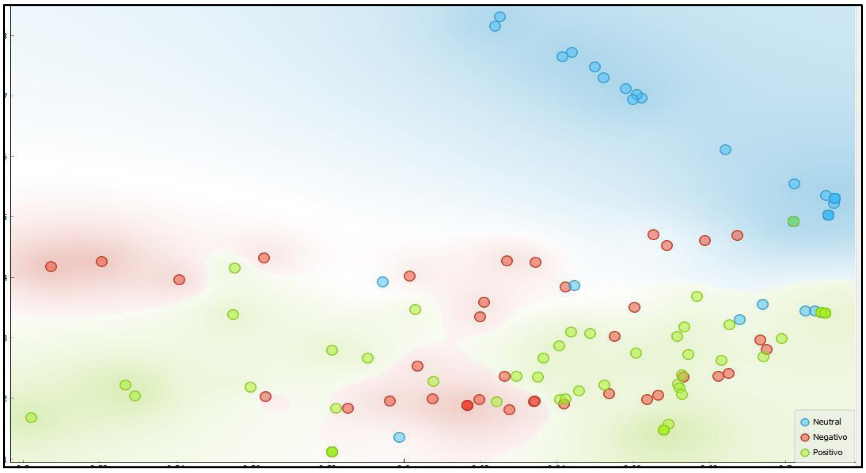

Figure 5: Results visualization. Source: Own elaboration (software output)

As could be observed for the experiment carried out, the neutral opinions show the highest level within the analyzed corpus, obtaining a higher prevalence of the positive ones over the negative ones. So it can be said that the general opinion among the students was rated as medium-positive. However, students may not have all the elements available to evaluate the process effectively. Therefore, it was decided to re-evaluate the opinions once all the elements of the judgment had been presented. They are listed below:

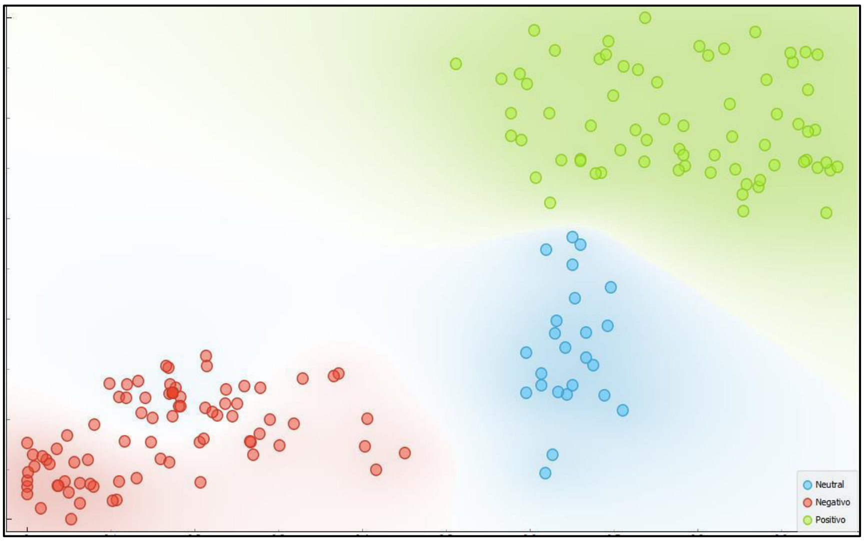

Figure 6: Second iterative round of the method. Source: Own elaboration (Orange software output).

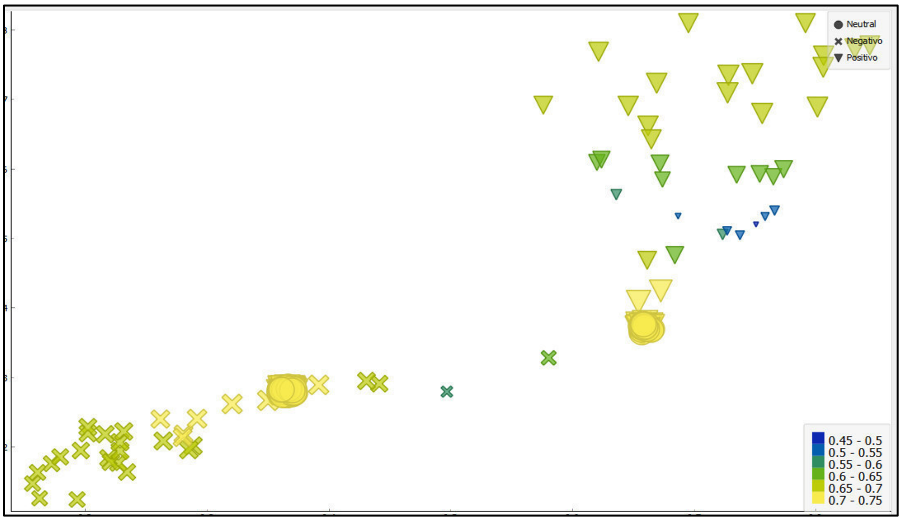

Figure 7: Second iterative round of the method. Source: Own elaboration (Orange software output).

It can be seen that the change of opinion is substantial. Although the experiment constitutes a test that could empirically determine and establish an "adequate" own judgment, it is necessary to have all the elements inherent to the case. However, each person depending on the affectation to the problem can develop more empathy than others and affect their point of view. Sensitive situation, so it is decided to expose the results to the students to obtain greater feedback on this subject in a legal debate for educational purposes.

Conclusion

It is worth remarking that in the consulted references, it could be observed that the authors are divided regarding the establishment of the similarities and differences of these terms. Some comment that there are differences since the first focuses on the narrative while the second on pure emotions. However, all agree on the help that both techniques provide for legal scientific work. Data mining is a discovery of knowledge that is carried out through the exploration and analysis of large volumes of data stored in the databases of the information unit, to discover significant correlations, new patterns and trends between the explored and analyzed data that facilitate decision-making to improve the services it provides.

The use of data mining processing tools fused with neutrosophy makes it possible to build very robust opinion mining systems. This will make it possible to carry out new sentiment or opinion analysis experiments focused on different domains of the social sciences, beyond legal scientific research. A project of this type is interdisciplinary and requires the assistance of specialists in the areas of Law and Data Mining as well as in the field of statistics. One of the complexities involved when obtaining an adequate model is understanding its internal functioning, hence the need for a combination of specialties. The achievement of synergy between the authors and collaborators allowed us to explore its components. Therefore, it can be said that this method is the result of a complex project based on the segmentation of knowledge to support decision-making, which must be properly interpreted.

For future lines of research, it would be interesting to identify the profiles of those who make the comments to combine them with other broader data such as gender, age range, false profiles, patterns in the messages, etc. It is necessary to combine them with a semantic analysis of the texts to extract more information, determining words and in which contexts they appear. It is suggested to carry out new studies that, with the use of these models contrasted with the knowledge of experts, allow to help strengthen and consolidate social research. As well as it is considered that it is of utmost importance to obtain feedback from the model to perfect it in search of continuous improvement and thus achieve an established algorithm within legal scientific research.

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Method for Recommending Custody to Minors based on Parental Responsibility using a Neutrosophic Cognitive Map

Patty Elizabeth del Pozo Franco[1], Gisella Karina Arreaga Farias[2], Laura Marlene Ochoa Escobar[3] and Alexandra Dolores Molina Manzo[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.pattydelpozo@uniandes.edu.ec

[2] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.gisellaarreaga@uniandes.edu.ec

[3] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.lauraochoa@uniandes.edu.ec

[4] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.alexandramolina@uniandes.edu.ec

Abstract. Children and adolescents under custody are a phenomenon that occurs daily in the country. Many homes are disorganized because parents abandon their children and leave them in the hands of guardians, who do not take good care of children and adolescents, usually being victims, having consequences in their behavior due to lack of the proper protection of their children parents. These children and adolescents are sometimes victims of violent situations, that is, the rights of children and adolescents are violated. It is necessary to analyze the use of neutrosophic cognitive maps on this problem to determine and characterize the variable factors that affect the custody of minors and the development of childhood and adolescence. So that, with the ranking of the incidence factors, decision-making by the government would be facilitated by defining strategies to mitigate the negative effects coming from custody not conceived under the parents' responsibility and the protection of the rights of childhood and adolescence.

Keywords: custody, effects, neutrosophic cognitive maps.

1 Introduction

Custody during childhood and adolescence is the right that Law confers to the person and property of the minor who is not subject to parental authority and represents him in all acts of civil life [1]. In its essence, custody is an institution of protection. It is sought, within what is humanly possible, that someone fills the void left by the lack of parents, who takes care of the minor, watching over their health and morals, attending to their education, managing their assets; that makes up for their disability, carrying out the acts that the minor cannot perform due to lack of natural aptitude [2].

It is, above all, a highly personal position and, as such, it cannot be transferred between the living or the last will. It cannot be assigned or replaced [3]; Without prejudice to the fact that the guardian is empowered to grant power to carry out certain particular acts, in the same way, that the father of the family can do it, provided that those acts are carried out under his directives and dependencies[4]. It is a public charge; no one can excuse himself or herself from performing it without sufficient cause, the very nature of the institution explains this character.

It is disconcerting to know that when they leave their children under the care of their guardians, they do not even know what role they should play, the care and rights that their wards should receive once they are in their care. It is important to know the reactions that the boy, girl, or adolescent has when separating him or her from their parents may cause psychosocial disorders, communication problems, behaviors associated with delinquency, drug abuse, or withdrawal from the educational system.

These behaviors are born in adolescents due to the psychological state at the time of their parents' departure and have a lot to do with their guardians since, like most of them, they have their occupations, children, and even greater problems than their parents. In turn, the same pupils produce that many of the tutors use their pupils as work instruments and are subject to both physical and psychological abuse as a result of a total or partial disregard of their parents.

A large part of the parents do not even communicate with them, there is a total abandonment of the parents so that some tutors cannot stand the behavior of their pupils, and as has been said, others take advantage of this neglect to use them in illicit situations. Moreover, it is worrying since guardians must replace the care and affection that parents should share with their children so that they do not feel the absence of their parents [5].

Men have certain duties of solidarity towards their fellow men, all the more so if they are close friends or relatives; succor and help the orphan [6], to the helpless minor, it is a moral obligation, to whose fulfillment no one can refuse without a just cause. Since the position is discerned in the interest of the minor, the state must monitor the proper fulfillment of the duties that the law imposes on the guardian [7]. Thus, among the best-known kinds of custody, we have:

Dative custody, when the father has not appointed a guardian and there are no suitable relatives called by law to the position, or when the persons who exercised it have resigned or were removed, the judge must provide custody, choosing according to his prudent discretion which has to play it [8]. When choosing a guardian, the magistrate's decision must be based primarily on the interests of the child. Therefore, it is prudent to consider the following circumstances:

- the religious confession of the guardianship, which does not mean that the diversity of cults is an insurmountable obstacle, but simply that, taking into account the peculiarities, a conflict of conscience would result, more generally, harm to the minor;
- the relationship;
- the circumstance of having cared for the minor [9];
- the opinion of the minor, if he is close to the age of majority;
- the offer to perform the position free of charge;
- The parents' wish reliably expressed, even if not with the formalities established for testamentary custody [10].

To achieve a greater understanding to provide notions for prior knowledge that allows analysis, the different types of custody are exposed:

- Legitimate custody: it is called legitimate custody the one that is discerned by a preference established by law. It has a subsidiary nature since the legal appeal only applies to the case that the father has not appointed another guardian. It is assumed that no one like the parents can indicate the person who best takes care of the child; but failing that, better performance is presumed on the part of grandparents and siblings, who will normally put more love and dedication than a stranger will.
- Testamentary custody: it is called testamentary custody when it originates in the last will provision of the father or mother [11].
- Custody or testamentary curatorship: is constituted by a testamentary act, and the choice corresponds to the parents since they are the ones who want the assets to be administered in the best way, after their days, by a person of her confidence.
- Custody or legal custody, this kind of legal guardianship is the one that is conferred by law on the relatives or spouse of the ward and it is resorted to, in general terms, when there is no testamentary guardian.
- Dative custody or curatorship, the dative guardianship is the one conferred by the magistrate, proceeding in the absence of another in such a way that it will be resorted to when there is no testamentary guardian, or spouse or relatives to whom the legitimate guardianship corresponds [12].

Today there is a lack of understanding regarding due process in these types of situations. Many times there are analyses focused on the custody of the children even when their parents live and due to elementary conditions they cannot take care of their children, they resort to custody (figure 1) that are carried out in the wrong way. That is why this work is focused on the custody of minors based on the responsibility of the parents.

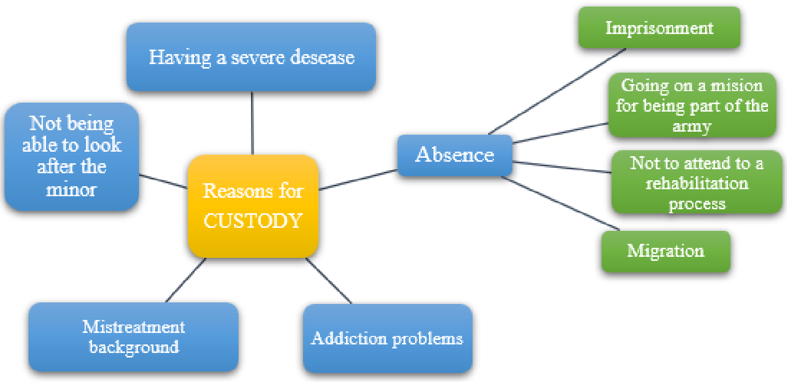

Figure 1: Conditioning factors of the custody process. Source: own elaboration

The main objective of this research is to analyze the variable factors affecting the custody of minors and the development of childhood and adolescence. Thus, by prioritizing the incidence factors, decision-making by the government will be facilitated, outlining strategies to mitigate the negative effects radiated by custody not conceived under the responsibility of the parents and in order to protect the rights of children and adolescents. To comply with the above, the following specific objectives are proposed:

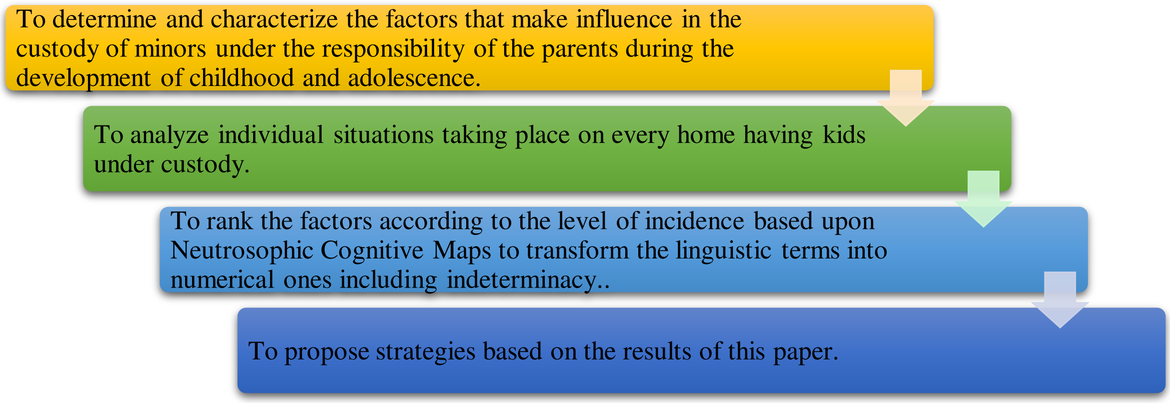

Figure 2: Specific objectives to develop during the investigation. Source: own elaboration.

After a review of the bibliography and consultation with several authors, it was decided that, due to its versatility in the investigation of factors, the neutrosophic cognitive maps from the theory of Neutrosophy proposed by Florentin Smarandache would be chosen for the treatment of the neutralities, which generalizes theories and has applications in many fields. In this case, sharp and fuzzy sets are where the indeterminacies have support. Neutrosophy is a valuable theory that is increasing its inclusion, enriching the possibilities of analysis, mainly due to two issues: first, the addition of the notion of indeterminacy and, secondly, the possibility of calculating using linguistic terms [22].

The decision for applying neutrosophic cognitive maps for this analysis lies in the fact that this represents knowledge as a directed graph. Each vertex of the graph represents a concept and each edge causal relationship between the concepts is represented by the vertices connected. Additionally, each edge is associated with a real value in the interval [-1,1], where a negative value means that there is an inverse relationship between the concepts and a positive value means that the relationship is direct. The value in modulus of the value measures the strength between the relationships. This method has been used successfully in social studies.

This technique will be used to represent the causal relationships among the variables in the relationship between guardian and minor in custody in Ecuador, in addition to classifying each of them as a transmitter, which is an impulse component, a receiver that is impacted, and an ordinary one that is an intermediate component. Hierarchizing the factors by their level of incidence based on the neutrosophic cognitive maps will allow indeterminacy to be treated in the expert consultation by transforming fuzzy linguistic terms into neutrosophic mathematical terms.

2 Materials and methods

During the development of this research, we used the quantitative methodology because it allows us to accurately analyze with numerical percentages and make an assessment and establish statistical data to collect the indices. In the same way, information was collected from different books of various jurists in Ecuador, comparative law, laws currently in force. It was possible to state in the present investigation that it was carried out concerning the subject of study, it has been possible to certify that there is not an adequate database of specific and organized data on this problem.

In addition, the method of documentary research, bibliographic, field and observational research, inductive/deductive method was used through results directed to different institutions to collect information, with respective tools of results that allow to analyze and compare them with the current norm in force to end with a conclusion according to law. After analyzing the previous speech, it was necessary to apply the following theoretical methods by the authors to prepare the document:

- Analysis and Synthesis of the information obtained from literature review, both international and national, of the specialized documentation, as well as the experience of actors consulted to develop logical and valid conclusions, as well as a set of premises and/or positions generated by relevant participants within the social system.

- Systemic - structural for the development of the analysis through the decomposition of the elements that comprise it.
- Hermeneutic to carry out a comparative interpretation of the legislation applicable to the subject in question.

2.1 Neutrosophic cognitive maps

Starting from the previous elements, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy in relationships [13]. NCMs were introduced by[14] in 2003. NCMs are an integration of the Fuzzy Cognitive Maps (NCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NCMs) introduced by Smarandache in 1995 [15]. This technique overcomes the inability of traditional NCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty.[15] exposes that DCMs constitute a technique that has received increasing attention due to its possibilities for representing causality. The following is a set of definitions necessary for working with NCMs. Firstly, it exposes the original definition of neutrosophic logic as shown in [16-37].

Definition 1. Let N = {(T, I, F): T, I, F∈ [0,1]} C [38]be a neutrosophic set of evaluation. v: P→N is a mapping of a group of propositional formulas into N, i.e., each sentence p∈ is associated to a value in N, as it is exposed in Equation 1, meaning that p is T% true, I% indeterminate, and F% false.

$\mathrm{v}\,(\mathrm{p}) \;=\; (\mathrm{T}, \mathrm{I}, \mathrm{F})$ (1)

Henceforth, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of Neutrosophy according to [37, 39].

Definition 2. (See[38, 40] Let K be the ring of real numbers. The ring generated by K∪I is called a neutrosophic ring if it involves the indeterminacy factor in it, where I satisfies I2 = I, I + I = 2I and in general, I + I + ... + I = nI, if k∈, then kI = kI, 0I = 0. The neutrosophic ring is denoted by K (I), which is generated by K∪I, ie, K (I) = <K∪I>, where <K∪I> denotes the ring generated by K and I.

Definition 3. A neutrosophic matrix is a matrix A = [aij] ij i = 1, 2,…, m and j = 1, 2,…, n; m, n≥1, such that each aij∈K (I), where K (I) is a neutrosophic ring, see [41].

Let us observe that an element of the matrix could have the form a + bI, where “a” and “b” are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from classical matrix operations.

For example,. $\begin{pmatrix} -1 & \mathrm{I} & 5\mathrm{I} \\ \mathrm{I} & 4 & 7 \end{pmatrix} \begin{pmatrix} \mathrm{I} & 9\mathrm{I} & 6 \\ 0 & \mathrm{I} & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21\mathrm{I} & 27\mathrm{I} & -6+25\mathrm{I} \\ -28+\mathrm{I} & 49+13\mathrm{I} & 35+6\mathrm{I} \end{pmatrix}$

Additionally, a neutrosophic graph is a graph that has at least one indeterminate edge or one indeterminate node [16, 31]. The neutrosophic adjacency matrix is an extension of the classical adjacency matrix in graph theory. aij = 0 means nodes i and j are not connected, aij = 1 means that these nodes are connected and aij = I, which means the connection is indeterminate. Fuzzy set theory does not use such kind of notions.

On the other hand, if the indetermination is introduced in a cognitive map as it is referred to in [42], this cognitive map is called a neutrosophic cognitive map, which is useful in representing and anlysis of causal knowledge [39, 43]. It is formally defined in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts, as nodes and causalities or indeterminate as edges. It represents the causal relationship between concepts.

The measures described below are used in the proposed model, based on the absolute values of the adjacency matrix [42]:

- Outdegree (vi) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of the outgoing relationships (cij) of the variable.

$$od(v_i) = \sum_{i=1}^{n} c_{ij} \qquad (2)$$

- Indegree (v_i) is the sum of the column elements. It reflects the strength of relations (cij) outgoing from the variable.

$$id(v_i) = \sum_{i=1}^{n} c_{ji} \qquad (3)$$

- Total centrality (total degree $td\ (vi)$), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \quad (4)$$

The static analysis is applied using the adjacency matrix, considering the absolute value of the weights [31]. Static analysis in Neutrosophic Cognitive Maps (NCM) [43], initially contains the neutrosophic number of the form (a + bI, where I = indetermination) [44]. Then, it requires a process of de-neutrosophication as proposed in[42], where I ∈ [0, 1].

Finally, we work with the average of the extreme values, which is calculated using Equation 5, which is useful to obtain a single value for connections [45]. This value contributes to the identification of the characteristics to be attended

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (5)$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (6)$$

3 Case study

Custody of minors occurs when the court orders a person who is not the parent of a minor to:

- ❖ Have custody of the minor; or
- ❖ Manage the minor's assets (called “estate”); or
- ❖ Both.

The information in this section refers to testamentary custody. These cases are started by the person who wants to be the guardian or by another relative who asks the court to appoint a guardian[46]. If the juvenile dependency court awarded custody of a minor to someone other than the parent, the information provided in this section does not apply to this case. Testamentary custody of the person is established when a minor is living with an adult other than the parent, and the adult needs a court order to make decisions on behalf of the minor. In general, such kinds of custody are for minors under 18 years of age. In the custody of minors, the following is established:

- ❖ Parents retain their parental rights. They can have reasonable contact with the minor.
- ❖ The court may end custody if the parents regain the ability to care for their child.
- ❖ The court may supervise guardians.

The guardian is also responsible for the supervision of the minor and may be liable for any intentional harm caused by the minor. Sometimes a guardian of a person is needed when parents cannot raise a minor, regardless of how much they love him[47]. The court will consider the child's best interest to ensure that the child is raised in a safe, stable, and nurturing environment. A legal guardian can take care of a minor when his parents are unable to do so.

4 Results

When analyzing the information regarding custody under the responsibility of parents to leave a guardian to represent them for their children when they cannot respond to the basic needs for their development in the stages of childhood and adolescence. The analysis determined two situations:

- ❖ Situation I: Analysis of the factors in custody focused on children and adolescents
  - Most of the boys, girls and adolescents live mostly abandoned, not living with their parents suffer psychological disorders due to abandonment.
  - The forgetfulness of their parents affects the behavior of children and adolescents.
  - Most of the children live under the custody of people who are not family.
  - Lack of care and protection directly impacts the normal development of children and adolescents since their parents rarely communicate with them.
  - They have no one to guide them or guide them in their schoolwork, children and young people feel alone because they do not have a person by their side to turn to in case of proper guidance
  - The lack of parents in the home directly influences school performance
  - Longing to live with parents, because the people who care for them cannot replace the parents
  - Abandonment in the homes of curators and tutors who do not receive money for the needs of the children, which constitutes even more of a problem when there is no money involved.
  - They are prone to suffer from child abuse as it affects the self-esteem of the boys and when they are punished, they have sequels that come to constitute notorious problems over the years.

❖ Situation II: Analysis of the factors in custody focused on guardians
- There is ignorance in knowing the meaning of what a tutor or curator is, this indicates that briefly, they know its meaning empirically and importantly so that these adolescents can lead a full life and in some way replace the absence of their parents
- Most parents leave their children in the hands of relatives to make up for their lack in some way.
- The lack of knowledge of the functions when taking care of minors and adolescents means that most of them suffer violations of their rights by their guardians and other people and institutions with which they have contact.
- It is difficult to provide the necessary care and attention to children under custody.
- Most tutors lack the aptitudes and attitudes to perform and don't know how to guide the pupil correctly
- The abuse of those under their care is not reported, mostly children and adolescents who do not have constant communication with their parents

Once the state of the elements under analysis has been analyzed, we proceed to the extraction of potential factors applying the following process:

Situation I: Custody (point of view of children and adolescents)
A. Psychological state
B. Physical state
C. School development
D. Poor communication (between parent and ward)
E. Life conditions
F. Economic environment

Situation II: Custody (guardian's point of view)
G. Economic conditions
H. Communication (between tutor and ward)
I. Life conditions
J. Family atmosphere
K. Legal scenario (rights and obligations of children and adolescents in custody)
L. Tutor training (attitudes and skills of the tutor to perform and to know how to guide his pupil)

When analyzing the negative criteria obtained from the extraction of the information, we decided to evaluate using the NCMs method, which are the strategies with the potential to mitigate the negative effects. These factors called variables will be denoted by alphanumeric codes (a1, b1, c1, d1, f1, g1) for situation I (figure 2) and (g1, h1, i1, j1, k1, l1) for situation II (figure 3), following the previous order in the table. A group of experts evaluates the causal relationships between the six previous variables with neutrosophic numbers; an average of the evaluations of the experts was used. From them, an adjacency matrix was obtained and the graph that represents it:

Situation I

$$N\,(E) = \begin{bmatrix} 0 & 1 & 1 & 0.9 & 1 & I \\ 1 & 0 & 0 & 0.3 & I & 0 \\ 0.2 & 0.3 & 0 & 0.2 & I & 0 \\ 0.9 & 0.5 & 0 & 0 & 1 & 0.9 \\ 1 & 1 & 0.8 & I & 0 & I \\ I & 0 & 0.2 & 0.9 & I & 0 \end{bmatrix}$$

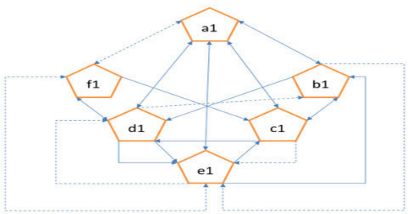

Figure 3: Neutrosophic, neutrosophied adjacency matrix and the means of the extreme values corresponding to the NCM.

$$N\,(E) = \begin{bmatrix} 0 & 1 & 1 & 0.9 & 1 & I \\ 1 & 0 & 0 & 0.3 & I & 0 \\ 0.2 & 0.3 & 0 & 0.2 & I & 0 \\ 0.9 & 0.5 & 0 & 0 & 1 & 0.9 \\ 1 & 1 & 0.8 & I & 0 & I \\ I & 0 & 0.2 & 0.9 & I & 0 \end{bmatrix} \qquad E = \begin{bmatrix} 0 & 1 & 1 & 0.9 & 1 & 0.5 \\ 1 & 0 & 0 & 0.3 & 0.5 & 0 \\ 0.2 & 0.3 & 0 & 0.2 & 0.5 & 0 \\ 0.9 & 0.5 & 0 & 0 & 1 & 0.9 \\ 1 & 1 & 0.8 & 0.5 & 0 & 0.5 \\ 0.5 & 0 & 0.2 & 0.9 & 0.5 & 0 \end{bmatrix}$$

	td
a1	1,81
e1	1,65
d1	1,38
b1	1,11
f1	0,90
c1	0,79

According to the above-explained, we can reach the following partial conclusion:

- When a1 is activated, all other nodes are activated, which means that the psychological state will cause an influence on the other problems identified in the other vertices, it will have a positive influence due to the causal relationship with the positive indices (if p1 increases then e1, d1, b1, f1, c1 will increase in the same way).
- The relationships with a1 and the rest of the nodes are bidirectional; therefore, the causal relationship is confirmed in both directions and magnitude.
- If a1 is activated, it can be verified that there is strong causal relationship also with the rest of the nodes, but not in both directions, unlike c1.
- A relationship of indeterminacy is observed from f1 to e1, e1 to b1.

Result: The order of importance of the factors will be as follows a_1≻e_1≻d_1≻b_1≻f_1≻c1
Priority factor to be analyzed: Mitigate the possible psychological effects of the minor under custody.

Situation II

$$N(E) = \begin{bmatrix} 0 & 0 & 1 & I & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 0.2 & 1 \\ I & 1 & 1 & 0 & 1 & I \\ 0 & 0 & 0.8 & 1 & 0 & 1 \\ 0 & 1 & 0.2 & 1 & 1 & 0 \end{bmatrix}$$

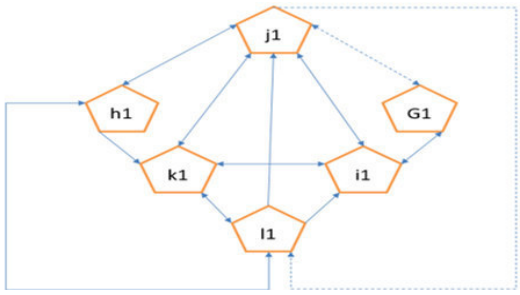

Figure 4: Neutrosophic, de-neutrosophied adjacency matrix and the means of the extreme values corresponding to the NCM.

$$N(E) = \begin{bmatrix} 0 & 0 & 1 & I & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 0.2 & 1 \\ I & 1 & 1 & 0 & 1 & I \\ 0 & 0 & 0.8 & 1 & 0 & 1 \\ 0 & 1 & 0.2 & 1 & 1 & 0 \end{bmatrix} \qquad E = \begin{bmatrix} 0 & 0 & 1 & 0.5 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 0.2 & 1 \\ 0.5 & 1 & 1 & 0 & 1 & 0.5 \\ 0 & 0 & 0.8 & 1 & 0 & 1 \\ 0 & 1 & 0.2 & 1 & 1 & 0 \end{bmatrix}$$

	td
j1	1,88
k1	1,33
l1	1,26
i1	1,15
h1	1,11
g1	0,66

Based on the above-mentioned, we can reach the following partial conclusion:

- When j1 is activated, all other nodes are activated, which means that an ideal family environment will collaborate to a state of comfort in the child. It will have an optimistic influence due to the causal relationship with positive indices (if j1 increases then k1, l1, i1, h1, g1 will increase in the same way).
- The relationships with p1 and nodes h1, k1, i1 are bidirectional, therefore, the causal relationship is confirmed in both directions and magnitude, except from node l1 to j1
- If j1 is activated, it can be verified that there is a strong causal relationship also with the rest of the nodes, but not in both directions, unlike l1.
- A relationship of indeterminacy is observed from h1 to l1 and from j1 to l1.

Result: The order of importance of the factors will be the following j_1≻k_1≻l_1≻i_1≻h_1≻g_1
Priority factor to analyze: Create a pleasant family environment that contributes to the child or adolescent's development in the absence of their parents.

5. Discussion of the case

Strategies to consider:

- From the minor's perspective (Situation I), the judges are focused on mitigating the psychological effects that may arise from the custody provided.
- From the guardian's perspective (situation II) an adequate family environment must be created to meet the necessary conditions in accordance with the Childhood and Adolescence Code.

Therefore, as a strategy to consider:

- No.1: Create a family environment, as a fundamental space conditioned to provide all the warmth of home to mitigate possible psychological disorders generated by the effect of the abandonment of their parents.

- No.2: Supervise by the competent judicial entities that the family environment and the psychological state of the minor are in harmony and that it positively influences the normal development of children and adolescents, to make up for the lack of their parents.

Conclusions

After developing this research, the following conclusions were reached:

- The indeterminacy is incorporated into modeling the causal relationships between the factors, where neutrosophic science is an active part of decision-making. It is mainly because it is a very subjective process where uncertainty reaches all decision levels. That is why neutrosophic cognitive maps are a useful tool for the analysis of this type of social problem.
- Children under custody are prone to child abuse, which affects their self-esteem. These, when punished, have sequels that constitute notorious problems that are transferred from year to year and can lead to unpleasant outcomes if they are not appropriately treated.
- Most of the children under custody live abandoned, which causes them to suffer psychological disorders in longing for their parents. That is why the tutors and the judges agree that an ideal family environment must be created so that the minor feel in a state of comfort and security as a result of due process.
- Most children do not remember their parents; this is because they were left under the care of other people at an early age, which directly affects the behavior of children and adolescents. This verifies that the priority factor in both situations is focused on mitigating possible disorders in the child's psychological state and improving the comfort, safety, and warmth provided by a healthy family environment in childhood and adolescence.

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Neutrosociology for Analyzing Public Procurement in Ecuador around the Health Emergency

Milena Elizabeth Álvarez Tapia[1], Marina Méndez Cabrita[2], Diego Fernando Coka Flores[3] and Cindy Gabriela Rodríguez Tapia[4]

[1] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.milenaalvarez@uniandes.edu.ec
[2] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.carmenmmc56@uniandes.edu.ec
[3] Director de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.diegocoka@uniandes.edu.ec
[4] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.cindyrodriguez@uniandes.edu.ec

Abstract. This research aims to carry out a sociological study on the causes of acts of corruption in public procurement around the health emergency imposed by COVID 19 in Ecuador regarding the role of the state in its prevention and the need for legal reform. For this purpose, we propose using Neutrosophic Sociology or Neutrosociology, to use an indeterminate membership function that allows modeling the unawareness, doubts, and contradictions that may exist in the answers of any human being. The results obtained showed that the city of Guayaquil identifies as the main cause of acts of corruption in public procurement during the COVID 19 health emergency in the country: the interference of public servants as partners in different companies supply medical supplies. However, it does not recognize as a possible cause the existence of legal gaps in the public procurement norm.

Keywords: Neutrosociology, survey, single-valued neutrosophic sets, public procurement, corruption.

1 Introduction

Public procurement has emerged since the beginning of the 20th century in Latin America. Ecuador, in the face of the systematic evolution of the world economy, has carried out reforms in public procurement, under the constitutionality of the principles and rights in terms of good living, adapting to public purchases of the state and of the contracting parties as natural and/or legal persons [1-3].

Public procurement includes the state budget for the effective management of public funds. Jose Luis Piñuel [1] In its publication, *The Communication Directorate* considers that the budget is the study of costs that covers a service or a product, presented with the need of interested people, for example, when buying rooms or products for a specific use [1].

According to those theoretical assumptions, the author Carmen Chinchilla [1] states that public procurement is a legal regime, including the conclusion of contracts in public administration in compliance with transparent procedures. Public entities contract obligations and duties through the contracting of the state between natural and legal persons, formalizing the relationship of public dependency between the state and the citizens in benefit of the rights and principles of good living.

As a way to attend and mitigate the adequate contingency caused by Covid 19, the National Public Procurement Service (SERCOP) reported in an official statement that the declaration of a state of emergency between the contracting entities will be executed according to the regulations that frame the state of exception, for its regulation and effective control [1].

According to the National Service for Risk and Emergency Management, the state of health emergency was declared on March 11, 2020, through ministerial agreement No. 00126-2020 issued by the Ministry of Public Health. During the state of emergency, public contracts were made to prevent the spread of Covid-19. At the end of the same year, the State Comptroller General's Office sent a report indicating that there were irregularities in at least 179 of the contracts that were executed in the health system.

The newspaper *El Comercio* [1] published under the title "Surcharges in contracts investigated by the State Comptroller General", the surcharges in medical supplies and biosafety instruments, where the purchase was detailed of 800 boxes of N95 masks at 159 USD each. Which gave the value of 127,200 USD to this State contract, in addition to 1,500 biosafety protective suits at USD 69.90 each, valuing the contract at a USD 104,850 difference in which its commercial sale was USD 20 per unit.

Among other relevant data, the newspaper El Universo [1] also circulated key statistics and mentioned that the Director of the National Public Procurement Service, Juan Aguirre, stated that between the first six months of 2020, when the country registered 2,230 million USD, before the declaration of the health emergency, complaints were reported on alleged surcharges for medical supplies.

In this context, the Director of the SERCOP requested amendments to the regulations of the Organic Law of the National System of Public Procurement, to maintain strict observance of transparency, in the face of contracting exposed as fraudulent, generally due to overpricing between State entities and their contracting parties. These facts, he argued, hinder rationality in the face of the state of emergency, forging an improper and illegal use that violates the rights of good living endorsed in the Constitution of Ecuador [1].

The emerging situation, which has frozen attitudes for the good of society, has been completely violated in Ecuador since the contracting system has perished without justification due to corruption, overpricing and attrition of the state. Susana Roa Chejin confronts the pandemic with corruption and tells about how much the cases of corruption in public procurement cost the country during the health crisis in one of her newspaper articles in the newspaper GK titled "The operation that went wrong" [1].

Given these statements, the Economic Regime Commission showed alarming figures that demonstrate the bleeding of the State budget for corruption purposes, where it was determined that in the special regime from January to June 2020; this figure reckoned 195 million USD (Ministry of Economy and Finance, 2020).

Likewise, under a common and competitive regime, 1,580 million dollars were contracted where a reduction of 9.7% was registered, taking into account that in the last six months there had been a consolidation of $ 2,230 million, as clarified by SERCOP in which 280 daily contests enter the system, of which 190 have been awarded [1].

Considering the abovementioned, it was determined that the public markets around the health crisis were affected, taking into account the guarantee of rights and principles that form the right to a dignified life, the right to equal conditions without discrimination some, to contractual freedom in honor of the effectiveness of transparency and good reputation.

This research aims to carry out a sociological study on the causes of acts of corruption in public procurement around the COVID 19 health emergency in Ecuador regarding the role of the state in its prevention and the need for legal reform.

For this purpose, we propose the use of Neutrosophic Sociology or Neutrosociology, which is the study of sociology using neutrosophic scientific methods [14]. It is argued that sociology data can be vague, incomplete, contradictory, hybrid, biased, ignorant, redundant, superfluous, meaningless, ambiguous, and unclear, among others. In this new approach to the study of sociology, the concepts are represented in the form of <A>, which is the primary concept, <Anti A>, which is the opposite and <Neut A>, which represents those that are neither <A> nor <Anti A>. The data collected in the form of a neutrosophic set allow the respondent to express himself with greater precision and also with greater indeterminacy about his true thoughts and feelings, due to the indeterminate membership function [4-22], which allows modeling unawareness, doubts, contradictions, etc. that can exist in the answers of any human being [7, 11].

2 Materials and methods

This section contains the main concepts related to neutrosophy, neutrosophic statistics and Neutrosociology that we use in this paper. The method used for the sociologic study is also described.

Definition 1: ([1]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow\ ]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

Definition 2:
([1]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate, and falseness of x in A. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Neutrosophy studies triads, where if <A> is an item or a concept then the triad is (<A>, <neut A>, <anti A>),[23, 24]. Neutrosociology is based on triads. E.g., the concept A = imperialist society, has an antiA = communist society, and neutA = neutral society.

Neutrosophic Statistics extends the classical statistics, such that we deal with set values rather than crisp values, [25]. Neutrosophic Statistics can be used as a quantitative research method in sociology for testing social hypotheses.

Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics.

Neutrosophic Inferential Statistics consists of methods that permit the generalization from a neutrosophic sampling to a population from which the sample was selected.

Neutrosophic Data is the data that contains some indeterminacy.

The *univariate neutrosophic data* is neutrosophic data that consists of observations on a neutrosophic single attribute.

A *Neutrosophic Frequency Distribution* is a table displaying the categories, frequencies, and relative frequencies with some indeterminacies. Most often, indeterminacies occur due to imprecise, incomplete, or unknown data related to frequency. Therefore, relative frequency becomes imprecise, incomplete, or unknown too.

Neutrosophic Survey Results are survey results that contain some indeterminacy.

In this study, we deal with indeterminacy based on single-valued neutrosophic sets and Neutrosociology concepts. The method consists of the following:

First, the primary concept to be measured is determined [1] and the social group in which the study will be carried out. Next, the questionnaire is designed to have information about the triad (<A>, <neut A>, <anti A>). Each question must have three variants, one of them related to one of the three elements of the triad. Ambiguous or vague answers such as "I don't know", "It is difficult to determine", etc., are associated with <neut A>.

The interviewer points out that the answers can be given in the form of intervals if it makes sense or if the respondent considers that it corresponds better with their opinions. In addition, questionnaires can include answers in the form of linguistic values.

In short, the respondent should feel free to write what they think about the topic of the questions.

For the processing of the results of the surveys, the following procedure will be carried out.

Let us denote $\mathrm{X_j} = \{\mathrm{x_i^j}\}_{\mathrm{i=1}}^{\mathrm{m_j}}\mathrm{q_j}$ as the set of possible answers to the question (j = 1, 2,…, n).

The frequency of every possible answer is calculated for every element of the triad, let us call them $\mathrm{f}_{<A>}(\mathrm{x_i^j})$, $\mathrm{f}_{<neut\ A>}(\mathrm{x_i^j})$, and $\mathrm{f}_{<anti\ A>}(\mathrm{x_i^j})$.x

If N is the size of the social group to study, we calculate the following probabilities:

$$p_{<A>}(\mathrm{x_i^j}) = \frac{\mathrm{f}_{<A>}(\mathrm{x_i^j})}{\mathrm{N}} \tag{2}$$

$$p_{<neut\ A>}(\mathrm{x_i^j}) = \frac{\mathrm{f}_{<neut\ A>}(\mathrm{x_i^j})}{\mathrm{N}} \tag{3}$$

$$p_{<anti\ A>}(\mathrm{x_i^j}) = \frac{\mathrm{f}_{<anti\ A>}(\mathrm{x_i^j})}{\mathrm{N}} \tag{4}$$

The properties of, $p_{<A>}$, and are the following:$(\mathrm{x_i^j})p_{<neut\ A>}(\mathrm{x_i^j})p_{<anti\ A>}(\mathrm{x_i^j})$

- For every $\mathrm{X_j}$ then $p_{<A>}(\mathrm{x_i^j}), p_{<neut\ A>}(\mathrm{x_i^j}), p_{<anti\ A>}(\mathrm{x_i^j}) \in [0, 1]$
- For every $\mathrm{X_j}$ then.$\sum_{i=1}^{\mathrm{m_j}}\left(p_{<A>}(\mathrm{x_i^j}) + p_{<anti\ A>}(\mathrm{x_i^j})\right) \leq 1$
- For every $\mathrm{X_j}$ then.$\sum_{i=1}^{\mathrm{m_j}}\left(p_{<A>}(\mathrm{x_i^j}) + p_{<neut\ A>}(\mathrm{x_i^j}) + p_{<anti\ A>}(\mathrm{x_i^j})\right) \geq 1$
- Let us remark that the probabilities $p_{<A>}(\mathrm{x_i^j})$ and $p_{<anti\ A>}(\mathrm{x_i^j})$ should satisfy the property of subjective probability approach, [26], whereas, when $p_{<neut\ A>}(\mathrm{x_i^j})$ is included then the sum can exceed the unity. This is because of $p_{<neut\ A>}(\mathrm{x_i^j})$ and the others two can have common answers for some individuals.
- Now, for every concept A we have a single-valued neutrosophic set defined as follows:

$$A = \left\{\langle \mathrm{x}, \min_{\mathrm{j}}\left(p_{<A>}(\mathrm{x}_{\mathrm{i}}^{\mathrm{j}})\right), \max_{\mathrm{j}}\left(p_{<neut\,A>}(\mathrm{x}_{\mathrm{i}}^{\mathrm{j}})\right), \max_{\mathrm{j}}\left(p_{<anti\,A>}(\mathrm{x}_{\mathrm{i}}^{\mathrm{j}})\right)\rangle : \mathrm{x} \in \Pi_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{X}_{\mathrm{j}}\right\} \quad (5)$$

– Let us note that Π is the Cartesian product and the set A contains the definition of n-norm, [27]. Also, let us remark we are using neutrosophic statistics with neutrosophic data.
– The single-valued neutrosophic set A can be de-neutrosophied to a crisp set where the elements of the triad are reduced to numerical values, using the scoring function or a precision index.
– A scoring function $\mathrm{s}: [0, 1]^3 \rightarrow [0, 3]$ is defined in Equation 6, it is an adapted scoring function since the one defined in [28].

$$\mathrm{s}(\mathrm{a}) = 2 + \mathrm{T} - \mathrm{F} - \mathrm{I} \quad (6)$$

– Where a is an SVNN with values (T, I, F).
– The definition of the precision index is given in Equation 7.

$$a(\mathrm{a}) = \mathrm{T} - \mathrm{F} \quad (7)$$

– Where $a: [0, 1]^3 \rightarrow [-1,\ 1]$.

3 Survey design and information processing

The technique used is the survey, since it allows obtaining information on the topic of interest provided by a considerable number of people through a questionnaire. The primary concept we want to measure is, A = "Cause of corruption in public procurement during the health emergency of COVID 19 in Ecuador", the antiA = "Not cause of corruption in public procurement during the health emergency of COVID 19 in Ecuador ", and the neut A =" Cannot be determined as cause".

The questionnaire applied consists of the following statement on the causes of acts of corruption in public procurement in Ecuador around the health emergency:

1. The acts of corruption that took place in public procurement in Ecuador during the health emergency were caused by:
   a) Lack of control of SERCOP as a regulatory entity.
   b) Belated action of SERCOP as a regulatory entity.
   c) Existence of legal gaps in the public procurement regulation.
   d) Existence of monopolization of public contracts for certain companies.
   e) The interference of public servants as partners in different companies that supply medical supplies.

The respondent must answer which ones he considers true, indeterminate, or false. The social group to be analyzed is the population of the city of Guayaquil, a canton that belongs to the province of Guayas.
According to the Ecuadorian Institute of Statistics and Censuses (INEC), the population of the city of Guayaquil according to the census carried out in November 2010 is 2,350,915 inhabitants; and has a growth rate of 2.5% on average each year, with a projection for the year 2021 of 2`720,000 according to ECLAC sources. Of this figure, approximately 1,673,851 should be available to survey since their ages range between 18 and 65 years, which represent 71.2% of the inhabitants.

For the calculation of the size of the population sample to be surveyed, equation (8) was used:

$$n = \frac{N * {Z_\alpha}^2 * p * q}{d^2 * (N-1) + {Z_\alpha}^2 * p * q} \quad (8)$$

Where:
n = Size of the required sample.
Z = confidence level which is the probability that a confidence interval includes the 95% population parameter (standard value of 1.96).
p = Probability of success. (95% = 0.95)
q = Probability of failure. (5% = 0.05)
d = Maximum level of error used. (3% = 0.03)
N = Total population.
For the processing of the results of the applied survey, we used the method described in the previous section:

4 Results

According to the result of the sample size formula (Equation 8) with a confidence level of 95% and a maximum error of 3%, a total of 203 people were selected using a Simple Random Sampling. The purpose of the study and how to answer the questionnaire was explained to these people.

The results of the applied survey are shown in Table 1.

i	Answer	*i*	Answer	*i*	Answer	*i*	Answer
1	({e}, {a, b}, {d, c})	52	({e, d}, {b}, {a, c})	103	({a, d}, {b, c}, {e})	154	({d, e}, {a}, {c, b})
2	({d, e}, {a, c}, {b})	53	({e, a}, {b, d}, {c})	104	({d, e}, {c}, {a, b})	155	({a, c}, {b, e}, {d})
3	({d, e}, {a, b}, {c})	54	({a, e}, {b, d}, {c})	105	({a, e}, {d, b}, {c})	156	({a, e}, {b, c}, {d})
4	({e}, {a, c}, {b, d})	55	({a, e}, {c, d}, {b})	106	({a, e}, {b, c}, {d})	157	({a, e}, {, d}, {c, b})
5	({a, e}, {d, c}, {, b})	56	({c, d}, {a, e}, {b})	107	({c, d}, {e, b}, {a})	158	({a, e}, {d, c}, {b})
6	({a, d}, {b, e}, {c})	57	({d, e}, {b}, {c, a})	108	({d, e}, {b}, {a, c})	159	({a, d}, {e, b}, {c})
7	({a, e}, {c, d}, {b})	58	({d, e}, {a, c}, {b})	109	({a, e}, {d, b}, {c})	160	({b, e}, {d}, {a, c})
8	({a, e}, {b, b}, {c})	59	({d, e}, {b}, {a, c})	110	({b, e}, {d}, {a, c})	161	({b, c}, {a, e}, {d})
9	({a, d}, {b, e}, {c})	60	({d, e}, {d}, {a, c})	111	({d, e}, {c}, {a, b})	162	({e}, {c, b}, {a, d})
10	({e, d}, {a, b}, {c})	61	({d, e}, {b}, {a, c})	112	({a, e}, {b, c}, {d})	163	({d, e}, {b, d}, {b})
11	({a, e}, {c, d}, {b})	62	({d, e}, {a, c}, {b})	113	({a, e}, {d}, {b, c})	164	({c, a}, {d, e}, {b})
12	({a, d}, {e, b}, {c})	63	({e, d}, {b}, {a, c})	114	({a, e}, {c}, {b, d})	165	({e, a}, {d, b}, {c})
13	({d, e}, {a, c}, {b})	64	({d, e}, {a, b}, {c})	115	({b, d}, {c, e}, {a})	166	({a, d}, {e}, {b, c})
14	({d, e}, {a, b}, {c})	65	({d, e}, {b, c}, {a})	116	({b, d}, {e, c}, {a})	167	({a, e}, {b}, {d, c})
15	({e, d}, {a, b}, {c})	66	({d, e}, {a}, {b, c})	117	({d, e}, {c, a}, {b})	168	({a, e}, {c, b}, {d})
16	({e, d}, {c, e}, {b})	67	({e, a}, {d, b}, {c})	118	({a, d}, {e}, {c, b})	169	({e, d}, {a}, {b, c})
17	({d}, {a, e}, {b, c})	68	({a, e}, {b, d}, {c})	119	({e}, {d, b}, {a, c})	170	({e, d}, {a}, {b, c})
18	({a, e}, {c, d}, {b})	69	({d, e}, {c, b}, {a})	120	({d, e}, {a}, {b, c})	171	({a, e}, {d}, {b, c})
19	({d, e}, {b, c}, {a})	70	({d, e}, {b}, {a, c})	121	({d, c}, {e}, {a, b})	172	({d, e}, {a}, {b, c})
20	({d, e}, {a, b}, {c})	71	({b, e}, {b}, {c, c})	122	({b, e}, {d}, {a, c})	173	({a, d}, {e, c}, {b})
21	({e, d}, {b, c}, {a})	72	({a, e}, {b, d}, {c})	123	({a, e}, {b}, {c, d})	174	({a, e}, {d, b}, {c})
22	({a, d}, {e, c}, {b})	73	({e, d}, {b, a}, {c})	124	({b}, {c, e}, {a, d})	175	({a}, {d, e}, {b, c})
23	({d, e}, {a, b}, {c})	74	({a, d}, {e, b}, {c})	125	({a, e}, {b, d}, {c})	176	({a, e}, {b, d}, {c})
24	({d, e}, {b, a}, {c})	75	({d, e}, {a, b}, {c})	126	({d}, {b, c}, {a, e})	177	({a, d}, {e, b}, {c})
25	({d, e}, {b, c}, {a})	76	({e, d}, {a, b}, {c})	127	({a, e}, {d, c}, {b})	178	({e, d}, {a}, {b, c})
26	({d, e}, {c}, {a, b})	77	({e, d}, {b}, {a, c})	128	({c, e}, {a, d}, {b})	179	({a, e}, {c, b}, {e})
27	({d, a}, {e, b}, {, c})	78	({d, e}, {c}, {a, b})	129	({a, d}, {e, c}, {b})	180	({a, c}, {e}, {d})
28	({b, e}, {d, c}, {a})	79	({e, d}, {a, b}, {c})	130	({e, c}, {b, d}, {a})	181	({d, e}, {b}, {c})
29	({a, e}, {b, d}, {c})	80	({e, d}, {a, b}, {c})	131	({a, e}, {b, c}, {d})	182	({a B C D E})
30	({a, d}, {c, e}, {, b})	81	({d, e}, {a, b}, {c})	132	({a, e}, {b, d}, {c})	183	({a, d}, {b, e}, {c})
31	({d, e}, {c}, {a, b})	82	({d, e}, {c}, {a, b})	133	({c, e}, {a, b}, {d})	184	({a}, {e, c}, {b, d})
32	({e, d}, {a, b}, {c})	83	({e, d}, {a, c}, {b})	134	({a, e}, {d, b}, {c})	185	({e, d}, {a, c}, {b})
33	({d, e}, {b}, {a, c})	84	({d, e}, {c, a}, {b})	135	({e, a}, {b, c}, {d})	186	({a, e}, {b, d}, {c})
34	({d, e}, {b}, {a, c})	85	({b, b}, {b}, {c, c})	136	({a, e}, {c, d}, {b})	187	({a, e}, {a, c}, {c})
35	({d, e}, {a, b}, {, c})	86	({d, e}, {, b}, {c, a})	137	({a, b}, {d}, {c, e})	188	({d, a}, {e}, {b, c})
36	({c, e}, {a, b}, {b})	87	({d, e}, {a}, {b, c})	138	({a, d}, {b, e}, {c})	189	({a, e}, {d, b}, {c})
37	({e, d}, {a, b}, {c})	88	({a, d}, {b, e}, {c})	139	({c, e}, {d, c}, {a})	190	({a, e}, {d, b}, {c})
38	({b, e}, {d, a}, {c})	89	({b, c}, {e}, {a, d})	140	({d, e}, {a, c}, {b})	191	({d, e}, {b, a}, {c})
39	({e, a}, {b, c}, {d})	90	({d}, {b, e}, {a, c})	141	({e, d}, {a, b}, {c})	192	({a, d}, {e, b}, {c})
40	({d, c}, {b, e}, {a})	91	({d, a}, {e}, {b, c})	142	({d, e}, {b, c}, {a})	193	({d, e}, {a, b}, {c})
41	({a, e}, {d, b}, {c})	92	({d, e}, {a, c}, {b})	143	({b, d}, {c}, {a, e})	194	({a, c}, {e, b}, {d})
42	({d, e}, {c, b}, {a})	93	({a, e}, {c, b}, {d})	144	({a, e}, {c, b}, {d})	195	({a, e}, {d, b}, {c})
43	({a, e}, {d, c}, {b})	94	({e, a}, {b, c}, {d})	145	({d, e}, {a, c}, {b})	196	({a, d}, {c, e}, {b})
44	({c, e}, {b, a}, {c})	95	({c, e}, {b, d}, {a})	146	({a, c}, {d, b}, {e})	197	({a, e}, {b, d}, {c})
45	({d, e}, {b}, {b, c})	96	({b, e}, {d, a}, {c})	147	({b, d}, {e, c}, {a})	198	({a, e}, {b, d}, {c})
46	({a, e}, {c, d}, {b})	97	({d, e}, {b}, {a, c})	148	({b, d}, {a, c}, {e})	199	({a, e}, {b, d}, {c})

47	({a, e}, {d, c}, {b})	98	({a, d}, {c, e}, {b})	149	({b, e}, {a, d}, {c})	200	({a, d}, {c, e}, {b})
48	({d, e}, {a, b}, {c})	99	({b, e}, {d, a}, {c})	150	({e, c}, {b, d}, {a})	201	({a, e}, {b, d}, {c})
49	({d, e}, {b}, {a, c})	100	({a, e}, {b, d}, {c})	151	({a, e}, {b}, {d, c})	202	({d, a}, {e, b}, {c})
50	({a, d}, {e}, {b, c})	101	({a, d}, {b, e}, {c})	152	({c, a}, {e}, {b, d})	203	({a, e}, {b, d}, {c})
51	({a, d}, {e}, {b, c})	102	({d, e}, {a}, {c, b})	153	({a, e}, {d}, {b, c})		

Table 1: Results of the applied survey

Table 2 summarizes the frequencies of each answer.

Answers X_1	$f_{<A>}(x_i^1)$	$f_{<neut\ A>}(x_i^1)$,	$f_{<anti\ A>}(x_i^1)$.
a	94	56	48
b	21	117	68
c	20	70	117
d	111	60	27
e	150	46	8

Table 2: Frequencies of the answers

From equations 2, 3, and 4, the probabilities were obtained. The truthfulness, indeterminacy, and falseness membership functions are depicted in Figure 1.

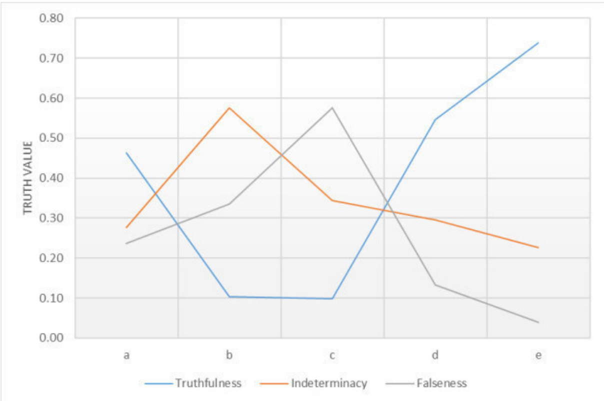

Figure 1. Truthfulness, indeterminacy and falseness membership functions of the concept "Cause of acts of corruption in public procurement during the health emergency of COVID 19 in Ecuador".

It can be seen in the figure that the highest truth values are reached by the causes listed in sections e), d) and a), in that order, the value of e) being much higher than the rest (approximately 72%). The highest falsehood value was reached by the cause listed in section c) and the greatest uncertainty was presented to assign section b) (both close to 58%).

Through equation 5, these functions are de-neutrosophicated to obtain a single probability function of the concept "Cause of acts of corruption in public procurement during the health emergency of COVID 19 in Ecuador". Figure 2 shows a chart of the scoring function.

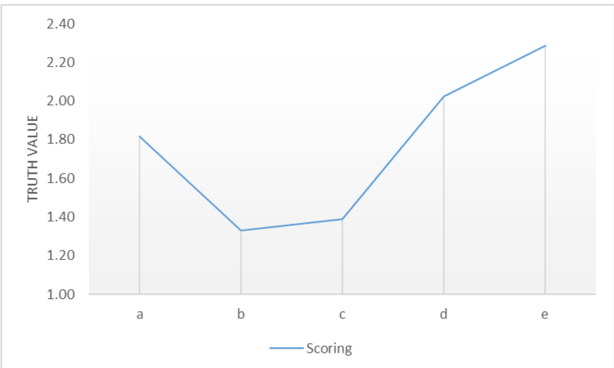

Figure 2: Scoring function of the single-valued neutrosophic set in Figure 1

It can be summarized that, according to the results obtained in this study, the main cause recognized by the population of acts of corruption in public procurement in the country during the health emergency is "interference by public servants as partners in different supplier companies of medical supplies" (e). The causes were also identified very frequently, although to a lesser extent: "lack of control of SERCOP as a regulatory entity" (a) and "the existence of monopolization of public contracts for certain companies" (d).

It is also interesting to note that the population does not recognize as a possible cause of corruption acts the existence of legal gaps in the public procurement norm and that we cannot affirm with certainty that SERCOP's late action is or is not a cause of corruption in public procurement during the health emergency.

Conclusions

During the state of health emergency, the public procurement processes in Ecuador were affected by acts of corruption in which the violation mainly corresponds to the lack of transparency as a universal principle of acquisition of accountability between the state and society.

Through this sociological study, it was possible to determine that the population of the city of Guayaquil identifies as the main cause of acts of corruption in public procurement during the health emergency imposed by COVID 19 in the country, *the interference of public servants as partners in different companies supplying medical supplies*. However, does not recognize as a possible cause *the existence of legal gaps in the public procurement regulation*.

The Neutrosociology method used allowed respondents to express their thoughts and feelings more accurately since indeterminacy is considered and a membership function independent of falsehood.

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Plithogenic Logic for Determination of Strategic Solutions for Ergonomic Occupational Health Risks

Gustavo Eduardo Fernández Villacrés[1], Fausto Alberto Viscaino Naranjo[2] and Roberto Rolando López López[3]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.faustoviscaino@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.faustoviscaino@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: capostgrado@uniandes.edu.ec

Abstract. This research aims to evaluate the knowledge about the incidence of ergonomic risks in the occupational health of the teachers of the UNIANDES University. Our starting point was the problem related to many physical affectations suffered by teachers and registered in the Institution's medical department system. Then they were scientifically based on topics such as occupational health, occupational risks, ergonomics, and technological elements. Methodologically, we worked with a population of 478 teachers from which a sample of 218 people was selected. Digital survey through the Forms application and the AHP Saaty method were the investigative techniques we used. Among the main findings, it can be noted that the vast majority of those investigated spend an average of 10 hours in front of the computer and are unaware of aspects related to ergonomics and its impact on occupational health. Finally, we make a proposal related to the use of technological elements to generate knowledge about the occupational risks generated by ergonomic aspects.

Keywords: Ergonomics, occupational health, teachers, AHP Saaty, plithogenic.

1. Introduction

The technological advance achieved in the 21st century has transformed the work aspect of all people. Today almost all people do their work supported by computer technology. In a preliminary investigation before this research, we found some other projects that serve as antecedent; among them, we would like to highlight the one developed by Magister Llamo Corrales Yzela Marelin with the title "Ergonomic risk in nursing graduates of the Emergency service of Las Mercedes Regional Teaching Hospital 2016", presented in 2017, which analyzes the existing problems at Las Mercedes Regional Teaching Hospital in the city of Pimentel, Peru.

In this health center, most of the nursing staff are exposed to ergonomic risks due to the various functions they perform; they are also exposed to occupational diseases, whose onset is slow and overlapping. These arise as a result of repeated occupational exposures or even just being in the workplace, but they can have a long latency period. Many of these diseases are progressive, irreversible, and severe, yet many are predictable [1].

The project initially develops bibliographic research on occupational hazards with ergonomic aspects. Then field research is carried out among 31 nurses. The results of this research are: the data obtained in the survey applied to the nursing staff yielded that 80% of the personnel knows ergonomic risks to which they are exposed; 77.42% do not take breaks during their shift; 83.87% of nurses maintain postures or movements that last more than one hour during their shift; and a 70.97% work uninterruptedly for more than 36 hours.

The Regional Autonomous University of the Andes "UNIANDES" is a Higher Education Center, a private and secular law entity, with legal status and administrative and financial autonomy, which offers integral training to its students, without distinction of sex, race, religion, or politics; therefore, the registration of the students depends only on their intellectual abilities. The presence of UNIANDES is based on the experience of more than 20 years in Ecuadorian private education. It was created on February 20, 1997, by Law of the Republic. The University "UNIANDES" has its headquarters in the city of Ambato; its extensions operate in the cities of: Tulcán, Ibarra, Santo Domingo, Quevedo, Babahoyo, Riobamba and Puyo. It currently has 10,000 students and approximately 500 teachers, both undergraduate and graduate [2].

Based on visits made to the Institution's medical department, we obtained information confirming that many teachers declare that they have back pain due to poor position during work, it is also stated that there are eye discomfort and ailments at the level of their hands. All this leads to thinking that UNIANDES teachers are doomed to occupational health problems due to ergonomic difficulties [3]. Based on this criterion, the problem can be formulated in the following terms: how to reduce the ergonomic risks that affect teachers' occupational health at the

Autonomous Regional University of the Andes?

To solve the formulated problem, we proceed to define a research project whose general objective is "to structure a set of strategies that allow reducing the ergonomic risks that affect the occupational health of teachers of the Autonomous Regional University of the Andes."

The multi-criteria decision method Analytic Hierarchy Process will be applied to achieve this objective, as exposed by Tomás Saaty (hereinafter AHP Saaty) in its version of plithogenic logic. The reason why this technique and its fusion to plithogenic logic are chosen is the nature of the phenomenon to be analyzed. Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and mergers of multiple contradictory and/or neutral and/or non-contradictory previous entities. Plithogeny advocates the connections and the unification of theories and ideas in varied fields of science such as social and technical sciences, theories of arts and letters, etc.[4, 5].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a type of opposites, Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites. The plithogenic set extends the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set, and has multiple scientific applications[4].

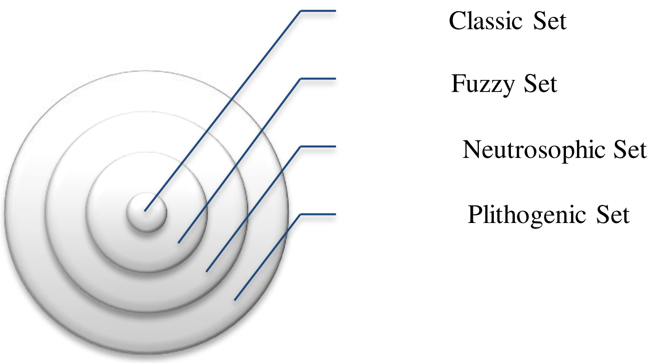

Figure 1. Logic of the plithogenic set.

To achieve the proposed general objective, the following specific objectives are required:

1. Scientifically substantiate the theoretical aspects related to occupational health, ergonomics, occupational hazards and technology.
2. Diagnose the different occupational risks currently suffered by teachers of the Autonomous Regional University of The Andes.
3. Expose solution strategies:
   a. Identify solution pathways
   b. Determine the order of preference in the application of these solutions.

Hereinafter it is structured as follows:

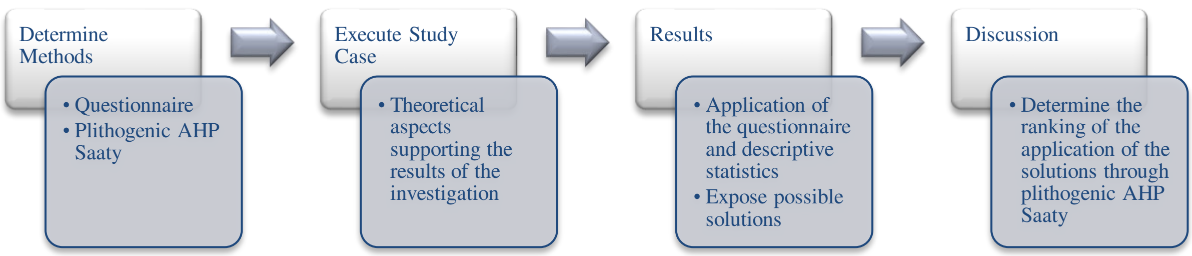

Figure 2. Sequence of the investigation.

In this work, we formulated and defend the idea that: "With the hierarchical ranking of the solutions determined according to their possibility of implementation in the short term, the ergonomic risks of UNIANDES teachers can be reduced and thus achieve the improvement of their occupational health in a short period".

2 Methods

The research was developed based on the following methods:

- Applied research methodology: qualitative-quantitative.

  The qualitative aspects of occupational hazards were related to ergonomic aspects obtained through observation.

  The quantitative was achieved based on the numerical tabulation of the surveys.

- Type of investigation:

  Bibliographic: to elaborate the theoretical foundation,

  Field: developed in situ where the manifestations of the problem took place.

- Theoretical research methods:

  Analytical-synthetic that served for the elaboration of the theoretical foundation.

  Inductive-deductive is used to induce a particular answer and deduce it for a general scope.

- Empirical research methods:

  Brainstorming, Direct observation, Interviews

  Questionnaires: A population of 478 teachers was stipulated for this research, from which a random sample of 218 people was selected. The survey was carried out electronically. The questionnaire generated in Microsoft's Forms application was shared with the institutional emails of the teachers. The instrument designed was the following:

  1. About how many hours a day do you spend in front of the computer?
  2. Do you know if your working position in front of the computer is adequate?
  3. Do you know if the distance from the screen is ideal?
  4. Do you know if your work chair, your keyboard, and your mouse have a good ergonomic design?
  5. Is your current work environment comfortable?
  6. In your current work environment, are the electrical installations adequate and safe (there are no loose or crossed cables)?
  7. In the work environment at the University, were the circulation corridors spacious?
  8. Have you received training in ergonomics aspects within an occupational health improvement process?
  9. Are all the elements necessary for your work very close to your workplace (printers, computers, copiers, documents, files)?

Saaty's AHP: Multicriteria analysis is used to make a comparative judgment between projects or heterogeneous measures and in the field of evaluation [6]. The multi-criteria analysis, the selection and adaptation of the tools used to achieve the proposed objectives is substantial. Professor Saaty, a doctorate in mathematics from Yale University, created a mathematical model called the Analytic Hierarchy Process as an effective way to define measures for such elements and use them in decision-making processes [7-23]. The AHP is a theory oriented towards the decision-maker and serves to identify the best alternative according to the resources allocated. This method can be applied to situations that involve technical, economic, political, social, and cultural factors [24]. It is a scientific tool to address those aspects that are difficult to quantify, but that sometimes requires a unit of measurement and structuring of complexity [20].

The AHP approach is systemic, although it analyzes the decisions based on the hierarchical decomposition and the existing interdependencies between the sets of factors, criteria and alternatives. Saaty's AHP Methodology:

1. Prioritization of the elements of the hierarchical model (table 1)

2. Pairwise comparison of elements
3. Evaluation of the elements by assigning weights
4. Ranking of the alternatives according to the given weights
5. Synthesis
6. Sensitivity analysis

Scale	
9 Extremely most preferred	3 Moderately more preferred
7 Very powerfully preferred	1 Equally preferred
5 Powerfully most preferred	

Table 1. Saaty assessment scale (Verbal judgment rate). Source: [5]

Number of alternatives for decision n	Random Index	Number of alternatives for decision n	Random Index
3	0.58	7	1.32
4	0.9	8	1.41
5	1.12	10	1/49
6	1.24		

Table 2: Random index for the calculation of the consistency coefficient Source: [5]

In the plithogenic extension of Saaty's AHP, the basic notions of plithogenic sets will be applied as follows [4, 5, 8, 10, 12-14, 16, 17, 24-35]:

Let U be a universe of discourse, and P a non-empty set of elements, $P \subseteq U$. Let A be a non-empty set of *uni-dimensional* attributes $A = (\alpha_1, \alpha_2, \dots, \alpha_m)$, $m \geq 1$, and $\alpha \in A$ is a given attribute whose spectrum of all the possible values (or states) is the non-empty set S, where S can be a set of finite discrete, $S = (s_1, s_2, \dots, s_l)$, $1 \leq l < \infty$, or infinitely numerable set $S = \{(, s_2, \dots, s_\infty)$, or an infinitely uncountable set (continuous), $S =]a, b[$, $a < b$, where] ... [is any open, semi-open, or a closed interval set of real numbers or another set.

Let V be a non-empty subset of S, where V is the range of all attribute values needed by experts for the application. Each element $x \in P$ is characterized by the values of all attributes in $V = (v_1, v_2, \dots, v_n)$, for $n \geq 1$.

In the set of attribute values, V in general, there is a dominant attribute value determined by experts in its application. Calling an attribute value *dominant* means that it is the most important attribute value that experts are interested in.

Each attribute value $v \in V$ has a corresponding *degree of membership* $d(x, v)$ of the element x, to the set P, concerning some given criteria.

The degree of membership can be a fuzzy degree of membership, a fuzzy intuitionist degree of membership, or a neutrosophic degree of membership to the plithogenic set.

Therefore, the membership degree function of the attribute value is:

$$\forall x \in P, d: P \times V \to \mathcal{P}([0,1]^z), \tag{1}$$

Such that $d(x, v)$ is a subset of $[0,1]^z$, where $\mathcal{P}([0,1]^z)$ is the power set of $[0,1]^z$, where z = 1 (fuzzy degree of membership), z = 2 (intuitionistic fuzzy degree of membership), or z = 3 (neutrosophic degree of membership).

Let $|V| \geq 1$ be the cardinality. Let $c: V \times V \to [0,1]$ be the *attribute value contradiction degree function* between any two attribute values v_1 and v_2, denoted by $c(v_1, v_2)$, and satisfying the following axioms:

$c(v_1, v_1) = 0$, the degree of contradiction between the same attribute values is zero;

$c(v_1, v_2) = c(v_2, v_1)$, commutativity.

We can define a fuzzy attribute value contradiction degree function (c as before, we denote by c_F to distinguish it from the following two), an intuitionistic fuzzy attribute value contradiction degree function ($c_{IF} : V \times V \to [0,1]^2$), or more generally, a neutrosophic attribute value contradiction degree function ($c_N : V \times V \to [0,1]^3$), the latter one can be used to increase the complexity of the calculation, but also to increase the accuracy.

The degree of contradiction between the values of the one-dimensional attributes is mainly calculated. For multidimensional attribute values, we can divide them into their corresponding one-dimensional attribute values.

The attribute value contradiction degree function helps the plithogenic aggregation and plithogenic inclusion (partial order) operators to obtain a more accurate result.

The attribute value contradiction degree function is designed in each field where a plithogenic set is used according to the application to be solved. If ignored, the aggregations still work, but the result may lose precision.

So, (P, a, V, d, c) is called a plithogenic set

1. Where "P" is a set, "a" is an attribute (multi-dimensional in general), "V" is the range of values of the attribute, "d" is the degree of appurtenance of the attribute value of each element x to the set P for some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy appurtenance, an intuitionistic fuzzy appurtenance, or a degree of neutrosophic appurtenance, respectively, of an element x to the plithogenic set P;
2. "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.

Functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that experts need to solve.

Then, the following notation is used:

$x(d(x, V))$, where $.d(x, V) = \{d(x, v), \text{for every } v \in V\}, \forall x \in P$

The attribute value contradiction degree function is calculated between each attribute value concerning the dominant attribute value (denoted by v_D) in particular, and for other attribute values as well.

The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Rightarrow$), equivalence ($\Leftrightarrow$), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of attribute values based on a t-norm and a t-conorm.

Most plithogenic aggregation operators are linear combinations of one fuzzy t-norm (denoted by $\wedge_F$) with one fuzzy t-conorm (denoted by $\vee_F$), but nonlinear combinations can also be constructed.

If the t-norm is applied over the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then v_2 is applied over the attribute value as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2), \tag{2}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \tag{3}$$

Similarly, if the t-conorm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2), \tag{4}$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2), \tag{5}$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right), \tag{6}$$

The plithogenic neutrosophic junction is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right), \tag{7}$$

In other words, regarding what applies to membership, the opposite applies to non-membership, while in indeterminacy, the average between them is what applies.

Plithogenic neutrosophic inclusion is defined as follows:

Since the degrees of contradiction are $c(a_1, a_2) = c(a_2, a_3) = c(b_1, b_2) = c(b_2, b_3) = 0.5$, it applies $a_2 \geq [1 - c(a_1, a_2)]b_2$ or $a_2 \geq (1 - 0.5)b_2$ or $a_2 \geq 0.5b_2$, while $c(a_1, a_3) = c(b_1, b_3) = 1$.

Having $a_1 \leq b_1$ the opposite is fulfilled for $a_3 \geq b_3$, hence $(a_1, a_2, a_3) \leq_P (b_1, b_2, b_3)$ if and only if $a_1 \leq b_1$, $a_2 \geq 0.5b_2$, and $a_3 \geq b_3$.

Next, an algorithm for the resolution of this research is presented where Plithogeny will be merged with Saaty's AHP algorithm:

- Evaluate each of the criteria (solutions) by the experts, substituting the value given in the classic Saaty AHP shown in table 1 with those in table 3:

Language expression	Plithogenic number
Low significance	(0.10, 0.70, 0.80)
Equal importance	(0.30, 0.40, 0.80)

Language expression	Plithogenic number
Robust importance	(0.50, 0.40, 0.60)
Very robust significance	(0.70, 0.30, 0.10)
Absolutely significant	(0.90, 0.10, 0.10)

Table 3. Linguistic values associated with plithogenic numbers for evaluating the weight of the criteria

- Make paired decision matrix

From this moment on, expressions 2 to 8 must be applied to execute the operations of the classical algorithm with plithogenic numbers.

For the elaboration of a single decision matrix, the median of the plithogenic numbers is calculated for each combination, for all specialists. The median is calculated using the following formula:

$$\mathrm{median}_{i=1}^{m}\{PN_i\} = (\mathrm{median}_{i=1}^{m}\{T(PN_i)\}, \mathrm{median}_{i=1}^{m}\{I(PN_i)\}, \mathrm{median}_{i=1}^{m}\{F(PN_i)\}), \quad (8)$$

Where, PN_i are plithogenic numbers, $T(PN_i)$ are the true components, $I(PN_i)$are the indeterminate components and $F(PN_i)$ are the false components. In other words, Equation 8 means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components:

To compare the relationships between the quadrants, we use the following formula to fuzzy a neutrosophic number [36]:

$$\mathcal{S}([T, I, F]) = \frac{2+T-I-F}{3}, \quad (9)$$

- Determine for each line of the pairwise comparison matrix, a weighted sum based on the sum of the product of each cell by the priority of each alternative or corresponding criterion.
- For each line, divide its weighted sum by the priority of its corresponding alternative or criterion
- Determine the mean ʎmax of the result of the previous stage.
- Calculate the consistency index (CI) for each alternative or criterion

$$CI = \frac{ʎ_{max}-m}{m-1} \quad (10)$$

Where m is the number of alternatives

- Determine the Random Index (AI) from table 2
- Determine the consistency ratio index (the ratio between the consistency index and the random index)

3 Case study

To comply with the first specific objective, we proceed to state the theoretical aspects that support the present investigation [37]:

- Ergonomics is a discipline that tries to adjust the conditions of the task and the environment to people's capacities, considered scientific-technical and design since it studies the relationship between the workplace and workers [38].
- Ergonomics is responsible for the study of the physical workspace, thermal environment, noise, vibrations, work postures, energy wear, mental load, nervous fatigue, and workload, taking care of preventing dangers that affect the health, balance, emotional and nervous condition of the worker [39].
- Ergonomics is intended to: adapt products, tasks, tools, spaces and in general, the environment to the capacities and needs of people, and thereby improve the efficiency of workers, safety and well-being [40].
- The benefits of ergonomics can be reflected in many ways: in productivity and quality, in safety and health, in reliability, in job satisfaction, and in personal development. This wide field of action is because the basic objective of ergonomics is to achieve efficiency in any activity carried out with a purpose, efficiency in the

broadest sense, to achieve the desired result without wasting resources, without errors and damage to the person involved or others. It is inefficient to waste energy or time due to poor design of work, workspace, environment, or working conditions [41].

- Nor is it to obtain the desired results despite the bad design of the position, instead of obtaining them with the support of a good design. The goal of ergonomics is to ensure that the work environment is in harmony with the activities carried out by the worker. This goal is valid in itself, but its achievement is not easy for several reasons. The human operator is flexible and adaptable and continually learns, but individual differences can be very great. Some differences, such as those in build and strength, are obvious, but others, such as differences in culture, style, or skills, are more difficult to identify [42].

Given the complexity of the situation, it might seem that the solution is to provide a flexible environment in which the human operator can optimize a specifically suitable way of doing things. Unfortunately, this approach cannot always be practiced, as the most efficient way is not always obvious and consequently the worker may continue to do something for years in an inappropriate way or under unacceptable conditions. Therefore, it is necessary to adopt a systematic approach: start from a grounded theory, establish quantifiable objectives and contrast the results with the objectives. The different possible objectives are detailed below [43]:

- Ergonomic risks, particularly overexertion, produce musculoskeletal disorders or injuries in workers, for example; inflammatory or degenerative pain and lesions in the back and upper extremities. Today musculoskeletal disorders are among the most frequent injuries suffered by workers in developed countries [44].
- Ergonomic risks apart from generating injuries to workers, also raise the economic costs of companies since they disrupt work activity, leading to sick leave and incapacity for work. The main ergonomic risks are generally produced by the adoption of forced postures, the realization of repetitive movements, the manual handling of loads, and the application of forces during the working day [44].
- Forced postures can be defined as "Positions that a worker adopts when performing the tasks of the position, where one or more anatomical regions are no longer in a natural position to move to a position that generates hypertensions, hyper-flexion, and hyper-rotations in different parts of the body [44].
- Repetitive work is considered to be any movement that is repeated in cycles of less than 30 seconds or when more than 50% of the cycle is used to carry out the same movement. In addition, when a repetitive task is carried out for at least 2 hours during the day, it is necessary to assess its level of risk [44].

Ergonomics is a discipline concerned with the adaptation of work to man. Although, its development is recent in our environment, there is a great need for health professionals to incorporate ergonomic criteria in their activities since in the modern world there is a set of pathologies that can be triggered or aggravated by work. In these cases, the treatments are not effective if the causes that generate them are not corrected. Health professionals treat workers who, in many cases, have pathologies derived from their working conditions. For example, in the modern world, work stress, musculoskeletal symptoms associated with repetitive work, inappropriate postures and manual handling of materials, obesity associated with sedentary work, chronic fatigue, etc., [45].

Modern societies are increasingly based on information and knowledge. For this reason, they need to constitute productive forces endowed with ICT skills, which allow them to handle information and provide them with the ability to reflect, create and solve problems, to generate knowledge. To promote that its citizens are educated and capable so that each one can effectively guide their own life and develop a full and satisfactory existence. Encourage all citizens to participate fully in society and influence the decisions that affect their lives. Promote intercultural understanding and peaceful conflict resolution [46].

E-learning makes it possible to create student-centered learning environments. They are characterized by being interactive, efficient, easily accessible, and distributed. An E-learning scenario must consider aspects such as institutional, pedagogical, technological, interface design, evaluation, management, support, and ethics of use. In this way, E-learning tries to be a combination of interactive resources that generate support and structured learning activities [46, 47].

The Massive Open Online Courses (MOOC) are classes taught through technological platforms linked through the Internet, these enable the teaching-learning process to thousands of students. MOOCs appeared as a response to the challenges faced by educational institutions and organizations in times of information overload: there is a need for training a population that seeks quality education at low cost and, in turn, hoping to achieve short-term results and without having to wait for a traditional school period to take the course [48].

4 Results

The questionnaire and the respective tabulation were applied through the descriptive statistics resulting from the data processing. The results are presented below by questions:

Question No 1: Approximately how many hours a day do you spend in front of the computer?

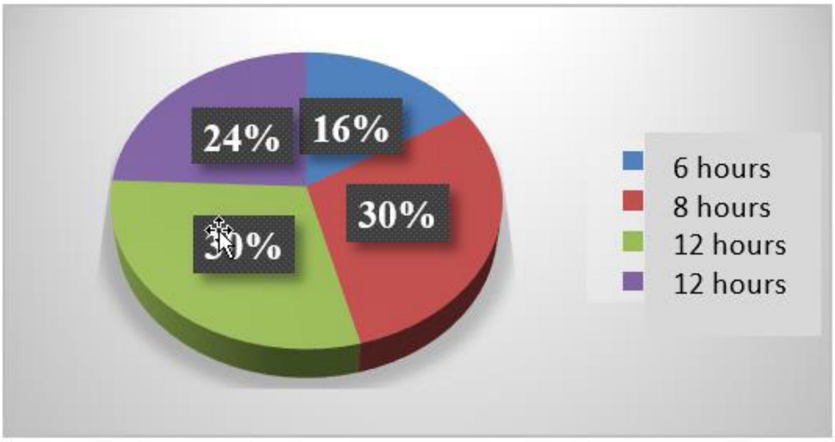

Figure 3. Results of question 1. **Source**: Own elaboration.

Question No 2. Do you know if your work position in front of the computer is adequate?

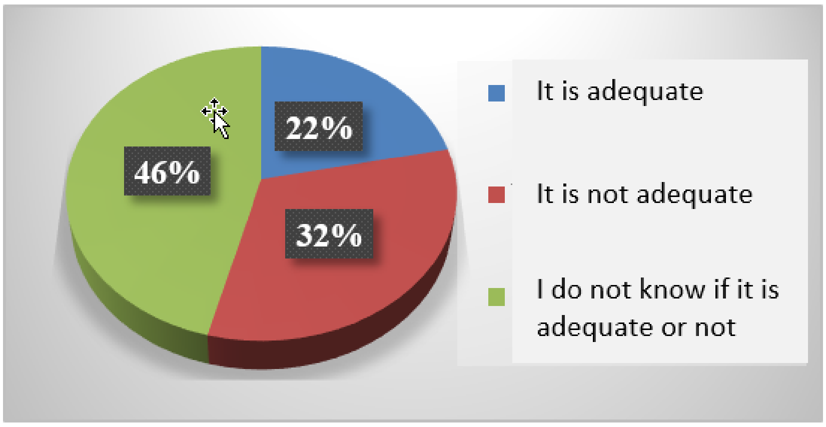

Figure 4. Results of question 2. **Source**: Own elaboration.

Question No 3. Do you know if the distance from the screen is the ideal one?

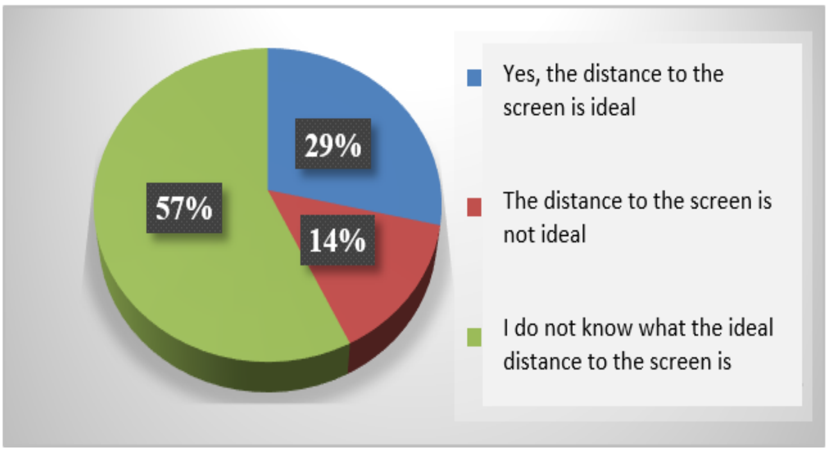

Figure 5. Results of question 3. **Source**: Own elaboration.

Question No 4. Do you know if your work chair, your keyboard and your mouse have a good ergonomic design?

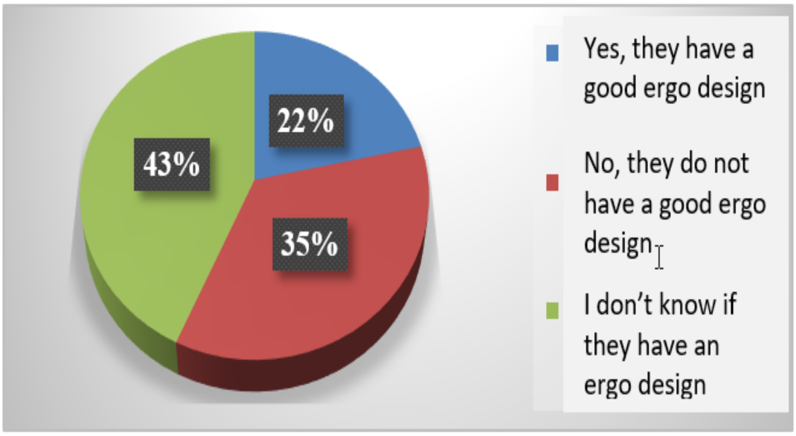

Figure 6. Results of question 4. **Source**: Own elaboration.

Question No 5 Is your current work environment comfortable?

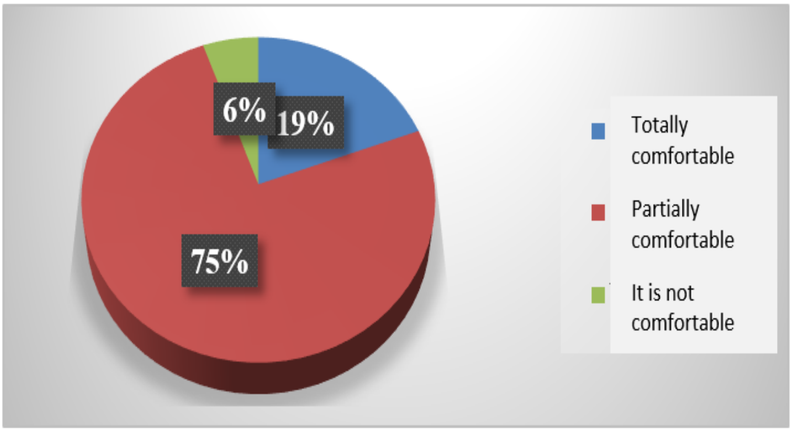

Figure 7. Results of question 1. **Source**: Own elaboration.

Question No 6. In your current work environment, are the electrical installations adequate and safe (There are no loose or crossed cables)?

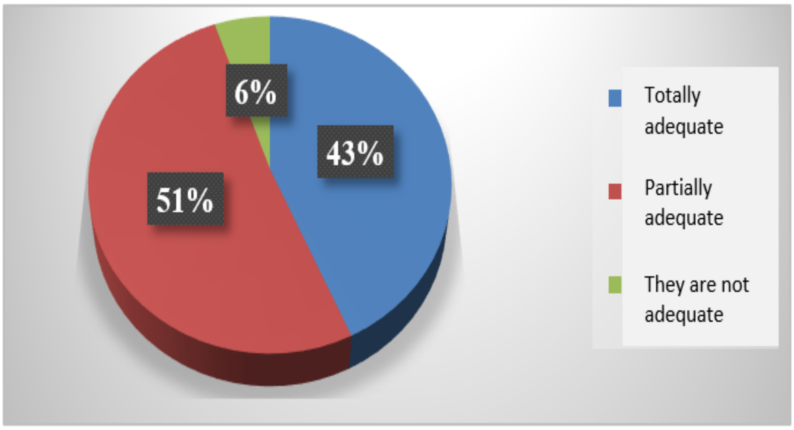

Figure 8. Results of question 6. **Source**: Own elaboration**.**

Question No 7. In the work environment at the University, were the corridors spacious?

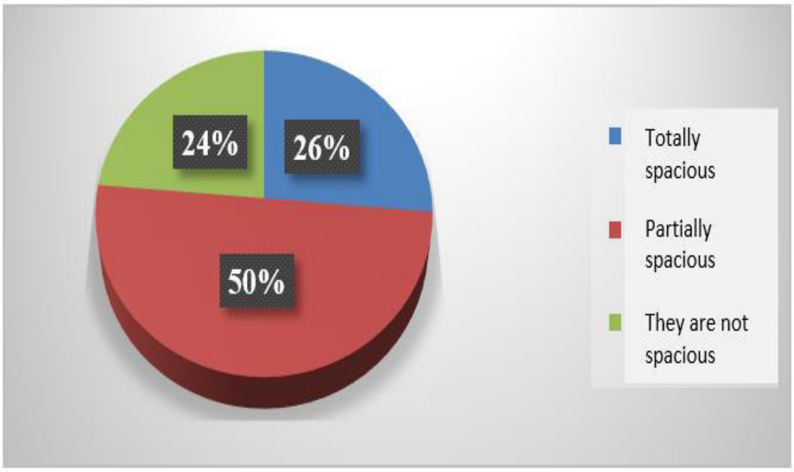

Figure 9. Results of question 7. **Source**: Own elaboration.

Question No 8. Have you received training in ergonomics aspects within an occupational health improvement process?

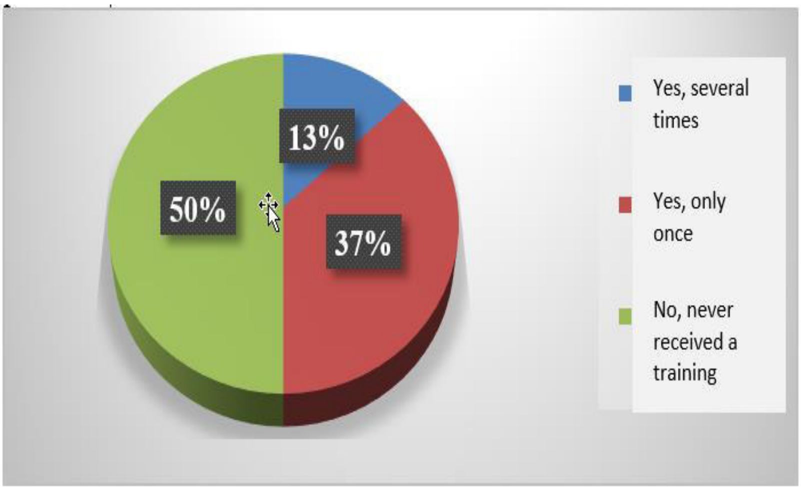

Figure 10. Results of question 8. **Source**: Own elaboration.

Question No 9. Are all the elements necessary for your work very close to your workplace (printers, computers, copiers, documents, files)?

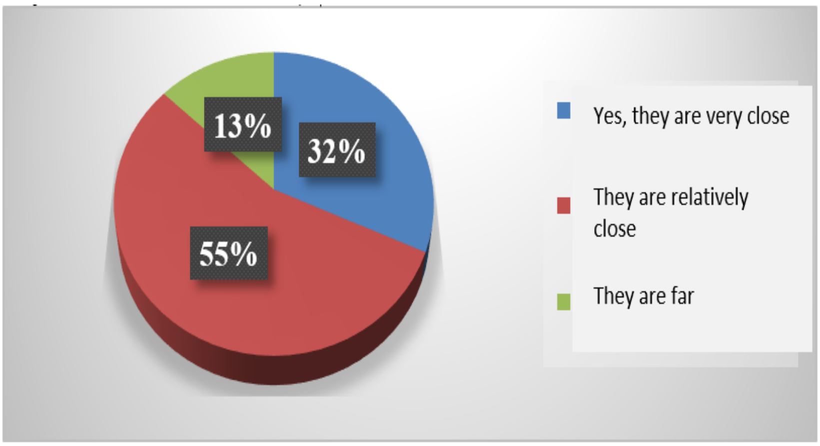

Figure 11. Results of question 9. **Source:** Own elaboration.

As can be seen, from the results obtained in the research on teachers, the situation behaves as follows:

- 60% work an average of 11 hours a day on the computer.

- 46% say they do not know if their position in front of the computer is adequate, and 32% say it is inadequate.
- 57% do not know what the ideal distance a person should sit to look at their computer screen is.
- 43% do not know if the chair, keyboard, and mouse elements have an ergonomic design, and 34% say that they do not have a good ergonomic design.
- Due to the pandemic, all teachers are developing telework, which is why 71% of those investigated say that their workplace is partially comfortable and 51% say that the electrical installations are partially adequate.
- It is also stated that the circulation corridors at the University are partially spacious.
- On the other hand, 50% state that they have never received a training process on ergonomic aspects related to occupational health. 35% declare that they received training only once.
- 55% indicate that the elements they use frequently in their work are relatively close, which means that they should not make additional efforts to reach them.

5 Discussion

To establish a discussion of the results from the comparative point of view, it is decided to take as a reference the results obtained in the research developed by [49] on ergonomic risks within the Paulo Emilio Macías Superior Technological Institute of Portoviejo. In this investigation, it is stated that:

- In 95% of the ergonomic risks that occur most frequently happen in the workplace regarding postures and the workspace itself.
- 90% of the teachers and administrative staff do not have ergonomic furniture for the development of their activities.
- According to the results obtained, 85% of the personnel studied show that they do not know the correct posture to adopt when working in front of a computer for more than two continuous hours during a working day.
- Because of the anti-ergonomic design of the 65 evaluated jobs, we found that the most persistent health problems that require periodic medical attention are those related to incorrect postures.
- Comparing the two research works, we may point out that there is a total similarity in them, the main ergonomic risk lies in the postures during the work time, also in the two investigations it is stated:
- Not knowing about ergonomic aspects,
- Most of those investigated are unaware of an ideal ergonomic posture.
- It is agreed that both the equipment and the furniture are not properly ergonomically designed.

As can be seen, the research results are very similar, which implies that this phenomenon has a general nature. Therefore, any proposed solution can be ideal for both institutions.

We then proceed to determine possible solutions to be implemented in the short term by brainstorming techniques, which are listed below:

1. Carry out an ergonomic study of the lighting and colors of the work and study rooms within the center.
2. Implement a web application to assess the level of ergonomic risks of each employee and occupation.
3. Training on ergonomics and occupational health through virtual classes complemented with synchronous classes. Encourage the dissemination of materials through different platforms and social networks, YouTube channels, blogs, SlideShare, among others.
4. Acquisition of furniture, such as desks, chairs and shelves with ergonomic designs.
5. Develop and implement a physical exercise program within the working day called "Active breaks" of 10

minutes in the morning session and 10 minutes in the afternoon, where teachers and administrators frequently perform physical exercises aimed at correcting certain postures.

6. Generate a digital campaign with tips related to ergonomics and occupational health in general.

Since it works with the idea that with the establishment of an order of priority in the implementation of short-term solutions, the ergonomic risks of UNIANDES teachers can be reduced and thus achieve the improvement of their occupational health in a short period. These solutions are subjected to the Saaty AHP technique in its plithogenic extension. For this topic, we chose administrative experts who intervene in the decision-making process. Their implementation will focus on two parts, one for teachers and administrators and a second for students. Therefore, two AHPs of Saaty will be executed for both parties as explained:

For the data processing and the construction of the binary comparison matrix, the median of the experts' evaluations is taken using equation 8, as shown below:

Strategies	Ergo study.	Web Application	Ergo furniture.	Active breaks	Digital campaign	Training
Ergo study.	(0.30, 0.40, 0.80)	(0.50, 0.40, 0.60)	(0.80, 0.10, 0.30)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)	(0.30, 0.40, 0.80)
Web Application	$\frac{1}{(0.50,0.40,0.60)}$	(0.30, 0.40, 0.80)	(0.80, 0.10, 0.30)	(0.80, 0.10, 0.30)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)
Ergo furniture.	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.80,0.10,0.30)}$	(0.30, 0.40, 0.80)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)
Active breaks	$\frac{1}{(0.65,0.30,0.45)}$	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.65,0.30,0.45)}$	(0.30, 0.40, 0.80)	(0.50, 0.40, 0.60)	(0.50, 0.40, 0.60)
Digital campaign	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.65,0.30,0.45)}$	$\frac{1}{(0.65,0.30,0.45)}$	$\frac{1}{(0.50,0.40,0.60)}$	(0.30, 0.40, 0.80)	(0.50, 0.40, 0.60)
Training	$\frac{1}{(0.30,0.40,0.80)}$	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.50,0.40,0.60)}$	$\frac{1}{(0.50,0.40,0.60)}$	(0.30, 0.40, 0.80)

Strategies	Ergo study.	Web Application	Ergo furniture.	Active breaks	Digital campaign	Training
Ergo study.	0.04	0.08	0.13	0.10	0.16	0.11
Web Application	0.22	0.06	0.13	0.12	0.13	0.24
Ergo furniture.	0.14	0.20	0.06	0.10	0.13	0.24
Active breaks	0.17	0.20	0.25	0.06	0.10	0.15
Digital campaign	0.14	0.25	0.25	0.31	0.07	0.15
Training	0.30	0.20	0.20	0.31	0.41	0.11

Strategies	Pesos	Order of importance for its implementation
Ergo study.	0.10	5
Web Application	0.15	3
Ergo furniture.	0.14	4
Active breaks	0.15	3
Digital campaign	0.20	two
Training	0.25	1

Table 4. Saaty's AHP application in its plithogenic extension for teachers

It is said that this study is validated because the CR index = 0.07 ≤ 0.10; therefore the application of the method is accepted.

Strategies	Ergo study.	Web Application	Ergo furniture.	Active breaks	Digital campaign	Training
Ergo study.	(0.30, 0.40, 0.80)	(0.50, 0.40, 0.60)	(0.70, 0.30, 0.10)	(0.70, 0.30, 0.10)	(0.70, 0.30, 0.10)	(0.50, 0.40, 0.60)
Web Application	$\frac{1}{(0.50,0.40,0.60)}$	(0.30, 0.40, 0.80)	(0.90, 0.10, 0.10)	(0.90, 0.10, 0.10)	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)
Ergo furniture.	$\frac{1}{(0.70,0.30,0.10)}$	$\frac{1}{(0.90,0.10,0.10)}$	(0.30, 0.40, 0.80)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.90, 0.10, 0.10)
Active breaks	$\frac{1}{(0.70,0.30,0.10)}$	$\frac{1}{(0.90,0.10,0.10)}$	$\frac{1}{(0.65,0.30,0.45)}$	(0.30, 0.40, 0.80)	(0.90, 0.10, 0.10)	(0.50, 0.40, 0.60)
Digital campaign	$\frac{1}{(0.70,0.30,0.10)}$	$\frac{1}{(0.65,0.30,0.45)}$	$\frac{1}{(0.50,0.40,0.60)}$	$\frac{1}{(0.90,0.10,0.10)}$	(0.30, 0.40, 0.80)	(0.90, 0.10, 0.10)
Training	$\frac{1}{(0.50,0.40,0.60)}$	$\frac{1}{(0.80,0.10,0.30)}$	$\frac{1}{(0.90,0.10,0.10)}$	$\frac{1}{(0.50,0.40,0.60)}$	$\frac{1}{(0.90,0.10,0.10)}$	(0.30, 0.40, 0.80)

Strategies	Ergonomic study	App	Ergo furniture.	Pauses	Bell	Training

		Web		active	digital	
Ergo study.	0.04	0.08	0.11	0.12	0.17	0.13
Web Application	0.23	0.06	0.14	0.16	0.15	0.20
Ergo furniture.	0.17	0.19	0.06	0.11	0.12	0.23
Active breaks	0.17	0.19	0.24	0.06	0.21	0.13
Digital campaign	0.17	0.27	0.30	0.19	0.09	0.23
Training	0.23	0.21	0.17	0.35	0.26	0.09

Strategies	Pesos	Order of importance for its implementation
Ergo study.	0.11	6
Web Application	0.16	4
Ergo furniture.	0.14	5
Active breaks	0.17	3
Digital campaign	0.21	2
Training	0.22	1

Table 5. Saaty's AHP application in its plithogenic extension for students

Strategies	Teachers and administrative	Students
Ergo study.	5	6
Web Application	3	4
Ergo furniture.	4	5
Active breaks	3	3
Digital campaign	2	2
Training	1	1

Table 6. Comparison of the order of priority for administrators, teachers and students

Conclusions

Ergonomic risks may cause physical problems for teachers and thus affect their academic performance. The vast majority of the studied teachers work an average of 11 hours on the computer; they also affirm that they do not know about the correct postures during the daily work process. However, we found that they are unaware of the fundamental concepts of ergonomics and therefore, no initiatives can be taken to prevent ergonomic risks since the vast majority of teachers have not received a training process on ergonomics and occupational health. Similarly, it was determined that the furniture does not have an adequate ergonomic design.

The study revealed the need to find quick solutions to avoid sick leave. Therefore, once Saaty's AHP was applied in its plithogenic version, the appropriate ranking could be determined based on the criteria of the administrative decision-makers consulted, and we obtained the following results:

1. Training on ergonomics and occupational health through virtual classes complemented with synchronous classes. Encourage the dissemination of materials through different platforms and social networks, YouTube channels, blogs, SlideShare, among others.

2. Generate a digital campaign with tips related to ergonomics and occupational health in general.

3. Develop and implement a physical exercise program within the working day called "Active breaks" of 10 minutes in the morning session and 10 minutes in the afternoon session, where teachers and administrators frequently perform physical exercises aimed at correcting certain postures.

The implementation of a web application to evaluate the level of ergonomic risks of each employee and work position, the ergonomic studies of the lighting and colors of the work and study rooms within the center, and the acquisition of furniture and shelves with ergonomic designs have a different order for each group. This shows that it is preferred to start a corrective and preventive protocol at the same time.

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Measuring Legal and Socioeconomic Effect of the Declared Debtors Usign The AHP Technique in a Neutrosophic Framework

Jesús Estupiñán Ricardo[1], Zoila Mireya Mariscal Rosado[2], Esther Karina Castro Pataron[3] and Verónica Yesenia Valencia Vargas[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.c.investigacion@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.c.contabilidad@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.coordinacionsg@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES), Avenida Jorge Villegas. Babahoyo, Los Ríos, Ecuador. E-mail: ub.veronicavalencia@uniandes.edu.ec

Abstract. For the development of a business and its inherent economic requirements, the owners usually have to accept bank commitments that turn them into debtors. Many times situations may occur that make it impossible to deal with these debts, so insolvency must be declared, a process that has adverse effects on both the debtors and their families and employees. The current economically precarious situation in Ecuador has led to an increase in this kind of problem. Due to the affectation observed in the canton of Pastaza. The authors of this paper have a special interest in studying this phenomenon, which comprises several edges of society. That is why the objective of this investigation is to measure the legal and socioeconomic effects of the debtors declared in this region. An efficient and simple technique is required for multicriteria decision problems such as the AHP Saaty in its neutrosophic version and the Pareto chart.

Keywords: effects, debtors, Neutrosophic AHP Saaty, Pareto Chart.

1 Introduction

In general, we may say that man develops economic activities as a social entity to satisfy his needs. To do so, he constantly seeks financing that makes it possible to obtain resources. These actions are achieved by accepting contractual banking obligations, which is why these are called debtors, which may incur in arrears if they maintain a poor financial culture. A situation that compromises the legality of the business and the person responsible for it, since arrears lead to the implementation of legal actions against the debtors. That is why many of them end up in auctions and sell their assets to meet these commitments. In other cases, in front of the impossibility to pay those debts, a person may declare himself bankrupt, which has juridical and economic consequences.

In Ecuadorian legislation, to guarantee the fulfillment of debtors' obligations, legal standards have been established to pay the credit commitments of natural or legal persons. In these processes, the rights of both parties regulate the declaration of arrears. Which endorses the money collection procedures before the jurisdictional authorities issued the sentence that condemns the payment of interest, capital and procedural costs, the bankruptcy process and the subsequent declaration of insolvency are established. The last stage of this lack of income, known as the declaration of insolvency, has several kinds of consequences: judicial, social, economic, and psychological, both for the main actors and for the families that suffer from it, which is a general concern.

The aforementioned is strengthened by the fact that Ecuador is in an economic crisis exacerbated by COVID-19 caused by a new species of coronavirus that has generated a global health crisis. This leads to a group of complications with a high rate of infection and fatality. That is why health authorities worldwide have implemented mandatory measures to mitigate a health emergency in many countries on all continents [1]. What happened has led to limitation of movement throughout 2020, imposing constant permanence in homes. Due to which the regular operation of many sectors has been affected and drastic measures have been needed in a short period [2], as can be seen in the following data collected during 2020, figures from the National Survey of Employment, Unemployment and Underemployment (Enemdu) [3]:

- The country's unemployment rate grew from 3.8% to 13.3% after the health crisis

- Only 32.1% of workers in Ecuador had a suitable job
- 48.6% of people with employment were in the informal sector of the economy, which means that five out of 10 people with adequate or inappropriate employment work in "companies that are not incorporated into society", to avoid the expenses that the legality entails.

Due to the affectation observed in the canton of Pastaza, the authors of this paper have a special interest in studying this phenomenon, which comprises several edges of society. That is why the objective of this investigation is to measure the legal and socioeconomic effects of the debtors declared in this region. For which an effective and simple technique is required for multicriteria decision problems such as the AHP Saaty (Analytic Hierarchy Process) in its neutrosophic version along with the Pareto Diagram. The latter is a strategic analysis to discern trivial effects from vital ones. Decision-making methods integrate multiple data sets [4-7] and several authors confirm that they are highly adequate in multidimensional frameworks and require a series of steps in which decisions must be made, especially in environments of uncertainty caused by the analysis of psychosocial phenomena where the nature of the variables does not come from an exact science [8-12]. That is why the evaluation of the criteria in the AHP Saaty will proceed to use the assessments provided by neutrosophic science. The work algorithm to follow is illustrated below using a process approach:

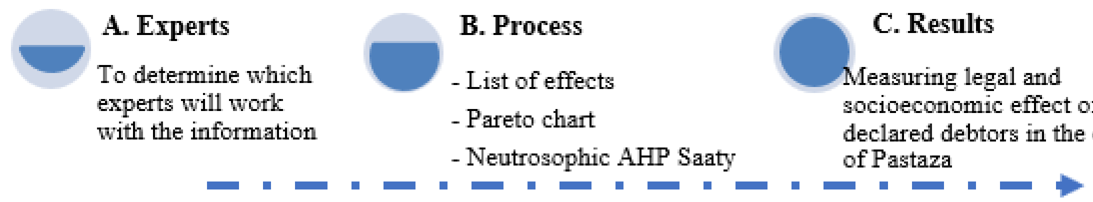

Figure 1. Guideline of the research.

2 Materials and Methods

The Analytic Hierarchy Process was proposed by Thomas Saaty in 1980 [13]. It is one of the most extensive methods in solving multicriteria decision-making problems. This method models the problem that leads to forming a hierarchy representative of the associated decision-making scheme. This hierarchy presents at the upper level the goal pursued in solving the problem and at the lower level, it includes the different alternatives from which a decision must be taken. The intermediate levels detail the set of criteria and attributes considered [14, 15].

The formulation of the decision-making problem in a hierarchical structure is the first stage. This stage is where the decision-maker must break down the problem into its relevant components. The basic hierarchy is made up of general goals or objectives, criteria, and alternatives [16-18]. The hierarchy is constructed so that each elements are of the same order of magnitude and can be related to some of the next levels.

In a typical hierarchy, the highest level locates the goal of the decision-making process. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. Finally, at the lowest level appear the decision options [13, 19-39]. Figure 2 shows the hierarchical structure of AHP.

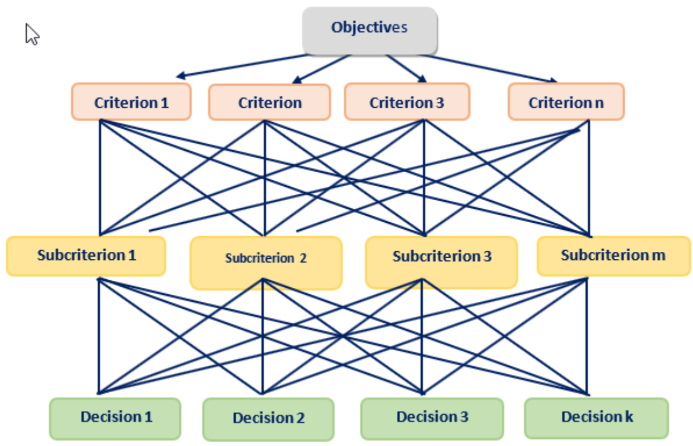

Figure 2. Scheme of a generic tree representing an Analytic Hierarchy Process. Source: [13]

For the description of the method, the following definitions are presented:

Definition 1: ([40, 41]) The Neutrosophic set N is characterized by three membership functions, which are the truth-membership function TA, indeterminacy-membership function IA, and falsehood-membership function FA, where U is the Universe of Discourse and ∀x∈U, TA(x), IA(x),FA(x) ⊆]-0, 1+[, and -0≤inf TA(x)+ inf IA (x) + inf FA (x) ≤sup TA(x)+ sup IA (x) + sup FA (x)≤3+. Notice that, according to the definition, TA(x), IA(x) and FA(x) are real standard or non-standard subsets of]-0, 1+ [and hence, TA(x), IA(x) and FA(x) can be subintervals of [0, 1].

Definition 2: ([40, 41]) The Single-Valued Neutrosophic Set (SVNS) N over U is A = {<x; TA(x), IA(x), FA(x)>: x∈U}, where TA:U→[0, 1], IA:U→[0, 1], and FA:U→[0, 1], 0 ≤TA(x) + IA(x) +FA(x) ≤ 3. The Single-Valued Neutrosophic Number (SVNN) is represented by N = (t, I, f), such that 0 ≤t, I, f ≤ 1 and 0 ≤t + I + f≤ 3.

Definition 3: ([40-43]) the single-valued trapezoidal neutrosophic number, $\tilde{a} = \langle(a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, is a neutrosophic set on ℝ, whose truth, indeterminacy and falsehood membership functions are defined respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & a_2 \le x \le a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \le x \le a_4 \\ 0, \text{ otherwise} \end{cases} \tag{1}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{2}$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Where, and. $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R} a_1 \le a_2 \le a_3 \le a_4$

Definition 4: ([40-43]) given $\tilde{a} = \langle(a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$ and $\tilde{b} = \langle(b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}}\rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$

Subtraction: $\tilde{a} - \tilde{b} = \langle(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$ (4)

Inversion: $\tilde{a}^{-1} = \langle(a_4{}^{-1}, a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{Bmatrix} \langle(\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda > 0 \\ \langle(\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda < 0 \end{Bmatrix}$$

Definitions 3 and 4 refer to single-valued triangular neutrosophic number when the condition $a_2 = a_3$, [44-46]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers (see Table 1 and compare it with the scale defined in [47]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6)[48].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \tag{5}$$

We can find in [47] the theory of the AHP technique in a neutrosophic framework. We can model the indeterminacy of decision-making by applying neutrosophic AHP (NAHP) . Equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{6}$$

Matrix $\widetilde{A}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4.

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [47], the score and accuracy indexes, respectively, see Equations 7 and 8:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{7}$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \tag{8}$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1. Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [49]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 6.

Step 3 Check the consistency of experts' judgments.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it into a deterministic matrix using Equations 9 and 10. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \tag{9}$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \tag{10}$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{11}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Note that Step 3 refers to consider the use of the calculus of the Consistency Index (CI), which is a function depending on λ max, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ [50]}, \tag{12}$$

where n is the order of the matrix. In addition, the *Consistency Ratio* (CR) is defined by the equation:

$$CR = \frac{CI}{RI} \tag{13}$$

RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated with each order.

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent and henceforward we can proceed to use NAHP. We apply this procedure to matrix "A" in Equation 12.

The Pareto chart was presented in 1930 by Jurán in his Quality Control Manual based on what was described in 1909 by Vilfredo Pareto under the principle of "the few vital the many trivial". This diagram is based on the analysis of the problem and is used to present data, drawing attention to the causes of great incidence in the problem being analyzed. It aims to determine 20% of the causes that provoke 80% of the problems [51, 52].

Its main advantages are:

- It allows you to focus on the aspects whose improvement will have the bigger impact, thus optimizing efforts.
- Provides a quick and easy view of the relative importance of issues.
- It helps prevent some causes from getting worse by trying to fix other less significant ones.
- His graphical view of the analysis is easy to understand and encourages the team to continue to improve.

It runs according to the following algorithm:

1. To collect the data and tabulate it.To calculate absolute and cumulative frequency, unit and cumulative relative frequency.
2. To make a graph by locating all the causes along the coordinate axis, ordered from highest to lowest incidence and match them with their corresponding percentages along the ordinate axis. Finally, the cumulative polygonal line is constructed, and the causes that are up to 80% will be those with the highest incidence

3 Results

Experts of diverse origins were selected for the investigation, all belonging to the region under study: Pastaza. The majority of this sample group was made up of process actors for this subset to represent the population to be studied faithfully. Within the population of interest, the sample was randomly chosen among legal professionals residing in the province of Pastaza. The mathematical exercise began with a round of individual interviews on a questionnaire designed to obtain data in three phases:

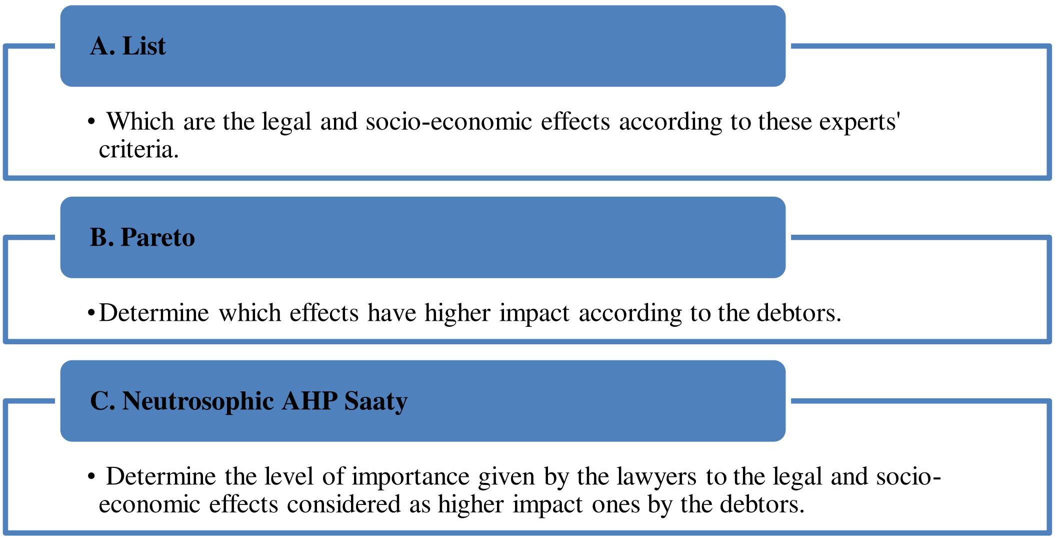

Figure 3. Guidelines for processing the results.

From the interviews carried out to the debtors, the following list of legal and socio-economic effects is shown:

1. Conjectures and accusations are initiated, so in this case, bad faith is judged, as well as the intention of not fulfilling its obligations to the detriment of its creditors
2. Inclusion of their identities in the Risk Center of the Ecuadorian Financial System, in the National System of Public Data, Ownership Registry, Databases of the Financial System, among others.
3. The property of the patrimony remains suspended, granting a transitory title to the trustee who represents it.
4. It produces discrimination towards the debtor declared as bankrupt, generating his rejection in his social circle, due to the decrease in his credibility for businesses
5. Impediment for the administration of assets, whether personal or others as a legal representative (which will not include family assets).
6. He will lose all the rights enshrined in the Constitution, except for the right to life, health, and education.
7. Impossibility of working in public entities, not being an employer or an employee, accessing credits, or entering into contracts).
8. Possibility of a criminal process leading to imprisonment
9. Automatic start of the tax investigation followed by a criminal process that can take away the right to liberty of the person if signs of Fraudulent Insolvency are found.
10. Impossibility of socially and economically rebuilding the life of the declared debtor.
11. The patrimony is submitted to the action and insolvency execution for which its administration, usufruct and disposition are deprived.

The resulting Pareto chart is shown below:

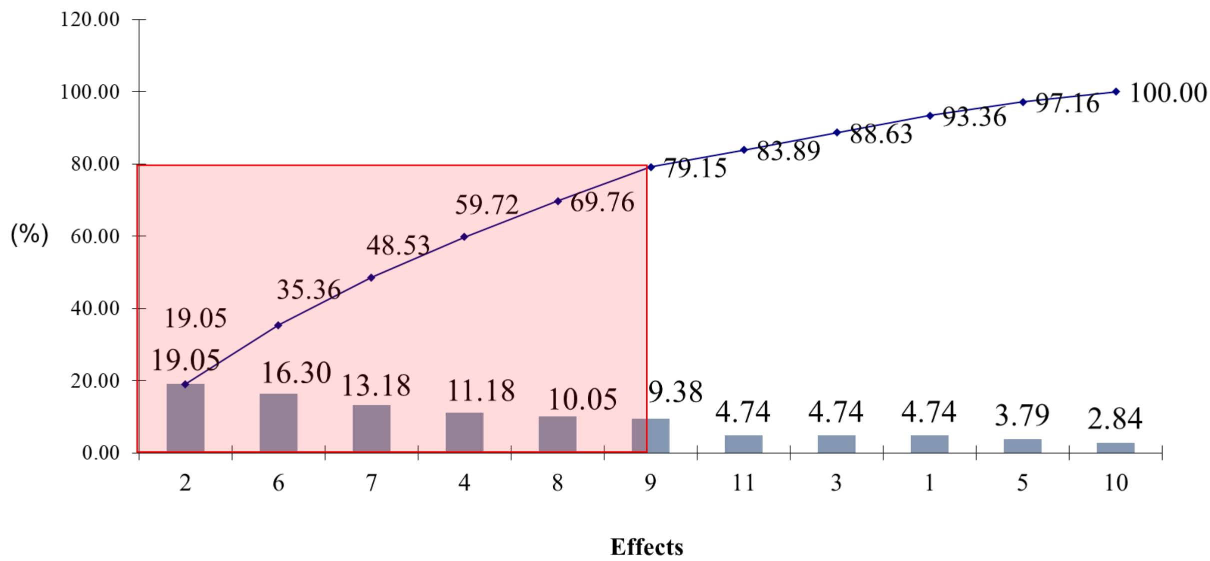

Figure 4. Pareto chart.

One of the benefits of the Pareto Chart is determining what is the key to a problem, separating them from other keys also present, but less important. Which is used both to investigate effects and to analyze causes. Therefore, following his 80-20% theory, it can be said that to continue the analysis, the following effects will be discarded:

- Conjectures and accusations are initiated, so in this case, bad faith is judged, as well as the intention of not fulfilling its obligations to the detriment of its creditors.
- The property of the patrimony remains suspended, granting a transitory title to the trustee who represents it.
- Impediment for the administration of assets, whether personal or others as a legal representative (which will not include family assets).
- Impossibility of socially and economically rebuilding the life of the declared debtor.
- The patrimony is submitted to the action and insolvency execution for which its administration, usufruct and disposition are deprived.

The execution of the AHP Saaty Neutrosophic analysis to determine the hierarchy in the measurement of the effects according to their weights was as follows:

A. He will lose all the rights enshrined in the Constitution, except for the right to life, health, and education.
B. It produces discrimination towards the debtor declared as bankrupt, generating his rejection in his social circle, due to the decrease in his credibility for businesses.
C. Inclusion of their identities in the Risk Center of the Ecuadorian Financial System, in the National System of Public Data, Property Registry, Databases of the Financial System, among others.
D. Impossibility of working in public entities, not being an employer or an employee, accessing credits, or entering into contracts.
E. Possibility of criminal proceedings leading to imprisonment.
F. Automatic start of the tax investigation followed by a criminal process that can take away the right to liberty of the person if signs of Fraudulent Insolvency are found.

Effects	**A**	**B**	**C**	**D**	**E**	**F**
A	1	〈(2,3,4); 0.30,0.75,0.70〉	〈(6,7,8); 0.90,0.10,0.10〉	〈(2,3,4); 0.30,0.75,0.70〉	〈(2,3,4); 0.30,0.75,0.70〉	〈(2,3,4); 0.30,0.75,0.70〉
B	〈(6,7,8); 0.90,0.10,0.10〉	1	〈(2,3,4); 0.30,0.75,0.70〉	〈(4,5,6); 0.80,0.15,0.20〉	〈(3,4,5); 0.60,0.35,0.40〉	〈(6,7,8); 0.90,0.10,0.10〉
C	〈(6,7,8); 0.90,0.10,0.10〉	〈(6,7,8); 0.90,0.10,0.10〉	1	〈(6,7,8); 0.90,0.10,0.10〉	〈(7,8,9); 0.85,0.10,0.15〉	〈(5,6,7); 0.70,0.25,0.30〉
D	〈(6,7,8); 0.90,0.10,0.10〉	〈(4,5,6); 0.80,0.15,0.20〉	〈(2,3,4); 0.30,0.75,0.70〉	1	〈(1,1,1); 0.50,0.50,0.50〉	〈(2,3,4); 0.30,0.75,0.70〉
E	〈(7,8,9); 0.85,0.10,0.15〉	〈(3,4,5); 0.60,0.35,0.40〉	〈(2,3,4); 0.30,0.75,0.70〉	〈(1,1,1); 0.50,0.50,0.50〉	1	〈(1,1,1); 0.50,0.50,0.50〉
F	〈(5,6,7); 0.70,0.25,0.30〉	〈(6,7,8); 0.90,0.10,0.10〉	〈(2,3,4); 0.30,0.75,0.70〉	〈(2,3,4); 0.30,0.75,0.70〉	〈(1,1,1); 0.50,0.50,0.50〉	1

Table 3. Paired matrix Neutrosophic AHP Saaty.

Effects	**A**	**B**	**C**	**D**	**E**	**F**	**WEIGHT**		
A	0.08	0.04	0.08	0.17	0.17	0.14	**0.11**	0.73	6,384
B	0.08	0.11	0.25	0.29	0.22	0.33	**0.21**	1.46	6,775
C	0.58	0.78	0.58	0.40	0.44	0.29	**0.51**	3.92	7,632
D	0.08	0.02	0.03	0.06	0.06	0.14	**0.06**	0.40	6,151
E	0.07	0.03	0.03	0.06	0.06	0.05	**0.05**	0.31	6,491
F	0.10	0.02	0.03	0.02	0.06	0.05	**0.04**	0.27	6,115

Table 4. Determination of the weights of criteria applying the Neutrosophic AHP method.

The analysis of the consistency of the method showed that its Eigen value is 6.591, IC = 0.12 and RC = 0.09, so it is confirmed that the exercise was correct.

Conclusions

- The correct economic management for a business is of paramount importance, as it ensures survival in the market, obtaining profits and the prestige of the owners and family members. Specific laws in Ecuador regulate the process. It needs a quick response to avoid the effects on the part of the debtors, who must establish strategies in good faith.
- A declaration of insolvency implies negative effects in a wide range of actions; these can be legal, social, economic, and psychological both for the debtor and the people around them, whether they are family members or employees. Due to the unpredictable nature of uncertainty, given that it is a social

phenomenon, the use of neutrosophic language was appropriate for the fulfillment of the objective of this research.

- To measure the effects, the techniques used were accurate. According to the Pareto chart for the socio-economic effects of the debtors in the Canton of Pastaza, it showed that once the state of insolvency has been declared, the greatest impact lies in the social consequences rather than the economic ones. This is mainly due to the psycho-family issues that they bring along. Issues such as the power over property and the administration and/or representation of one's own and/or other people's property go to the background in front of the idea of a criminal process or the possibility of imprisonment, as well as the rejection that is experienced at the social level.
- In the case of the analysis carried out using the AHP Saaty Neutrosophic technique, it complemented what was stated in Pareto. It revealed that in order of importance, the lawyers and debtors confer the following hierarchical order of the effects described:

I. Inclusion of their identities in the Risk Center of the Ecuadorian Financial System, in the National System of Public Data, Property Registry, Databases of the Financial System, among others.
II. It produces discrimination towards the debtor declared as bankrupt, generating his rejection from his social circle, due to the decrease in his credibility for businesses.
III. He will lose all the rights enshrined in the Constitution, except for the right to life, health, and education.
IV. Impossibility of working in public entities, not being an employer or an employee, accessing credits, or entering into contracts).
V. Possibility of criminal proceedings leading to imprisonment.
VI. Automatic start of the tax investigation followed by a criminal process that can take away the right to liberty of the person if signs of Fraudulent Insolvency are found.

- The need to reconstruct life after the legal and economic effects is imposed in the measurement of the Neutrosophic AHP Saaty. Faced with demoralization as a social entity and the possibility of not reconstructing itself economically is what weighs most heavily in the analysis since once the identity of the debtor is included in the national databases, he loses civil rights and this possibility of rebirth is diminished in a considerable percentage.
- As one of the strategies to be followed proposed by the authors of this paper, it is recommended to promote a policy of debtors in good faith, where they can eliminate the arrears in payments as agreed. Similarly, it is necessary to legally reform the legislation according to the Basic Guarantees of Due Process to allow the bankrupt to submit payment proposals and to achieve the long-awaited rehabilitation of the right to representation, administration, and ownership of properties and assets.

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Neutrosophic Multicriteria Methods and PESTEL Analysis for the Evaluation of Informal Trade Impact

Oscar Roberto Espinoza Lastra[1], Luis Eduardo Álvarez Cortez[2], Dina Angélica Ipiales Espín[3] and Beatriz Elizabeth Ramírez Rodríguez[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.oscarespinoza@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.luisalvarez@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.dinaipiales@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.beatrizramirez@uniandes.edu.ec

Abstract: In towns where social phenomena such as poverty, migration and unemployment prevail, the informal market acquires special relevance, as is the case in Ecuador. The country has currently experienced a rise in this market, for example in the province of Pastaza, City of Puyo, where the Mariscal Market is located. In this market, most people are engaged in informal trade. A situation that has a negative impact on the economy and therefore requires an analysis which, due to the nature of the phenomenon, requires the intervention of multicriteria methods for its evaluation and decision-making. That is why this research aims to evaluate the negative impacts of informal trade related to the Mariscal de Puyo Market to offer strategies for the Government's decision-making process. In order to select the best strategies to determine a path to follow, we used the technique called neutrosophic TOPSIS enriched with the application of the neutrosophic AHP Saaty and PESTEL. The paper ends with conclusions on the strategies to follow to mitigate the negative impacts of informal trade in this region.

Keywords: impact, informal trade, neutrosophic TOPSIS, neutrosophic AHP Saaty, PESTEL

1. Introduction

All over the world, commerce is characterized by its versatility. That is why the mercantile society and the diverse social strata are directly related to the levels of trade. At these levels, economic transactions take place, which can be formal or informal, regarding the development characteristics of the towns where they occur. Depending on it, one form prevails over another [1]. This informal market acquires special relevance in towns where social phenomena such as poverty, migration, and unemployment prevail. As is the case of Ecuador, where there has been a rise in this market at the current commercial situation in the country [2]. Until December 2019, 46.7% of the country's employees were in the informal sector of the economy and only eight months later, amid the consequences of a pandemic, the country still does not know the deterioration that this market would have had, whose figures are of concern at the regional level. The Ecuadorian Institute of Statistics and Censuses (INEC) released the following data [2, 3] that illustrate the current situation that Ecuador is going through:

- The country's unemployment rate grew from 3.8% to 13.3% after the health crisis caused by Covid-19.
- In September 2020, 32.1% of workers in Ecuador had a suitable job, according to the latest figures from the National Survey of Employment, Unemployment, and Underemployment (Enemdu)[3].
- On October 15, the last National Survey of Employment, Unemployment, and Underemployment stated that one of the data that shows the deterioration of the labor market due to the economic crisis is that of informality. In September 2020, 48.6% of people with a job were working in the informal sector of the economy, which means that five out of 10 people with adequate or inadequate employment are working in "companies that are not incorporated in society",
- The job insecurity that Ecuador is experiencing has the informal employment as an output, mostly due to restrictions, which do not allow to enjoy better working conditions or access credit for businesses or better direct public policies.

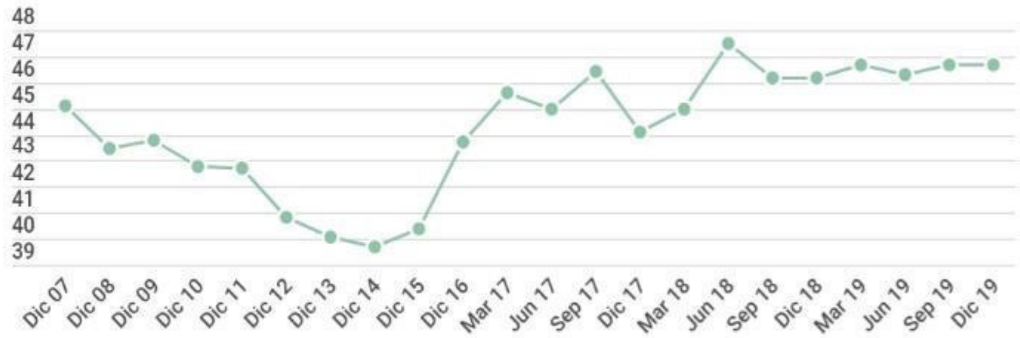

Figure 1. Percentage change in the informal employment rate from 2001 to 2019. Source: [2]

The loss of jobs in year-on-year terms turns into an increase in people who are unemployed or have an inappropriate job. The unemployment rate in one year went from 4.9% in September 2019, which meant 406,871 people, to 6.6% in the same month of 2020, which represents more than 522,620 citizens. The population group hardest hit by unemployment is that of women, because according to the INEC, the unemployment rate was 8% for women, while in the case of men it was only 5.7%[3]. The reality in numbers does not reflect the increase in the migration of people from formality to the informal market. It does not provide the authorities with many decision tools, which is detrimental to economically active people, since the government, not being accurately informed about this phenomenon, can't properly plan the economy[4].

This situation takes place in the province of Pastaza, City of Puyo, where the Mariscal Market is located. In this market, most people are engaged in informal trade. Activity that is evident due to the increase in people who offer necessities in the streets surrounding the market. This implies competition in unfavorable conditions for those who carry out commercial activity in an orderly way and with the consequent payment of taxes, permits, rental fees, employees, and the risk of losing capital. A situation that has a negative impact on the economy and therefore requires an analysis which, due to the nature of the phenomenon, involves the intervention of multicriteria methods for its evaluation and decision-making.

According to the aforesaid, the objective of this paper is to evaluate the negative impacts of informal trade related to the Mariscal de Puyo Market in order to offer strategies for the Government's decision-making process. To select the best strategies to determine a path to follow, we used the technique called TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). This technique is characterized by its effectiveness and the simplicity of its principle in solving multicriteria decision problems. To enrich this technique, the AHP (Hierarchical Analysis Process) is applied in its neutrosophic version and also the PESTEL method. The latter is a strategic analysis to determine the external environment that affects the following factors, namely, political, economic, sociocultural, technological, ecological, and legal, which allows the design of strategies to defend, take advantage of or adapt to anything that affects the sector [5].

Neutrosophy is the branch of philosophy that studies the origin, nature and scope of neutralities. Logic and neutrosophic sets constitute generalizations of Zadeh's logic and fuzzy sets of Atanassov's intuitionist logic. The incorporation of the neutrosophic sets in AHP Saaty and TOPSIS guarantees that the uncertainty of decision making is taken into account, including indeterminacies. In both techniques, the experts will evaluate in linguistic and not numerical terms, which constitutes the most natural form of measurement for humans.[6-19]. From now on, the document will consist of several sections where we will be presenting the materials and methods, results and discussion, and finally, the conclusions reached. For the resolution of the mathematical exercise, the information will be processed as follows:

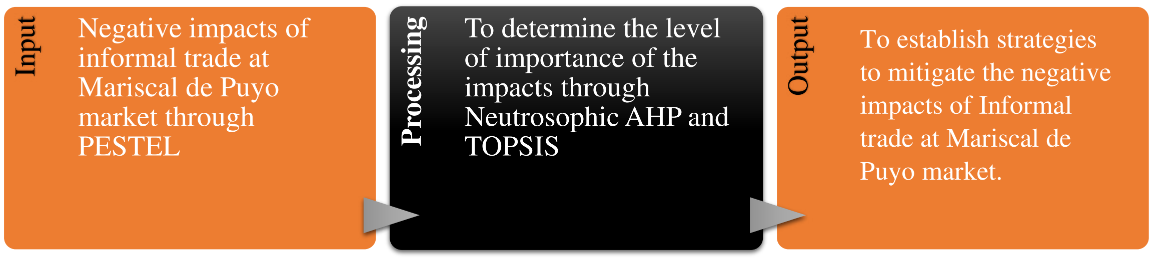

Figure 2. Process approach for the resolution of the exercise.

2 Materials and methods

A multicriteria decision problem starts from the evaluation given by a group of experts on the subject, around a set of alternatives on certain criteria. The problem is to find the best-evaluated alternative. The following section describes the methods used throughout the current investigation to meet the specific objectives set. The methods used are listed below:

PESTEL:

It is a strategic analysis technique to determine the external environment that affects the following factors, namely, political, economic, sociocultural, technological, ecological, and legal. It consists of determining the forces that affect the specific environment: sector, job market, target groups, competition, among others. It is a technique to analyze a business that allows and determines the context in which it operates, and at the same time, it allows the design of strategies to defend itself, takes advantage of, or adapt to anything that affects the sector [5, 20-22].

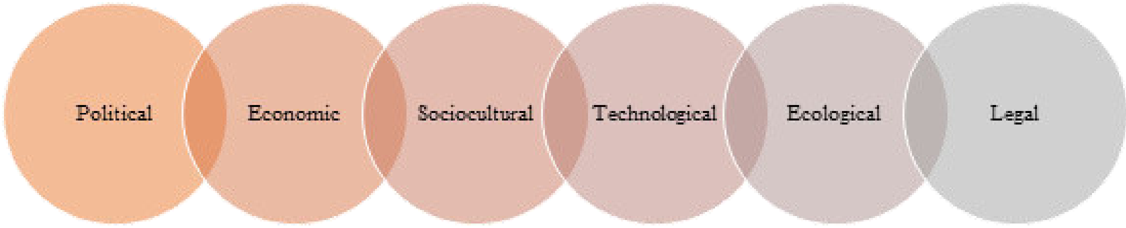

Figure 3. Dimensions of the PESTEL analysis.

AHP Saaty Neutrosophic:

Analytic Hierarchy Process (AHP Saaty): it was proposed by Thomas Saaty in 1980 [23]. It is one of the most widespread methods for solving multicriteria decision-making problems. This technique models the problem that leads to the formation of a representative hierarchy of the associated decision-making scheme. This hierarchy presents at the upper level the objective pursued in the solution of the problem and at the lower level, the different alternatives are included from which a decision must be made. The intermediate levels detail the set of criteria and attributes considered [24-36].

For the description of the method, the following definitions must be presented:

Definition 1: ([37, 38]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsehood-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$. Notice that, according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2: ([37, 38]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is A = [39], where $T_A:U\rightarrow[0, 1]$, $I_A:U\rightarrow[0, 1]$, and $F_A:U\rightarrow[0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. The *Single-Valued Neutrosophic Number* (SVNN) is represented by N = (t, I, f), such that $0 \leq t, I, f \leq 1$ and $0 \leq t + I + f \leq 3$.

Definition 3: ([37, 38, 40, 41]) the *single-valued trapezoidal neutrosophic number*, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{ otherwise} & \end{cases} \tag{1}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \tag{2}$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Where, $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R} a_1 \leq a_2 \leq a_3 \leq a_4$

Definition 4: ([37, 38, 40, 41]) given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Subtraction: (4)$\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Inversion: $\tilde{a}^{-1} = \langle (a_4{}^{-1}, a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ where $a_1, a_2, a_3, a_4 \neq 0$

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$

Definitions 3 and 4 refer to single-valued triangular neutrosophic number when the condition $a_2 = a_3$, [42-44]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers (see Table 1 and compare it with the scale defined in [45]. The hierarchical analytical process was proposed by Thomas Saaty in 1980 [23]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [24, 25]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components[46], [47, 48]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level, the decision options are placed [49]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6) [50].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \tag{5}$$

We can find in [45] the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP or NAHP for short. Equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{6}$$

Matrix $\tilde{A}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4.

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [45]. They are the so-called score and accuracy indexes, respectively, see Equations 8 and 9:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{7}$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \tag{8}$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle (1,1,1); 0.50, 0.50, 0.50 \rangle$
3	Slightly influential	$\tilde{3} = \langle (2,3,4); 0.30, 0.75, 0.70 \rangle$
5	Strongly influential	$\tilde{5} = \langle (4,5,6); 0.80, 0.15, 0.20 \rangle$
7	Very strongly influential	$\tilde{7} = \langle (6,7,8); 0.90, 0.10, 0.10 \rangle$
9	Absolutely influential	$\tilde{9} = \langle (9,9,9); 1.00, 1.00, 1.00 \rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle (1,2,3); 0.40, 0.65, 0.60 \rangle$
		$\tilde{4} = \langle (3,4,5); 0.60, 0.35, 0.40 \rangle$
		$\tilde{6} = \langle (5,6,7); 0.70, 0.25, 0.30 \rangle$
		$\tilde{8} = \langle (7,8,9); 0.85, 0.10, 0.15 \rangle$

Table 1. Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions[51]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 6.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i,j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4. Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 9 and 10. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \tag{9}$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \tag{10}$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{11}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Note that Step 3 refers to consider the use of the calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ [52]}, \tag{12}$$

where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by equation:

$$CR = \frac{CI}{RI} \tag{13}$$

RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2. RI associated with every order.

If CR≤0.1 we may consider that experts' evaluation is sufficiently consistent and hence we can proceed to use NAHP. We apply this procedure to matrix "*A*" in Equation 12.

TOPSIS

In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and in turn moves further away to the worst solution. It was developed by Hwang and Yoon in 1981 and is based on the concept that a given alternative should be located at the shortest distance from an ideal alternative that represents the best (positive ideal or simply ideal), and at the greatest distance from an ideal alternative that represents the worst (negative ideal or anti-ideal) [53-60]. This method had its evolution towards Neutrosophy, so in this paper, linguistic terms will be associated with Single-Valued Neutrosophic Numbers (SVNN), so that experts can carry out their assessments in linguistic terms, which is more natural. Therefore, the scales shown in Table 3 will be taken into account.

Linguistic term	**SVNN**
Very Important (VI)	(0.9, 0.1, 0.1)
Important (I)	(0.75,0.25,0.20)
Medium (M)	(0.50,0.50,0.50)
Not Important (NI)	(0.35,0.75,0.80)
Very Not Important (NVI)	(0.10,0.90,0.90)

Table 3. Linguistic terms represent the evaluation of the criteria in the alternatives.

The TOPSIS method for SVNN consists of the following, assuming that A={ρ_1,ρ_2,…,ρ_m } is a set of alternatives and G={β_1,β_2,…,β_n } is a set of criteria, where the following steps will be carried out:

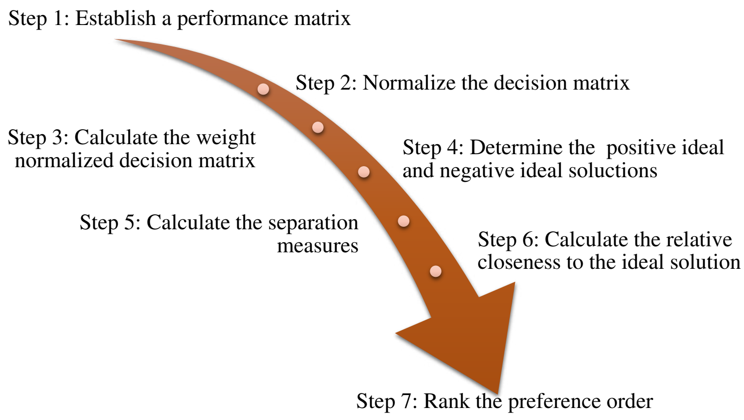

Figure 4. TOPSIS steps.

Step 1: Establish a performance matrix

In this step, we proceed to the construction of the neutrosophic decision matrix of aggregated unique values. Which is used to aggregate all individual evaluations. Each d_{ij} is calculated as the aggregation of the evaluations given by each expert $\left(u_{ij}^t, r_{ij}^t, v_{ij}^t\right)$ using the weights of the AHP Saaty of each criterion with the help of equations 7 and 8 and tables 1 and 2. In this way, a matrix $D = (d_{ij})_{ij}$ is obtained, where each d_{ij} is a SVNN (i = 1,2, .., m; j = 1,2,…, n).

Step 2: Normalize the decision matrix

Suppose that the weight of each criterion is given by $W = (w_1, w_2,\dots, w_n)$, where w_j denotes the relative importance of criterion w_j. If $w_j^t = (a_j^t, b_j^t, c_j^t)$ is the evaluation of criterion w_j by the t-th expert. Then Equation 13 is used to add the w_j^t with the weights. The construction of the normalized matrix will be as follows:

$$w_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \tag{14}$$

Where: wij is the normalized value for the qualification of alternative i against criterion j and f_{ij} is the indicator of each alternative i against each indicator j.

Step 3: Calculate the weight normalized decision matrix

We proceed to the construction of the neutrosophic decision matrix of the single values weighted mean with respect to the criteria.

$$D^* = D{*}W, \text{ where } d_{ij}^* = w_j * d_{ij} = (a_{ij}, b_{ij}, c_{ij}) \tag{15}$$

Step 4: *Determine the positive ideal and negative ideal solutions*

$$s^+ = (x_1^+, x_2^+, \dots x_{j+l}^+) \text{ that is to say,} s_i^+ = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2\right\}\right)^{\frac{1}{2}} \tag{16}$$

$$s^- = (x_1^-, x_2^-, \dots x_{j+l}^-) \text{ that is to say,} s_i^- = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2\right\}\right)^{\frac{1}{2}} \tag{17}$$

Step 5: *Calculation of the distances to the ideal positive and negative SVNN solutions.* With the help of Equation 6, the following Equations are calculated:

$$\rho(A^k, A^+) = \|w * (TA^k - TA^+)\| \tag{18}$$

$$\rho(A^k, A^-) = \|w * (TA^k - TA^-)\| \tag{19}$$

Step 6: Calculate the relative closeness to the ideal solution

To calculate the Relative Proximity Index (Ri), it is done as follows: the proximity coefficient of each alternative is calculated concerning the positive and negative ideal solutions.

$$Ri(A^k, A^i) = \frac{\rho(A^k, A^+)}{\rho(A^k, A^+) + \rho(A^k, A^-)} \tag{20}$$

Step 7: Rank the preference order

The alternatives are ordered from highest to lowest, under the condition that Ri→1 is the optimal solution.

3 RESULTS

In the following section, we preferred to start with the establishment of the negative impacts caused by the rise of informal trade in the specific region of the Mariscal de Puyo market. Which will be exposed by the PESTEL technique as follows:

Political

- Little control by the authorities, sistematically failing to comply with current regulations on the use of public space, commerce and tax legistation.

Economic

- Survival economy: employees survive on precarious and informal jobs
- It imposes a reduction in hours and wages.
- It does not aim efforts towards an adecuate formalization of the company, the nation remains excent from receiving the economic contributions from the taxes that legally must have been reported.
- Puts the formalized sector at a competitive disadvantage, being them who are subject to laws, regulations, rules and agreements that bring along a tax payment responsability.

Social

- People get used to buying cheap products without worrying about its legal origin.
- Not being used to formal working hours, which leads to a trend of not to apply for formal jobs.
- Invasion of public and private space.
- Riots between mechants arguing about space, prices, offers.

Technological

- No impacts are detected in this regard.

Ecological

- They ilegally sell products that are usually comming from not eco-friendly sources.
- They don't opt for products certified with environmental labels.

Legal

- They offer similar products to the pedestrians, occupying the public space and not respecting the legal right to purchase.
- Informal and non-contractual relations between employers and employees without any social segurity or legal support.
- They are not supported by any documents, so profit margin might be increased.

Figure 5. Impacts caused by informal trade in the Mariscal de Puyo market.

To continue with the analysis, the experts who will take part in the team for the evaluation of the impacts will be determined using the AHP Saaty and TOPSIS multicriteria techniques:

- Formal and informal market traders
- Neighbors of the area
- Local government officials

We proceed to verify whether we are in the presence of an uncertainty problem. For this, the following is established: Set of criteria: $C = \{c_1 \dots c_8\}; m \geq 1; \forall Cm \notin \emptyset, 1 \leq m \leq 6$; Expert set: $E = \{e_1 \dots e_{12}\}; n \geq 1; \forall Em \notin \emptyset, 1 \leq m \leq 58$; Set of alternatives: $A = \{a_1 \dots a_{12}\}; k \geq 1; \forall Ak \notin \emptyset, 1 \leq k \leq 6$. This verifies the need for the interaction of neutrosophy as a science that studies the indeterminacies that may exist in these cases. Then it leads to the execution of multicriteria techniques from the neutrosophic perspective.

Neutrosophic AHP Saaty to determine weights of the criteria on which the experts will be based to evaluate the alternatives of primary indicators:

Criteria	Product or service	Business location	Origin of the business	Areas covered	Predominant gender	Stay time
Product or service	1	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(7,8,9); 0.85,0.10,0.15⟩	⟨(5,6,7); 0.70,0.25,0.30⟩
Business location	$\tilde{7}$	1	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(3,4,5); 0.60,0.35,0.40⟩	⟨(6,7,8); 0.90,0.10,0.10⟩

Origin of the business	$\tilde{7}$	$\tilde{3}$	1	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
Areas covered	$\tilde{7}$	$\tilde{5}$	$\tilde{3}$	1	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
Predominant gender	$\tilde{8}$	$\tilde{4}$	$\tilde{3}$	$\tilde{1}$	1	⟨(1,1,1); 0.50,0.50,0.50⟩
Stay time	$\tilde{6}$	$\tilde{7}$	$\tilde{3}$	$\tilde{3}$	$\tilde{1}$	1

Table 4. Paired matrix Neutrosophic AHP Saaty.

Criteria	Product or service	Business location	Origin of the business	Areas covered	Predominant gender	Stay time	WEIGHT	Ax Weight	Approx. Eigenvalues
Product or service	0.60	0.79	0.62	0.42	0.48	0.30	0.5138	3.92	7.6322
Business location	0.08	0.10	0.21	0.30	0.22	0.37	0.2148	1.46	6.7752
Origin of the business	0.08	0.04	0.08	0.14	0.14	0.12	0.1143	0.73	6.3841
Areas covered	0.08	0.02	0.03	0.06	0.05	0.12	0.0648	0.40	6.1512
Predominant gender	0.07	0.03	0.03	0.06	0.05	0.05	0.0482	0.31	6.4916
Stay time	0.10	0.01	0.03	0.02	0.06	0.05	0.0438	0.27	6.1158

Table 5. Determination of criteria weights applying the Neutrosophic AHP method.

The analysis of the consistency of the method showed that its own value is 6.59171, IC = 0.12, and RC = 0.09, so it is confirmed that the exercise was correct.

Neutrosophic TOPSIS

Alternatives / Criteria	Product or service	Business location	Origin of the business	Areas covered	Predominant gender	Stay time
P	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)
E	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)
S	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)
T	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)
E	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)	(0.50,0.50,0.50)
L	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)	(0.75,0.25,0.20)	(0.9, 0.1, 0.1)

Table 6. Performance matrix

Alternatives/ Criteria	**Product or service**	**Business location**	**Origin of the business**	**Areas covered**	**Predominant gender**	**Stay time**	**D +**	**D-**	**Ri**	**Hierarchy order**
P	0.420	0.494	0.404	0.456	0.491	0.438	0.029	0.100	0.772	4
E	0.489	0.420	0.505	0.485	0.427	0.487	0	0.130	1	1
S	0.489	0.525	0.505	0.485	0.534	0.487	0.008	0.128	0.938	2
T	0.195	0.210	0.202	0.097	0.106	0.097	0.128	0.001	0.013	6
E	0.274	0.284	0.262	0.291	0.309	0.292	0.094	0.035	0.272	5
L	0.479	0.420	0.464	0.475	0.427	0.487	0.009	0.124	0.929	3
Weights	0.489	0.525	0.505	0.485	0.534	0.487	/// ////			

Table 7. Weighted normalized matrix, Proximity calculation relative to the ideal solution, and hierarchical order

Conclusions

Informal trade in Ecuador is in a boom at an economic-social level that is currently being promoted by the situation of poverty in which the country is submerged. This implies that the activities carried out by informal traders are exponentially strengthened since the activity will continue to rise as long as there is a demand from the population. Traders start with the objective of generating resources and profitability that allow them to mobilize resources and have a favorable flow of money for them, but they end up causing negative impacts in the places where they take place. This is why the evaluation is necessary, which presents the following main results:

- The PESTEL analysis shows that there is a prevalence in the existence of negative impacts due to the growing informal trade in this locality. Despite the benefit that many people who work in it may obtain. The external view provided by the technique shows that both the economic and social aspects are substantially suffering because of this situation.
- We found that the criteria by which informal markets are governed and established are the following: product or service in high demand, location of the business in public spaces, the non-legal origin of the business, which presupposes a low initial investment cost, areas covered or extent achieved by the merchant, predominant gender, length of stay. With the proper development of these factors, informal merchants achieve an exponential impact as they achieve competitiveness, strategic and operational management.
- The experts consistently agreed that each of these criteria or factors is taken into account for the establishment of businesses, and that is why they cause the greatest impact within their successful development. Thus, if you want to reduce this rise in the informal market, you must initially establish policies and/or actions to regulate the variables of product or service offer, the location of the business, and its legal origin.
- The modeling through the application of the neutrosophic TOPSIS showed that the previous criteria mainly enhance the economic, social, legal, political, ecological impacts and finally, the technological ones where they do not have any incidence. Therefore, economic social strategies must be drawn up, with legal and political support, such as those proposed below:
  - Increased control by the authorities is needed.
  - In the Mariscal Market, coordinated actions must be taken so that merchants limit their aspirations to carry out illegal activity, as well as to minimize social mobility and include corrective measures and support for the informal sector in zonal planning.
  - Local authorities must carry out joint activities to deal with the problem and develop a plan that allows for the socialization of established public policies and the benefits they can have in informal trade.
  - Carry out socialization processes that limit the purchase to sellers who do not have identification as well as to reformulate the ordinance of use of public space.

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Selection of Criteria for the Prioritization of Information Technology Services in a Neutrosophic Environment

Luis Javier Molina Chalacan[1], Marco Antonio Checa Cabrera[2], Luz Marina Aguirre Paz[3] , Robert Vinicio Lalama Flores[4] and Arlen Martín Rabelo[5]

[1] Docente de la carrera de Sistemas. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador. Email: uq.luismolina@uniandes.edu.ec
[2] Docente de la carrera de Administración de Empresas. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador. Email: ui.marcocheca@uniandes.edu.ec
[3] Docente de la carrera de Sistemas. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: direccionadmision@uniandes.edu.ec
[4] Director. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador. Email: us.robertlalama@uniandes.edu.ec
[5]Exxis, Avda. Aviadores del Chaco N° 1669 c/ San Martin; Edif. Aymac I, 4to. piso, Asunción, Paraguay. Email: arlen.martin@exxis-group.com

Abstract. Nowadays, the provision of quality service should be the main goal of service companies. Those that provide information technology services have a greater challenge since technology is rapidly updating and pleasing customers in an enjoyable way is essential. The selection of certain criteria that allow prioritizing which client an information technology service is provided to, allows optimizing the working time of developers and technicians depending on the type of service demanded. Therefore, the objective of this work is to determine what criteria are necessary to develop software that allows prioritizing information technology services. We applied the Saaty AHP multicriteria method from the neutrosophic perspective by selecting the criteria from a Pareto Diagram.

Keywords: information technology, services, selection criteria, neutrosophic AHP, Pareto.

1 Introduction

As humanity evolves, it can improve the means and services necessary to guarantee a better development of economic, social, technological, and environmental activities, among others. An element that has distinguished this development is information technology, an element that has made a difference regarding others, since it is inserted in the social, economic, medical, and military sectors, in short, it is vital for the progress of each sector.

From the appearance of language in ancient times to the use of electronic devices and its digitization today, the evolution of information has made it possible to optimize the time it takes to provide products or services from large companies to institutions without profit. Technology, in this case, information technology, has favored innovation, the growth of the countries' economies, although more and more work is being done on its sustainability.

In 2015, the Sustainable Development Goals were proposed, key elements to guide the countries towards a transformation for economic, social and environmental sustainability. There are 17 of these goals and are reflected in the United Nations 2030 Agenda for Sustainable Development. Goal 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation", states that investments in infrastructure (transport, irrigation, energy, and information and communications technology) are essential to achieve sustainable development and empower communities in many countries [1]. In other goals, it is reflected how information technology contributes to reaching the goals for achieving the objectives (objectives 4, 5, and 17).

Therefore, information technology services are gaining strength in the business and institutional world, as they are increasingly demanded by customers who need them to achieve their objectives. The demand for these services tends to increase and a bottleneck may occur, which does not allow pleasing all customers efficiently and effectively. This is a reason to establish strategic criteria to provide quality service to customers and prioritize activities.

Within the consulted bibliography [2-25] it was possible to establish that there are no systematized criteria for prioritizing information technology services. Therefore, some proposals have been gathered that can serve as criteria to prioritize their selection. A service provider needs to know which customer will need attention first. Thus, if software is developed for the selection of clients to whom an information technology service is provided, it must be determined what criteria are necessary for the design and implementation of an application that manages prioritization criteria. That is why the objective of this research is established taking into account the use of the Analytic Hierarchy Process proposed by Tomas Saaty (AHP Saaty from this moment on).

When conducting a bibliography study on the subject [26-29], it was established that some authors have algorithmically sophisticated multi-criteria evaluation models, where hierarchical techniques such as AHP Saaty are used in conjunction with other heterogeneous methods related to decision-making. In addition to the fact that all the methods used are based on the criteria of experts in a majority way. In this research, the environment of uncertainty and possible uncertainties that this social phenomenon brings with it will be taken into account. The abovementioned is given because Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities. Its incorporation guarantees that the uncertainty of decision-making is considered, including indeterminacies where the experts will issue their criteria evaluating linguistic and not numerical terms [30-47].

According to the previous statements, we have defined as specific objectives of this work:

1. Establish strategic criteria
2. Selection of criteria to prioritize using Pareto Diagram
3. Determine prioritization through AHP Saaty in a neutrosophic environment and then apply it to decision-making regarding the criteria for software development.

2 Materials and methods

The following section describes the theoretical and empirical methods used throughout the current research to meet the specific objectives outlined. The methods used are listed below:

- Inductive, deductive: to verify the factors raised regarding the research topic in addition to structuring the research profile for its application.
- Analytical-synthetic: to compare all the phenomena involved in the research
- Historical-logical and descriptive-systematic: to analyze the problem situation of the research, it is intended to make a current observation of the phenomena for their interpretation.
- Surveys and interviews will be applied to the sample comprised of the target population and selected experts. Questionnaires were prepared aimed at obtaining information about the real problem and issuing possible solutions, to obtain valid conclusions and support the results.

Chain or network samples, known as snowball, are where key participants are identified and added to the sample, they are asked if they know other people who can provide more extensive data, and once their data is obtained, they are included. In other words, it is a non-probability sampling technique in which the experts give information about other known experts. Thus, allows access to difficult-to-sample experts, is an easy and inexpensive process [48].

The Pareto Diagram was presented by JM Jurán in his Quality Control Manual based on what was described in 1909 by V. Pareto under the principle of "the few vital, the many trivial". This diagram is based on problem analysis and is used to present data, drawing attention to the causes of great incidence in the problem in question. Aims to determine 20% of the causes that provoke 80% of the problems [49, 50].

Its main advantages are:

- It allows focusing on the aspects whose improvement will have the most significant impact, thus optimizing efforts.
- Provides a quick and easy view of the relative importance of issues.
- It helps prevent some causes from getting worse by trying to fix other less significant ones.
- His graphical view of the analysis is easy to understand and encourages the team to continue with improvement.

The following algorithm is used to execute the method:

1. Collect the data and tabulate it.
2. Calculate absolute and cumulative frequency, unit, and cumulative relative frequency.
3. Graph by locating all the causes along the coordinate axis ordered from highest to lowest incidence and correspond with their percentages along the ordinate axis. Finally, the cumulative polygonal line is built, and the causes that are up to 80% will be the ones with the highest incidence.

Neutrosophic AHP Saaty: The hierarchical analytical process was proposed by Thomas Saaty in 1980 [30]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [31, 32]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [33], [34, 35]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels [36]. Finally, the levels of importance or weighting of the criteria are estimated using pair-wise comparisons between them.

For the description of the method, the following definitions must be presented:

Definition 1: ([51, 52]) The Neutrosophic set N is characterized by three membership functions, which are the truth-membership function TA, indeterminacy-membership function IA, and falsehood-membership function FA, where U is the Universe of Discourse and ∀x∈U, TA (x), IA (x), FA (x)⊆] -0, 1+ [, and -0≤inf TA (x) + inf IA (x) + inf FA (x)≤sup TA (x) + sup IA (x) + sup FA (x)≤3+. Notice that, according to the definition, TA (x), IA (x) and FA (x) are real standard or non-standard subsets of] -0, 1+ [and hence, TA (x), IA (x) and FA (x) can be subintervals of [0, 1].

Definition 2: ([51, 52]) The Single-Valued Neutrosophic Set (SVNS) N over U is A = [48], where TA: U→[0, 1], IA: U→[0, 1], and FA: U→[0, 1], 0 ≤TA (x) + IA (x) + FA (x)≤ 3. The Single-Valued Neutrosophic Number (SVNN) is represented by N = (t, I, f), such that 0 ≤t, I, f ≤ 1 and 0 ≤t + I + f≤ 3.

Definition 3: ([51-54]) the single-valued trapezoidal neutrosophic number, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on ℝ, whose truth, indeterminacy and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & a_2 \le x \le a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \le x \le a_4 \\ 0, \text{ otherwise} \end{cases} \tag{1}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{2}$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Where, and. $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$ $a_1, a_2, a_3, a_4 \in \mathbb{R} a_1 \le a_2 \le a_3 \le a_4$

Definition 4: ([55]) given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Subtraction: (4)$\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$

Inversion: where.$\tilde{a}^{-1} = \langle (a_4^{-1}, a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle a_1, a_2, a_3, a_4 \neq 0$

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{Bmatrix} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{Bmatrix}$$

Definitions 3 and 4 refer to single-valued triangular neutrosophic number when the condition a2 = a3, [56-58]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in[59]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6)[60].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \tag{5}$$

We can find in [59] the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP or NAHP for short. Equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{6}$$

The matrix must satisfy the condition, based on the inversion operator of Definition 4. $\tilde{A}$ $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [59].

They are the so-called score and accuracy indexes, respectively, see Equations 7 and 8:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{7}$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \tag{8}$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [61]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 6.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, ie., Aik = aijajk for all i, j and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it into a deterministic matrix using Equations 9 and 10. To get the score and the accuracy degree of the following equations are used:$\tilde{a}_{ji}$

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \tag{9}$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \tag{10}$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{11}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Note that Step 3 refers to consider the use of the calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ [62]}, \tag{12}$$

where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by equation:

$$CR = \frac{CI}{RI} \tag{13}$$

RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated with every order.

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent and hence we can proceed to use NAHP. We apply this procedure to matrix "A" in Equation 12.

3 Results

For a case study, the following bibliography was consulted [2-24] where we found that the most representative criteria for the analysis in question are:

- Customer satisfaction in previous services
- Type of work to be done
- Distance between the client and the company
- Availability of material and human resources to carry out the work
- Type of work carried out by the client
- Increased number of services offered to customers
- Clients that bring greater benefits to the company
- Service request order
- Facilities assured by the client
- Mobility towards the client

For the ratification of these criteria, we consulted through the snowball method a panel of experts who are related to information technologies and work in various institutions, both in companies and in entities budgeted. A semi-structured interview was applied to them to determine criteria for the prioritization of information technology services through software. From the interviews carried out with the experts, the influence of the criteria was determined, which was plotted using a Pareto Diagram. As shown in Figure 1, 6 criteria that influence 80% of the most important criteria were selected.

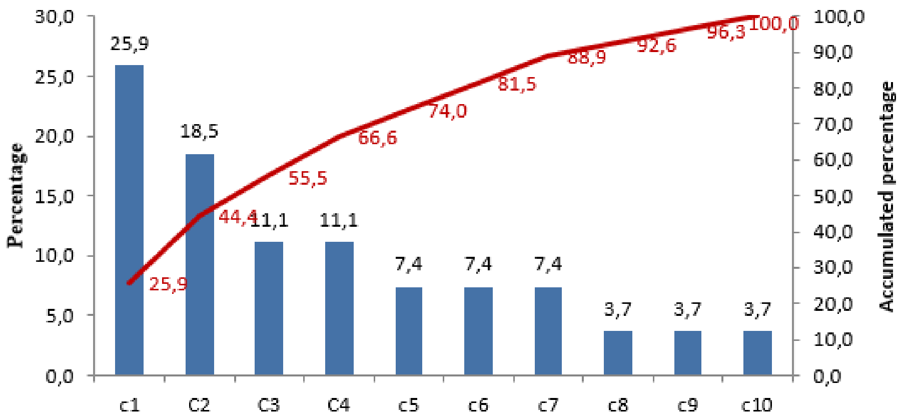

Figure 1: Pareto chart for the selection of criteria.

Legend: Criteria

1. Request order
2. Type of work to be done
3. Clients with greater financial solvency and joint work time
4. Priority of the work performed by the client
5. Mobility towards the client
6. Availability of material and human resources
7. Distance between the client and the company
8. Facilities provided by the client
9. Greater number of services offered per client
10. Customer satisfaction

As a result, the AHP Saaty is applied to the following criteria: Order of the service request; Type of work to be done; Clients that bring greater benefits to the company; Type of work carried out by the client; Mobility towards the client and Availability of material and human resources to carry out the work

Criteria	c1	c2	c3	c4	c5	c6
c1	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(4,5,6); 0.80,0.15,0.20⟩
c2	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(4,5,6); 0.80,0.15,0.20⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
c3	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
c4	$\frac{1}{⟨(4,5,6);\ 0.80,0.15,0.20⟩}$	$\frac{1}{⟨(4,5,6);\ 0.80,0.15,0.20⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩
c5	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩
c6	$\frac{1}{⟨(4,5,6);\ 0.80,0.15,0.20⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	$\frac{1}{⟨(2,3,4);\ 0.30,0.75,0.70⟩}$	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩

Table 3: AHP Saaty Neutrosophic paired matrix.

Criteria	c1	c2	c3	c4	c5	c6	WEIGHT	Ax Weight	Approx. Eigenvalues
	0.42	0.58	0.38	0.33	0.21	0.36	0.378	2.55	6.7477
	0.14	0.19	0.38	0.33	0.21	0.21	0.243	1.68	6.8892
	0.14	0.06	0.13	0.20	0.21	0.21	0.159	1.03	6.4660
	0.08	0.04	0.04	0.07	0.21	0.07	0.086	0.53	6.2251
	0.14	0.06	0.04	0.02	0.07	0.07	0.068	0.42	6,2006
	0.08	0.06	0.04	0.07	0.07	0.07	0.066	0.43	6.4918

Table 4: Determination of criteria weights applying the Neutrosophic AHP method.

When performing the consistency analysis, according to the proposed method, an eigenvalue of 6.5034 was obtained, IC = 0.10 and RC = 0.08, which allows us to affirm that the exercise was carried out correctly.

As could be seen, services should be prioritized according to the following order of criteria:

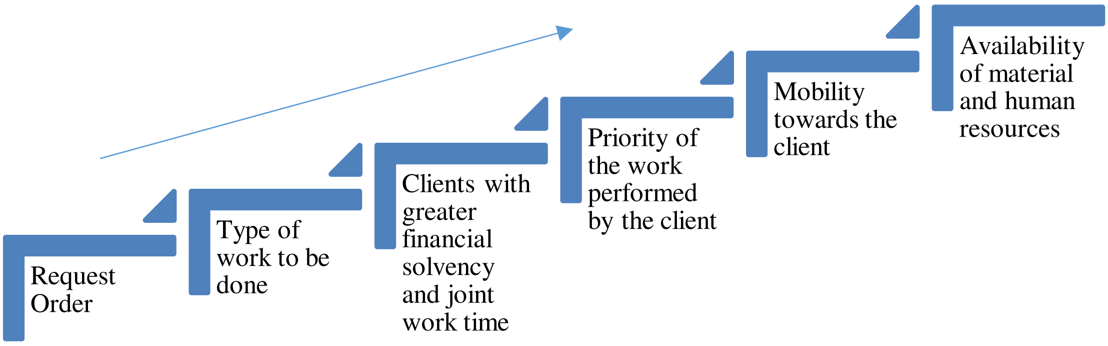

Figure 2: Criteria prioritization.

The work team in charge of programming should consider this as the primary source of data in the interface of the designed software. In this way, when the user interacts with the product, they will be able to provide feedback on the designed system.

Conclusion

Once the investigation was completed, the following conclusions were reached:

- The selection of criteria for the development of software optimizes the time to provide customer service, facilitates the presence of the product in the market and meets the skills required for this type of company. Customer satisfaction brings along increased profits for the company and the request for new services increasing the profits and prestige of the company.
- The use of neutrosophic language for the realization of the paper was important since the nature of the exercise requires it. Mainly for the determination of the criteria to work, where the application of the Pareto Diagram was successful. According to the Pareto Diagram, respect for the order of the service request by customers allows the client to feel important and empowered. The rest of the criteria that were not selected more frequently by the experts should be analyzed in the strategic themes of the company, due to their possible repercussions.
- In the case of the analysis carried out using the AHP Saaty Neutrosophic technique, it complemented what was stated in Pareto's definition. It was revealed that in order of importance, the experts place the following hierarchical order of the criteria:

  - ✓ Order of service request is a topic valued by customers;
  - ✓ Type of work to be done;
  - ✓ Clients that bring greater benefits to the company;
  - ✓ Type of work carried out by the client;
  - ✓ Mobility towards the client; and
  - ✓ Availability of material and human resources to carry out the work.

- After receiving their request, the need to please customers is important in the measurement of the AHP Neutrosophic Saaty. Given the urgency of the use of new technologies, it is essential to apply the services that a company can provide to itself, and other competing companies.

- One of the elements that must be taken into account in this work, is recommended to keep the portfolio of services that an information technology company can provide updated. In the same way that technologies are regenerated very quickly at present, the application of this type of exercise regularly, allows the company and the software to be in continuous improvement for greater customer satisfaction, which leads to the generation of greater benefits.

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Neutrosophic Research Method for the Analysis of Indeterminacy on Academic Visibility for Quality Digital Inclusion

Rita Maricela Plúas Salazar[1], Germánico René Tovar Arcos[2], Raúl Ruperto Pánchez Hernández[3] and Ariana Daniela Del Pino Espinoza[4]

[1] Universidad Estatal de Milagro, Guayas Ecuador. Email: rpluass@unemi.edu.ec
[2]Universidad Estatal de Milagro, Guayas Ecuador. Email: gtovara@unemi.edu.ec
[3]Universidad Estatal de Milagro, Guayas Ecuador. Email: rpanchezh@unemi.edu.ec
[4]Escuela Superior Politécnica del Litoral, Guayas, Ecuador. Email: ariddel@espol.edu.ec

Abstract. This paper aims to promote educational inclusion and achieve a positioning that makes visible the actions involved in this academic process. It has as a reference a project aimed at families of students with SEN during their schooling, this need arises due to the difficulties that parents have to deal with the academic performance of children and adolescents. Technology in the educational context is the new trend in the process of teaching and learning in students, the media and digital education are the tools now to promote educational inclusion in the Ecuadorian context. It is intended to implement the activities immersed within the programs covered by the project, reach homes, regionally, nationally, and internationally on the management carried out in the chosen population, which are children with SEN. This study corresponds to a mixed research design, The neutrosophic research method was used for the analysis and indeterminacy through the neutrosophic descriptive statistics. The results obtained indicate a clear interest of students in the virtual environment and make use of the various tools that can be provided to improve learning conditions.

Keywords: digital visibility, advertising, inclusion, virtual education, social networks, neutrosophic research method, neutrosophic descriptive statistics

1 Introduction

The digital world has become a trend nowadays, given the health circumstances that are experienced in all contexts; for this reason, it has been necessary to migrate human activities to the screen environment to somehow continue with the development of social systems. In the educational field, it has been proposed that all kinds of academic activities be carried out through platforms to maintain the educational system of children and adolescents[1].

This new form of teaching has represented a real challenge for parents, given that they must guide their children in the academic accompaniment of their activities, especially in the case of those families who have infants with Special Educational Needs (SEN) associated with disability[2]. The role of parents has always been to provide the necessary tools for the optimal development of their children; however, they are not prepared to be able to meet their needs from the educational environment, thus being one more need that is generated in the sector community.

This research deals with the demonstration of the development of a project that meets the satisfaction of those needs that parents require, an orientation through a preparation process to be able to meet the educational needs of their children. It is important to highlight that assisted education at home where the leading figures are the guide for the children, in this case, their parents, must have a specific preparation to understand the nature of education in the sense of personalized teaching that should be imparted to this population of children and adolescents[3].

For the authors [4], from the perspective of educators, attention must be paid to the possibility that students leave their role and responsibilities at school if they are not encouraged appropriately. Ideally, the school should add the student and take him with it, not leave him behind at the end of each class. Therefore, parents must be included and understand that it is also on their part to encourage the study and active participation in the learning process of their children [5].

According to [6] it is essential that the family understand the role of the student in school and understand that they have duties, responsibilities and that they assume these commitments. As has been said, the family and the institution must work together, but from the moment that the parents interfere in the process that is focused between the school and the student, new problems tend to arise and the most affected is the student himself[7].

Communication should go beyond applying activities and asking parents to supervise their children. Make space for parents to talk about the educational institution and give their opinion on everything that is being done. This feedback is of utmost importance to improve this methodology of distance classes, which was little explored by schools until then, especially at the levels of basic education, secondary and early childhood education[6]. In this work, a study of these phenomena is carried out using the neutrosophic research method and neutrosophic statistics.

Synchronous tools

Synchronous Tools require the participation of teachers and students in scheduled events, with specific times for their completion. They are carried out in real-time (online), for years, for some of the EADs and teachers, as well as for all those involved in the institution, the groups and communities interact instantly and with the feeling of perseverance in the continuity of their course[7].

The chat (chat room), with educational potential to be studied, that is little used in pedagogical activities, allows synchronous communication between different people who are connected at any given time. Literature studies or the pedagogical use of chat are still incipient, most of these materials are limited to assimilate their specific characteristics, they will go into details about their specific possibilities. In addition, it is necessary to carry out experimental studies related to its use as a communication tool and pedagogical tool, generating learning and mechanisms to overcome the difficulties and limitations it offers, not using Chat for learning[8].

Videoconferencing is a form of interactive communication that allows two or more people to be in different places, where they can meet face to face with auditory and visual communication in real-time. Its use presents a series of benefits: saving time, avoiding physical relocation to a special place, and saving, with the reduction of two expenses with more travel resources, so that the meeting can be recorded and available later[9].

Research method basics and neutrosophic statistics

The neutrosophic research method is a generalization of Hegel's dialectic (dynamics of opposites: <A> and <antiA>). It suggests that scientific and humanistic research will progress by studying not only opposing ideas but also the neutral ideas related to them to have a broader vision of the whole problem to be solved. These ideas are based on neutrosophy (study of opposites and their neutrals: <A> and <antiA> and <neutA>), a new philosophy created by the Romanian researcher Florentín Smarandache [10]

In neutrosophy, to resolve the contradiction between opposites $\langle A\rangle$ and $\langle \text{anti}A\rangle$ (thesis and antithesis), the neutral $\langle \text{neutral}A\rangle$ contributes to one side or the other or both (neutrothesis). The contradiction is resolved in neutrosynthesis. Thus, the triad of dialectics (synthesis, thesis, and antithesis) is expanded to a quadruple by neutrosynthesis (thesis, antithesis, neutrothesis, and neutrosynthesis) providing a better reflection of reality.

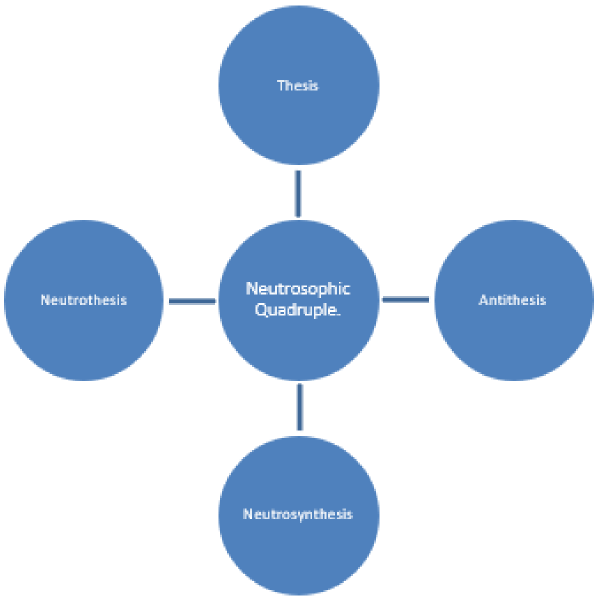

Figure 1. Neutrosophic Quadruple.

Neutrosophic Statistics extends the classical statistics, such that we deal with set values rather than crisp values. Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics and Neutrosophic Inferential Statistics consists of methods that allow the generalization from a neutrosophic sampling to a population from which it was selected the sample.

Neutrosophic Descriptive Statistics comprises all the techniques to summarize and describe the characteristics of neutrosophic numerical data [11]

To calculate the neutrosophic absolute frequency, as there is imprecise information, it is necessary to calculate the extremes (min and max) of the absolute or estimated frequencies.

$$mín_{fn} = 15 + 20 + 25 + 10 = 70$$

$$máx_{fn} = 15 + 30 + 25 + 24 = 84$$

Then, to calculate the neutrosophic relative frequencies, we must calculate the minimum and maximum values of these for each tabulated result. For this, the following formula will be applied:

$mín_{fnri} = \frac{mín_{fni}}{máx_{fn}}$, and $máx_{fnri} = \frac{máx_{fni}}{mín_{fn}}$

For the case of frequencies that do not present indeterminacy, it is true that:

$$mín_{fni} = máx_{fni} = fni$$

The value of the accumulated neutrosophic relative frequency was obtained by adding the observed neutrosophic relative frequencies, for example:

$$Frna = [0.179\,, 0.214] + [0.238\,, 0.429] + [0.298\,, 0.357] + [0.119\,, 0.2] = [0.833\,, 1.2]$$

2 Materials and methods

The neutrosophic research method was used for the analysis and indeterminacy through the neutrosophic descriptive statistics [12-16]. The information obtained for the preparation of the research is from bibliographic information and the data collection through instruments that contain qualitative indicators. An observation record of the development of behavioral skills was also designed, both instruments with multiple alternatives.

For the information processing, as for the scientific papers, a careful reading of their key aspects was carried out, such as the objectives, the methodology, and the results obtained. This way it can be perceived how these documents can significantly contribute to the theoretical construction of this research its processing through the interpretive hermeneutical method to synthesize information and be able to know reality. On the other hand, for the information collected through observation, the Microsoft Excel program was used through the descriptive analysis of neutrosophic frequencies, to be able to analyze the data quantitatively and include the determination, and thus to be able to contrast results with regard to the problem.

Analysis of results

The information obtained from the observation is summarized below, including the indeterminacy of the observation process. In this table, you can see the ability to handle didactic tools for learning

Use alternative language (Sign Language, Braille, or Sign Language)		
	Frequency	**Neutrosophic absolute frequency**
Always	[2.4]	[0.143, 0.5]
Sometimes	[3.7]	[0.214, 0.875]
Never	3	[0.214, 0.375]
Total	[8.14]	[0.571,1.75]

Table 1. Descriptive neutrosophic statistics on the use of teaching resources

The use of goes from 3 to 7 students who use it sometimes, never 3 and always from 3 to 4. The information is represented graphically below

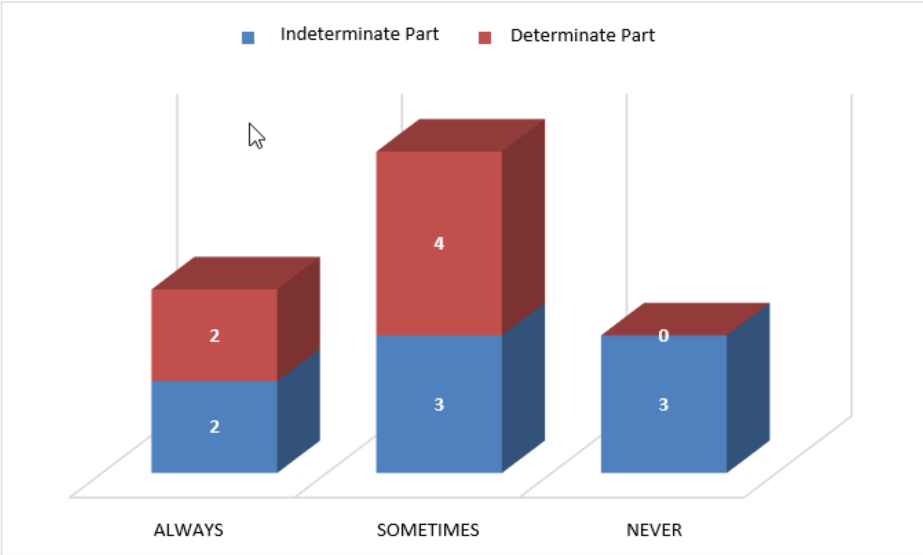

Figure 2. Descriptive neutrosophic graph of use of teaching resources

This table shows the ability to read through the use of pictograms (logos, brands, or symbolic aspects).

Read pictographically (logos, brand, or symbolic locations)		
	Frequency	Neutrosophic absolute frequency
Always	[2.6]	[0.143, 0.75
Sometimes	3	[0.214, 0.375]
Never	[3.5]	[0.214, 0.625]
Total	[8.14]	[0.571,1.75]

Table 2. Descriptive statistics of pictographic reading ability.

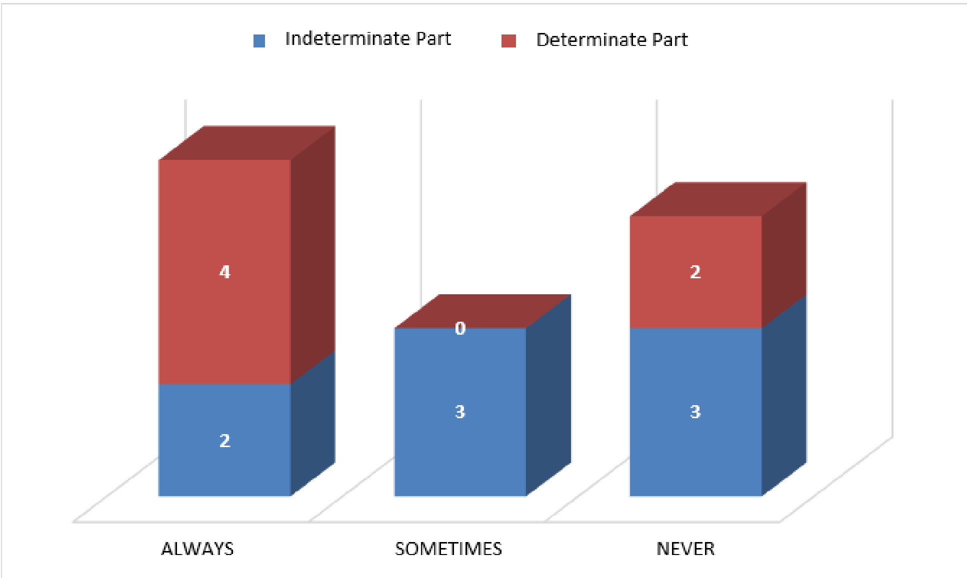

Figure 3. Neutrosophic graph of pictographic reading ability.

Where 2-6 students always refer to making use of this methodology, and on the other hand, those who have never used 3 to 5, and finally there are those who sometimes use 3.

Discussion

Some investigations have analyzed this type of tool within the school context. For this, the authors [19] carried out a study on the various school activities that can most serve as a means of knowledge in students and selected reading. Their methodology was action research, for which they designed a blog and uploaded certain contents of a subject, after which the students were given the same physical material, as results were obtained that the students visited the web page more to read the content.

They conclude that the virtual environment in a correct adaptation and with attractants of interest such as the subjects taught captures people's attention, above the traditional reading media. This research agrees with the need for a better implementation of virtual activities for better learning.

Another research developed by [20] deals with trends in virtual education applied through the design of institutional platforms. His work focused on being able to locate educational institutions that promote virtual practice through the implementation of school and secondary activity using the online modality. Its research model was qualitative because it collected information from statistically proven facts, such as the effectiveness of the use of the platform, the new forms of interaction on the pages, the dissemination of information through social networks and the expansion of academic advertising in the Web.

Results indicate that few education centers allocate digital resources to complement the teaching process of students in the Latin American context. For this reason, the prevailing need to be able to promote and open spaces that allow increasing the interest and need for power is perceived connect education with virtuality.

Conclusions

Education in current times has had to reinvent itself, the modality that is being lived is nothing more than an approach that has had an unexpected impact on the student community, however, despite the sanitary conditions that are currently being experienced, it has become a unique choice to be able to continue with the studies.

The results obtained indicated an evident interest on the part of the students in being increasingly involved in the online modality, since, far apart from education in recent years, the increase in the use of technology has appropriated the interest and attention of people, nowadays in all ages. Therefore, implementing the educational model through this trend has not been a very complex work, but it is not very adaptive, due to the lack of a culture of participation in virtuality.

The use of the neutrosophic method and the neutrosophic statistics allow adequate management of the uncertainty and indeterminacy in the observation process. In future work, the use of new statistical methods based on neutrosophic theory will be proposed.

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Definition of Strategies in Ecuadorian Hospitals in a Plithogenic Environment

María Fernanda Cueva Moncayo[1], Lina Espinosa Freire[2], Lenin Carlos Gabriel Flores[3] and José Luis García Delgado[4]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.mariafcueva@uniandes.edu.ec
[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.linaespinosa@uniandes.edu.ec
[3] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.leningabriel@uniandes.edu.ec
[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.josegarcia@uniandes.edu.ec

Abstract. The modeling of a SWOT matrix in a plithogenic environment is an excellent decision support tool that allows selecting alternatives most effectively and optimally. Then, it gives rise to the approach of how to develop an adequate SWOT matrix for hospitals that allows the study and definition of strategies in a plithogenic environment. To solve the problem, the main objective of the research is to develop a SWOT matrix using plithogenic sets. Given the fact that if an adequate strategy that includes uncertainty is implemented, it will be possible to provide an effective tool that optimizes the decision-making process. A theoretical framework of the SWOT matrix will be developed to achieve this objective, and a method for its processing in a neutrosophic environment will be implemented. Afterward, it will be applied to the actual situation of Ecuadorian hospitals and pertinent strategies will be proposed.

Keywords: SWOT, uncertainty, Plithogeny, hospital institutions, strategies.

1. Introduction

Today there is a fiercely competitive environment characterized by low-profit margins, high consumer expectations for quality products and efficient workforce, where organizations are forced to seize any opportunity to optimize and avoid threats in their business processes regardless of their social object [1, 2]. Initially, strategic management had been widely used by companies to face fierce market competition, so it was only associated with obtaining economic benefits since the strategic management process consists of three stages: formulation of the strategy, strategy implementation, and strategy evaluation [3]. Despite this, entities of various types have currently appropriated this tool, such as in the case of hospitals [2, 4-6].

Originally, this analysis was designed to provide a complete study of companies in other types of industries. However, as time has passed, people who saw its benefits are also bringing its use in the healthcare industry [7]. The hospital and healthcare industry is made up of hundreds of licensed operators that offer a range of services that are often lucrative and constitute a representative part of the countries' Gross Domestic Product. Especially in the environment of uncertainty created by the Covid-19 pandemic, where the health system has been collapsed. Therefore, it is necessary to carry out a thorough and detailed analysis to provide the best strategy to follow. Due to the extension of medical services, whether public or private, it is advisable to apply a business management strategy to strengthen its insertion as a service provider [8].

The health services sector has experienced a growing demand, including health tourism as a form of consumption within current trends, which is coupled with the exacerbation of chronic diseases and the aging of the population. There has been an increase in capital inflows in hospitals of various countries such as Brazil, Mexico, Singapore, and Thailand from health tourists. That is, residents of developed countries from the United States and Great Britain for example, have found an economic solution: health tourism in these less developed countries such as those mentioned above. Therefore, it has contributed to the generation of foreign exchange and employment [9].

In Ecuador, hospitals have a similar situation, where it is necessary to achieve the established objectives on a solid basis. Therefore, managers must ensure that they follow due process regarding the establishment or management of the institution. It is essential to work with a detailed SWOT (Strengths, Opportunities, Weaknesses and Threats) analysis [8, 10, 11]. This analysis allows the evaluation of an organization from a neutral perspective through a detailed discussion of the strengths, weaknesses, opportunities and threats [7]. It could be said that to guarantee that a hospital or health center or another form of business works to the maximum, it is necessary to make certain adjustments endorsed in a tool of this nature [4, 7, 12-14]. It is necessary to clarify that in this research the term SWOT will be chosen to refer to the technique.

Despite the positive in the use of the tool, for the decision-making process regarding the strategy to be taken, the use of multi-criteria methods is preferred for the SWOT processing [1], where the statistic is denoted in its classical and neutrosophic versions. In this way, deficiencies and/or inaccuracies due to the subjective nature of the technique in the measurement and evaluation steps are eliminated [4, 13]. In this particular case, the authors preferred to link Neutrosophy since imprecision is involved throughout the whole process, and it makes the study more natural and allows achieving a greater enrichment in the analysis when formulating strategies [15-18].

It can be said then, that the modeling of a SWOT matrix processed in a neutrosophic environment is convenient since the classical method may be less appropriate. So, it is necessary to have a decision-making support tool that allows the most effective and optimal selection of the steps to be followed by these types of institutions that provide such a broad service to the population [17, 19, 20]. The following problem is formulated: how to develop a SWOT matrix for hospital institutions that allows the study and definition of strategies in a plithogenic environment? For the solution to the problem, the main objective of the research is to develop a SWOT matrix, using plithogenic sets since if an adequate strategy that includes uncertainty is implemented, it will be possible to provide an effective tool that optimizes the process of decision-making. To achieve this objective, the following specific objectives must be executed:

1. Develop a theoretical framework of the SWOT matrix
2. Develop a method for processing by plithogenic assemblies.
3. Apply method to the current situation of health institutions today in Ecuador
4. Propose strategies

From now on, the report of the present investigation is made up of several sections where the used methods are exposed, a case study is carried out, and then the results, discussion, and conclusions of the investigative exercise are exposed.

2. Theoretical framework of SWOT analysis

Over the years, various approaches and criteria on strategic management have been enunciated in management theory. Result of the accumulation of research and studies on the subject, which has contributed to the enrichment and improvement of the theory to become the most used management tool in the world. The use of strategy in management theory appears in the early years of the 60s of the 20th century and emerges as a way for organizations to respond to the challenge imposed by increasing instability, uncertainty and competition on the market which got more and more intense every day [1, 5, 12, 21].

The approach to organizational strategies became widespread globally, both in profit-making and non-profit companies, until it became one of the most universally used management tools [1, 5]. Despite the diversity of research, there is uniformity in the use of the SWOT matrix for strategic analysis regardless of the corporate purpose or type of company, business, institution; due to the impacts that it generates on the strategic management of organizations in general [1, 4, 13, 14, 21-23].

	External	
Internal	**Opportunities**	**Threats**
Strengths	Try to make the most of the opportunities. Offensive Strategy Maxi - Maxi	Minimize threats by relying on strengths. Defensive Strategy Maxi -Mini
Weaknesses	Reduce or eliminate weaknesses to take advantage of opportunities. Adaptive Strategy Mini - Maxi	Resist without having to give in so as not to lose positions. Survival Strategy Mini - Mini

Table 1. High impact matrix Source: [24]

The study of strategic planning SWOT is a tool that allows raising a picture of the current situation of a group, company, or organization. In addition, it makes it possible to accurately diagnose the organization and, based on this, allow decisions to be made according to the objectives and policies [12]. That is why it is said to be an advanced strategic planning model that helps companies and organizations identify where they are doing well and where they can improve, both from an internal and external perspective. The strengths and weaknesses are internal to the organization, while the opportunities and threats are of external origin being the strengths and opportunities useful for the strategy of your organization, and the weaknesses and harmful threats. Importantly, this analysis is not a final product: it is the first step to help align the strategy around the areas that have been identified as strengths, weaknesses, opportunities, and threats [1, 4, 8, 13, 14, 23, 25].

On [12], they say that:

- Strengths: Are special capabilities of the group or company to be analyzed, instruments that give it a privileged position in the face of the competition. Capacities and abilities that are possessed, resources that are controlled, activities that are developed positively, among others.
- Opportunities: Factors that are positive, favorable, and exploitable that must be discovered in the environment in which the group or company operates and that allow obtaining competitive advantages.
- Weaknesses: Factors that cause an unfavorable position in the face of the competition, resources that are lacking, skills that are not possessed, activities that do not develop positively, and so on.
- Threats: Situations that come from the environment and that can even threaten the permanence of the organization.

For the classic matrix, the following steps must be performed:

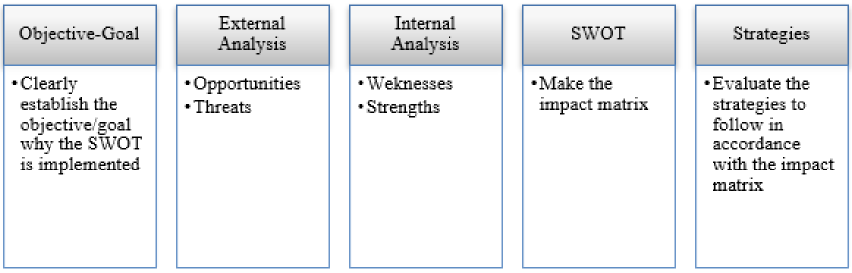

Figure 1. Steps for the elaboration of the SWOT. Source:[7]

Based on the results of the SWOT analysis, the strategic recommendations for the company should be focused on how the institution can [7]: counteract the weaknesses, enhance the strengths, seize opportunities, defend from a threat. At this point, you must also choose one of the normative strategies set out in table 1, which are explained by [26]:

- Defensive strategy is one to be developed to improve weaknesses and that these do not make the threats in the environment even more threatening.
- Reactive strategy will be developed to further reinforce strengths and eliminate threats.
- Adaptive strategy will consist of strengthening weaknesses so that they do not impede taking advantage of opportunities.
- Offensive strategy is the one that will offer the possibilities to take advantage of the opportunities thanks to the fact that the position in the sector is still being strengthened.

3. Methods

The methods used for the development of the research are exposed below:

- Scientific Method: allows getting to know the phenomena that occur in nature and society, by combining comprehensive reflection and direct contact with objective reality.
- Inductive and Deductive Method: with its application, it is possible to know the reality of the problem under investigation, starting from the particular to the general and from the general to the particular of the problem.
- Historical Method: it allows knowing the source and the progress of the problem to compare it with its actuality.
- Descriptive Method: with its application, it is possible to objectively describe the current reality in which the problem develops and thus evidences the aspects of the SWOT.
- Surveys: they are applied to experts who are nothing more than the actors who will intervene in decision-making.

As previously stated for the processing of SWOT, a neutrosophic environment in its plithogenic extension is convenient, since uncertainty is dealt with within the process and decision-making can be more natural. Therefore, for a better understanding, interesting knowledge about mathematical modeling using plithogenic logic is presented below.

Smarandache introduced Neutrosophic sets into the literature because fuzzy intuitionistic sets could only handle incomplete information, but not the indeterminate and inconsistent information, which commonly exists in fuzzy systems. The term neutrosophy means knowledge of neutral thought and this neutrality represents the main distinction between fuzzy logic and fuzzy intuitionist [27]. In neutrosophic sets, the indeterminacy is explicitly quantified through a new parameter I. True membership (t), indeterminate membership (I), and false membership

(F) are independent of each other and the sum between them satisfies the inequalities $0 \leq T + I + F \leq 3$. In fuzzy intuitionistic sets, the uncertainty depends on the degree of membership and the degree of non-membership [28]. In neutrosophic sets, the indeterminacy factor (I) is independent of the true and false values. There are no restrictions between the degree of truth, the degree of indeterminacy, and the degree of falsehood [29, 30].

If U is a universe of discourse, a Neutrosophic Set (CN) is characterized by three membership functions, $uA(x), rA(x), vA(x) : X \rightarrow \ ]0-, 1+[$, which satisfy the condition $0 \leq -\inf uA(x) + \inf rA(x) + \inf vA(x) \leq \sup uA(x) + \sup rA(x) + \sup vA(x) \leq 3+$ for all $x \in X$. $uA(x), rA(x)$ and $vA(x)$ are the membership functions of the truth, the indeterminacy, and the falsehood of x in A, respectively and their images are standard or non-standard subsets of $]0-, 1+[$. When approaching the perspective of indeterminacy and contradiction, as is the case with Gödel's incompleteness theorem, it states that any proposition in a mathematical axiom system will present a degree of truth (T), falsehood (F), and indeterminacy (I). Neutrosophy, therefore, establishes a unique solution for the existence of paradoxes in philosophy [31].

Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and mergers of multiple contradictory and/or neutral and/or non-contradictory previous entities. Plithogeny advocates the connections and unification of theories and ideas in varied fields of science. "Knowledge" is taken as "entities", in various fields, such as social sciences, technical sciences, theories of arts and letters, and so on [32].

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of a type of opposites: <A> and <antiA>), neutrosophy (dynamics of a type of opposites and their neutrals: <A> and <antiA> and <neutA>) , since Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites (<A> and <antiA> and <neutA>, <B> and <antiB> and <neutB>, etc.), and many do not opposites (<C>, <D>, etc.) all together. As an application and particular case derived from Plithogeny, the plithogenic set is an extension of the classical set, fuzzy set, fuzzy intuitionist set, and neutrosophic set, and has multiple scientific applications[32].

So, (P, a, V, d, c) is called a plithogenic set

a) Where "P" is a set, "a" is an attribute (multi-dimensional in general), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x to the set P with respect to some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P;
b) "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.

Functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that experts need to solve.

Then, the following notation is used: $x(d(x,V))$, where $d(x,V) = (d(x,v)$, for all $v \in V), \forall x \in P$.

The attribute value contradiction degree function is calculated between each attribute value with respect to the dominant attribute value (denoted by) in particular, and also for other attribute values.v_D

The attribute value contradiction degree function is calculated between each attribute value with respect to the dominant attribute value (denoted by v_D) in particular, and with respect to other attribute values as well.

The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication (⟹), equivalence (⟺), inclusion (partial order), and other plithogenic aggregation operators that combine two or more degrees of values of the attribute based on a t-norm and a t-conorm. Most plithogenic aggregation operators are linear combinations of a fuzzy t-norm (indicated by) with a fuzzy t-conorm (indicated by), but nonlinear combinations can also be constructed. $\wedge D$ and $\vee D$ [33]. If the t-norm is applied on the value of the dominant attribute denoted by, and the contradiction between and is, then it is applied on the value of the attribute as follows:

$$1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2) \quad (1)$$

Or, using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2) \quad (2)$$

Similarly, if the t-conorm applies to the value of the dominant attribute denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then v_2 applies to the value of the attribute as follows

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2) \quad (3)$$

Or, using symbols:

$$[1-c(v_D,v_2)]\cdot(v_D \vee_F v_2)\ +\ c(v_D,v_2)\cdot(v_D \wedge_F v_2) \tag{4}$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1,a_2,a_3)\wedge_P(b_1,b_2,b_3)\ =\ \left(a_1\wedge_F b_1,\frac{1}{2}[(a_2\wedge_F b_2)+(a_2\vee_F b_2)],a_3\vee_F b_3\right) \tag{5}$$

The plithogenic neutrosophic junction is defined as:

$$(a_1,a_2,a_3)\vee_P(b_1,b_2,b_3)\ =\ \left(a_1\vee_F b_1,\frac{1}{2}[(a_2\wedge_F b_2)+(a_2\vee_F b_2)],a_3\wedge_F b_3\right) \tag{6}$$

In other words, with respect to what applies to membership, the opposite applies to non-membership, while in indeterminacy what appies is the average among them. Plithogenic neutrosophic inclusion is defined as follows:

Since the degrees of contradiction are:

$c(a\_1,a\_2)\ =\ c(a\_2,a\_3)\ =\ c(b\_1,b\_2)\ =\ c(b\_2,b\_3)\ =\ 0.5,$

We apply, $a_2\geq\ [1-c(a_1,a_2)]b_2$ o $a_2\geq\ (1-0.5)b_2$ o $a_2\geq\ 0.5b_2$, while $c(a_1,a_3)\ =\ c(b_1,b_3)\ =\ 1$

So, having the opposite being true for $a_1\leq b_1$ if and only if $a_3\geq b_3$, therefore $(a_1,a_2,a_3)\leq_P(b_1,b_2,b_3)$ if and only if $a_1\leq b_1$, $a_2\geq\ 0.5b_2$, y $a_3\geq b_3$. Next, an algorithm for the resolution of this research is presented where Plithogeny will be merged with the algorithm of neutrosophy. From this moment on, expressions 2 to 8 must be applied to execute the operations of the classical algorithm with plithogenic numbers. For the elaboration of a single decision matrix, the median of the plithogenic numbers is calculated for each combination, for all specialists. The median is calculated using the following formula:

$$\text{median}_{i=1}^{m}\{PN_i\}=(\text{median}_{i=1}^{m}\{T(PN_i)\},\text{median}_{i=1}^{m}\{I(PN_i)\},\text{median}_{i=1}^{m}\{F(PN_i)\}) \tag{7}$$

Where PN_i, are plithogenic numbers, $T(PN_i)$ are their true components, $I(PN_i)$ are their indeterminate components and $F(PN_i)$are their false components. In other words, Equation 8 means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components.

Therefore, the procedure designed based on the plithogenic sets will be explained below:

Objective/Goal: Determine the business strategies to follow in hospital institutions in Ecuador

1. Determine the characteristics of the organization in its external and internal environments through surveys and brainstorming.
2. Make the SWOT matrix
3. Process the matrix in a plithogenic environment:
   Weight the criteria using the following linguistic terms shown in Table 2, since it is more suitable to evaluate a numerical scale since human beings identify better with natural language than with numerical scales:

Linguistic Expression	Phytogenic number (T, I, F)
Very poor (VP)	(0.10, 0.75, 0.85)
Poor (P)	(0.25, 0.60, 0.80)
Moderately poor (MP)	(0.40, 0.70, 0.50)
Medium (M)	(0.50, 0.40, 0.60)
Fairly good (FG)	(0.65, 0.30, 0.45)
Good (G)	(0.80, 0.10, 0.30)
Very good (VG)	(0.95, 0.05, 0.05)

   Process the weights for each quadrant using equation 7.
4. Prepare a high impact matrix using the union between plithogenic sets using equation 6.
5. Determine strategies to follow

4 Results

The results of the application of the designed procedure are shown below.

INTERNAL FACTORS	EXTERNAL FACTORS
WEAKNESSES	**THREATS**
Lack of motivation in doctors due to salary issues and work skedules	Great ammount of competitors offering low price services which makes the general prices to go lower
Resource gap for the medical activity	Sanitary emergency due to Covid-19
Contracted market's segment	The competence offers free treatments
It requires a lot of cash to be able to acquire the best medical equipments and also to hire some of the best consultants of the industry	Constant update of the technology and the medical equipment which optimizes services but increases costs
	Cultural rooting of the population in the indigenous treatments
STRENGTHS	**OPPORTUNITIES**
Technical and administrative processes to reach the organization's goals	Increase of the migration to Ecuador of peple with low incomes
Qualified health professionals team	Need for client service due to Covid-19 crisis
Several payment options	Existence of alternative medications that minimize costs
Properly equipped health center	Increase of health tourism at international level
Wide network of institutions with diversity and quality of services	Goverment focused in mitigating the sanitary crisis

Figure 2. Steps 1 and 2 of the procedure.

For the processing of the matrix in a plithogenic environment, the groups among themselves will be chosen as attributes, to achieve the high impact matrix, that is, they will face each other according to what is stated in table 1. Therefore, for the plithogenic analysis of the multi-attribute of dimension 4 and cardinality (4x5x5x5) 500, which is established in pairs. This is given because experts agree that the greatest degree of influence lies in the internal component. Therefore, the degrees of contradiction between the pairs are the following:

- $c_D(S1, S2) = c_D(S1, S3) = c_D(S1, S4) = c_D(S1, S5) = 0.2$
- $c_D(W1, W2) = c_D(W1, W3) = c_D(W1, W4) = 0.25$
- $c_D(T2, T1) = c_D(T2, T3) = c_D(T2, T4) = c_D(T2, T5) = 0.2$
- $c_D(O2, O1) = c_D(O2, O3) = c_D(O2, O4) = c_D(O2, O5) = 0.2$

The dominant values are F1, D1, A2, and O2.

The evaluation of the pairs by the experts was as follows:

W	*Medium*	*T*	*Medium*	*S*	*Medium*	*O*	*Medium*
W1	[0.45,0.55,0.55]	*T1*	[0.5,0.4,0.6]	*S1*	[0.899,0.075,0.135]	*O1*	[0.63,0.1,0.47]
W2	[0.575,0.35,0.525]	*T2*	[0.65,0.25,0.45]	*S2*	[0.698,0.25,0.402]	*O2*	[0.848,0.175,0.186]
W3	[0.525,0.35,0.55]	*T3*	[0.65,0.3,0.45]	*S3*	[0.749,0.2,0.351]	*O3*	[0.599,0.35,0.501]
W4	[0.525,0.5,0.475]	*T4*	[0.725,0.225,0.325]	*S4*	[0.749,0.2,0.351]	*O4*	[0.5,0.4,0.6]
WM	**[0.525,0.425,0.5375]**	*T5*	[0.725,0.225,0.325]	*S5*	[0.432,0.25,0.668]	*O5*	[0.698,0.25,0.402]
		TM	**[0.575,0.25,0.45]**	***FM***	**[0.749,0.2,0.351]**	***OM***	**[0.63,0.25,0.47]**

Plithogenic neutrosophic union between attributes according to equation 6 is defined as for the creation of the impact matrix:

	Opportunities	**Threats**
Strengths	[0.47187,0.25,0.16497]	[0.430675,0.25,0.15795]
Weaknesses	[0.33075,0.390625,0.252625]	[0.301875,0.390625,0.241875]

Figure 2. High impact matrix.

As can be seen, experts agree that the current situation of hospitals in Ecuador needs to improve their competitive strategy, so it is recommended to choose:

Defensive strategy: invest in new production facilities for current services to deal with the technological obsolescence of the process.

Reactive strategy to reaffirm strengths and mitigate threats, seeking care and personalized attention to achieve a high level of satisfaction and thus achieve their loyalty.

Adaptive strategy so that weaknesses do not prevent taking advantage of opportunities by opting for an increase in out-of-hospital services to achieve greater commercial attractiveness.

Offensive strategy to take advantage of opportunities due to the lack of an advantageous position in the sector through a strong campaign to promote one of the products and services in certain distribution channels to improve market share and web presence within tourism of health. Tasks that will require follow-up are proposed below:

Main area	***Indicators or criteria by area***
Market share	Strategic positioning vision Market development Partnership development Product development
Price Competitiveness	Cost review Pricing strategies Sales cost Operational structure and functionality
Financial position	Financial structure review Financial and accounting management Review of Financial Statements Company valuation
Product quality	Product development Improvement of benefits Compliance with specificities
Customer loyalty	Customer orientation Loyalty strategies

Table 4. Follow-up actions for the offensive strategy

It is also recommended to keep in mind the following principles for the implementation of the strategies:

- Efficiency: the relationship between those produced and the resources consumed or used. In this sense, there would be economic profitability, sales/labor cost, sales profitability.
- Effectiveness: degree or level of objectives achieved. It would be used to assess market share, sales growth, meet shareholders' expectations.
- Fairness: impartiality or equality with which the activities of the company are carried out concerning the environment. In this case, there would be the dividends of the shareholders, price/quality ratio of the products to the various clients, taxes paid, employment.
- Responsibility: degree of importance that a company attaches to meet demands. For example, average delivery time, number of complaints and claims handled, ability to react under pressure.

Conclusions

SWOT is a simple tool to handle; however, its processing may lead to errors in the classical environment. For this reason, the neutrosophic environment in its plithogenic extension is very convenient. The latter allows working with uncertainty at all times and therefore obtaining more realistic conclusions. The identification of the threats and opportunities in the environment, and the weaknesses and strengths are essential for the creation of variants of strategies. In this context, the situation can be defined qualitatively and quantitatively, which makes it possible to determine the reality of the analyzed system and, therefore, gives the possibility of building and developing a competitive advantage. During the research development, the proposed objective was achieved by designing a procedure to determine the business strategies to be followed in hospitals in Ecuador, which consists of 5 steps. First, modifying the algorithm enunciated by other authors, including Plithogeny in the determination of the high impact matrix. With the application of the model, strategies based on the real situation were established, which denotes the tool's usefulness.

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Neutrosophic Statistics in the Strategic Planning of Information Systems

Dionisio Vitalio Ponce Ruiz[1], Rita Azucena Díaz Vásquez[2], Bolívar Enrique Villalta Jadan[3] and Cristian Yovao Dorado Ceballos[4]

[1] Docente de la carrera de Software. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.dionisioponce@uniandes.edu.ec
[2] Docente de la carrera de Software. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.ritadiaz@uniandes.edu.ec
[3] Docente de la carrera de Software. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida La Lorena, Santo Domingo. Ecuador Email: us.bolivarvillalta@uniandes.edu.ec
[4] Docente de la carrera de Software. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.cristiandorado@uniandes.edu.ec

Abstract. The purpose of carrying out an Information System Plan within any organization is to ensure the adequacy between its strategic objectives and the information necessary to support the major objectives. Discovering opportunities to innovate the processes of a company taking advantage of the advantages that information technologies provide, emphasizes the link between technology and business strategies, using information technologies (IT) as a facilitator to transform infrastructure and processes of the business. The success of the strategic planning of systems depends a lot on the support and involvement of the management, the understanding of the business objectives and strategies, the leadership and capabilities of the information system (IS) and IT management, as well as the realism and ability to execute the plan.

Keywords: Information systems, technology, neutrosophic statistics

1 Introduction

The Strategic Information System Planning is defined as the process and documentation in which is identified the portfolio of applications and the technological infrastructure that the company must develop to obtain sustainable advantages over its competitors [1, 2] and its purpose is to review the current state of the organization, the identification of the desired strategic situation and the planning of the projects and changes in the organization necessary to achieve the desired state, in a period of 3 to 5 years [3]. Systems planning has been limited to the technical area and has been conducted by the staff of the systems department to record the evolution of existing platforms, justifying significant new investments or handling user requests [4-8].

A strategy is a set of decisions that are made to achieve something. In the case of an organization, a long-term strategy is what allows to achieve the vision of the organization in the future. This strategy is the result of a series of decisions about its scope, competencies, and management [2]. The Information System strategy [6, 7] has to do with business demand. It is a shared story, a space for dialogue between computing and business.

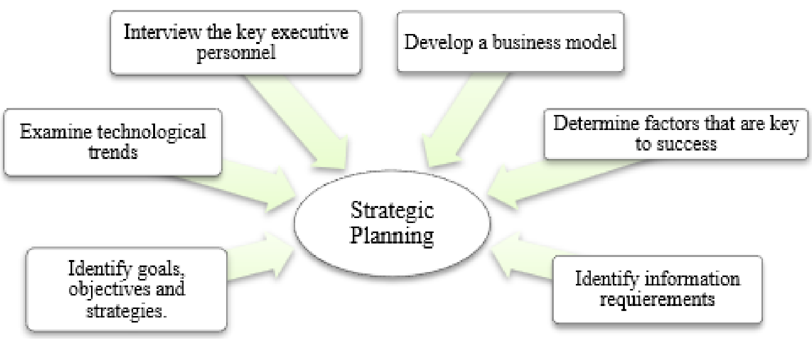

Figure 1. Strategic planning.

According to [4], strategy provides numerous benefits that allow an organization to influence its environment, instead of reacting to it, thus exerting some control over its destiny [2]. The Information System (IS) is the ordered set of mechanisms whose purpose is to manage data and information so that they can be easily and quickly retrieved and processed [9-12]. Its implementation offers the possibility of obtaining great advantages, increasing the organizational capacity of the company, and in this way turning the processes into true competitiveness, which is why an effective system that offers multiple possibilities is necessary, allowing access to the relevant data of frequent and timely manner [13]. Through the adoption of these systems, the manager manages to gather a series of important information, which can impact both the service to the client and internal processes [14] (figure 2).

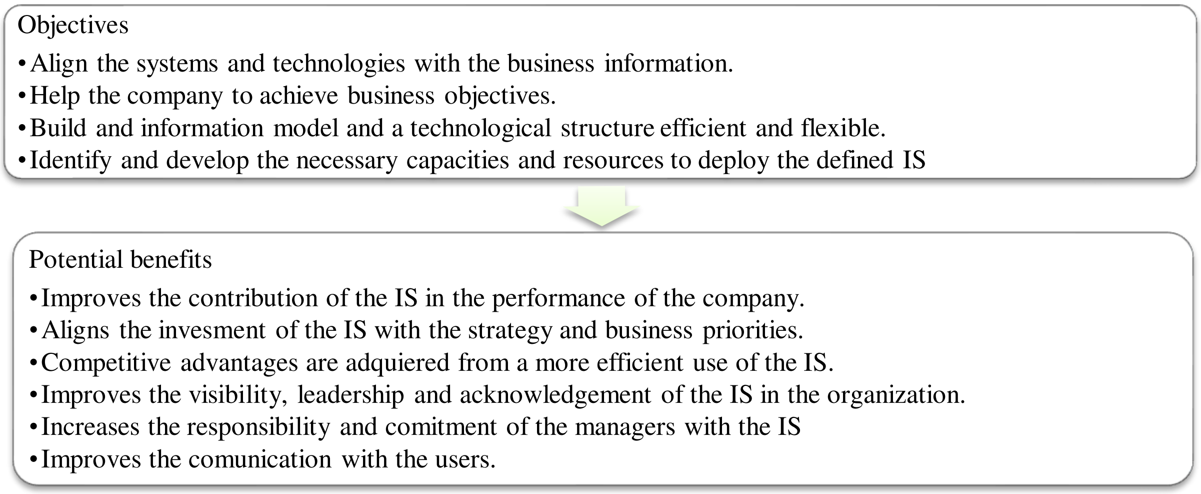

Figure 2. Objectives and benefits of strategic planning.

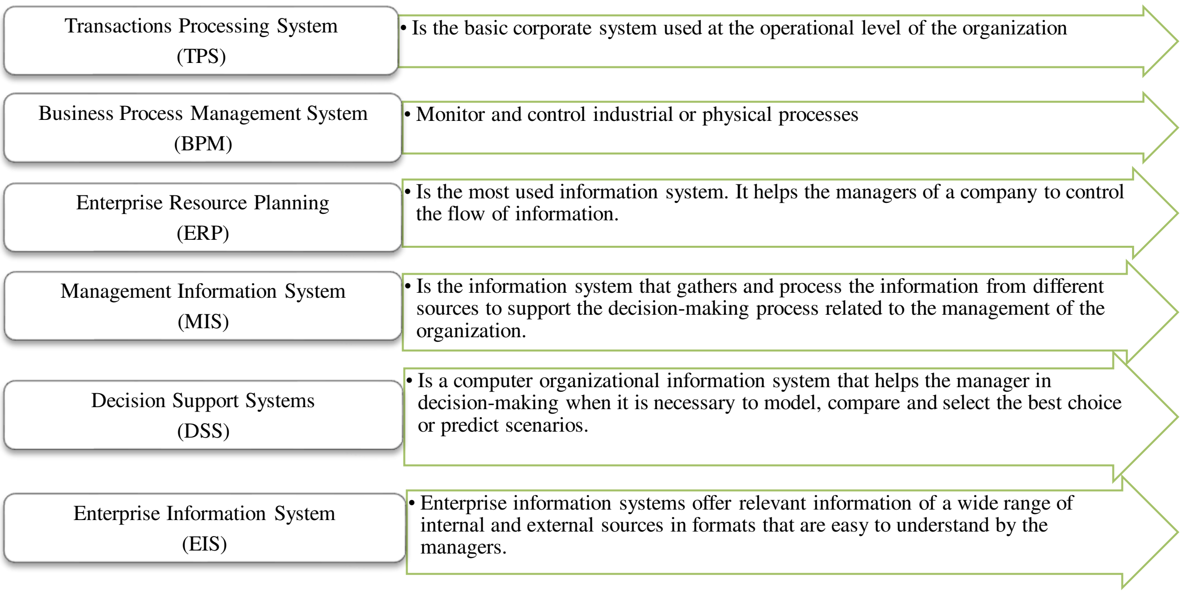

Figure 3. Types of information systems (IS).

The objective of information systems is to understand and analyze how the impact of the adoption of information technologies occurs in companies' managerial and administrative decision processes [15, 16]. Currently, information systems make the business process easier because with the characteristics of the software, export, and import operations are facilitated and in this way all processes are simplified, costs are lowered and there is more security in transactions. These facilities are part of a structure adopted by governments, companies, and many success cases have emerged because of this modernization [17]. Information systems can often fail, not because of technical errors that originated in the computer aspect, but because of cultural visions opposed to the incorporation of this type of tools, since there are still companies that observe with suspicion the possible implementation of information systems in their processes because they imply an enormous change in the organizational and institutional structures of the companies [18].

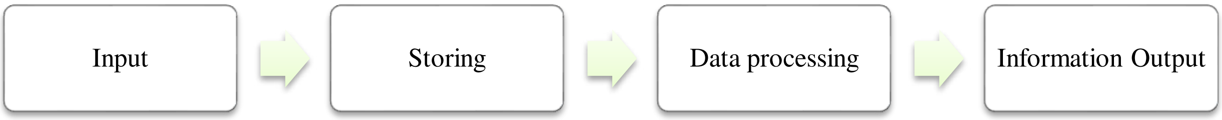

Figure 4. Development of an information system..

An adequate information system offers significant and notable satisfaction to the users who operate it, due to its ease of use and constant access, which may result in employees achieving the objectives set by the company. Therefore, to become more competitive, organizations must take into account their employees as those resources that can be improved through education and training, when applying information technology [14, 19]. This work is developed in a process control system, by understanding a whole range of equipment, computer programs, and operating procedures in oil refining, it is important to mention how the entire company is connected in this system from the operator to the company's management who, based on this information, is in charge of structuring the business expansion plan. From the analysis of the information systems and determining the factors that intervene in the crude oil process control system, we can define the following aspects:

1. Problem situation: incidents in the oil refining process
2. Main objective: use of information systems to achieve a competitive advantage in an oil refining plant and detect incidents in the process
3. Specific objectives:
   3.1. Determine the factors that affect the oil production variable
   3.2. Carry out the measurement and modeling of the variable
   3.3. Analyze the potential alternatives to determine the incidents that influence the oil refining process through information systems.

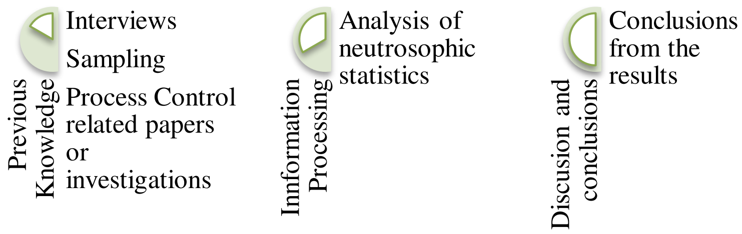

Figure 5. Development of the research..

2 Materials and methods

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that event E will occur [20], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3 +. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T (x) represents the probability that the value x occurs, F (x) represents the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x [21-43].

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [44], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow the interpretation and organization of neutrosophic data (data that can be ambiguous, vague, imprecise, incomplete, or even unknown) to reveal the underlying patterns [45]. In short, the Neutrosophic Logic [46, 47], Neutrosophic Sets and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference of study in full development. The Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data [48]. Neutrosophic Numbers are numbers of the form where a and b are real or complex numbers [49], while "I" is the indeterminacy part of the neutrosophic number $N = a + bI$.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the corresponding lower and upper level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable when formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}, \bar{x}_b = \frac{1}{n_N}\sum_{i=1'}^{n_N} X_{iu}\, n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows:

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\begin{bmatrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\(a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\(a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{bmatrix}, I\epsilon[I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the NCV value, the more consistent the factor's performance is. NCV can be calculated as follows [50].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U]$$

3 Results

Data collection

After analyzing the different approaches in introducing the document, we proceed to apply the techniques outlined above, for a better operation of industrial processes and the impact of information systems. After analyzing the acquired data, the significant degree of indeterminacy and the modeling approach are detected with the use of neutrosophic statistics for the studied variable. From the results obtained from the information and the consensus of the experts, the factors that most affect the process control system implicit in the variable were determined (Table 1).

Variable analyzed: functionality of the crude oil process control system, for a sample of n = 110 for each factor (f).

Parameters	Initials	Factors that affect the oil refining process	Scale	Incidence range
Cost-effectiveness	DI	Decrease in income	[0; 3]	From 0 to 3 times a day, the accounting measurement indicator reported low income below plan
Performance	LPP	Low production performance	[0; 4]	From 0 to 4 times a day, the software reported a slight decrease in production
Quality	VCC	Variations in the quality of crude oil	[0; 5]	From 0 to 5 times a day, the quality technician reported variations in the quality of the crude

Safety	MI	Maintenance increase	[0; 3]	0 to 3 times per day the instrumentation and control sensors detected a failure in the production system
Infrastructure	IB	Increased breakage	[0; 3]	From 0 to 3 times a day minor maintenance was performed at the refinery reported by a safety sensor

Table 1. Values provided by the SI, in the incidents of crude oil development

For the modeling of the neutrosophic statistics, we decided to code the factors to make the results viable (Table 2).

Code	Initials	Factors that affect the oil refining process
L	DI	Decrease in income
M	LPP	Low production performance
N	VCC	Variations in the quality of crude oil
Ñ	MI	Maintenance increase
O	IB	Increased breakage

Table 2. Determining factors in the oil refining process

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the oil refining process are analyzed. For each factor, an incidence is analyzed in days for each factor, which makes up the set of effects on oil production (table 3).

Days	Neutrosophic frequencies				
	DI	LPP	VCC	MI	IB
1	[2 ; 2]	[3 ; 3]	[5 ; 5]	[3 ; 3]	[1 ; 1]
2	[0; 0]	[4 ; 4]	[2 ; 7]	[1 ; 4]	[2 ; 5]
3	[0; 2]	[3 ; 6]	[2 ; 4]	[1 ; 2]	[3 ; 6]
4	[3 ; 4]	[4 ; 8]	[5 ; 6]	[0; 3]	[0; 1]
5	[3 ; 4]	[0; 0]	[3 ; 7]	[1 ; 4]	[1 ; 4]
6	[0; 3]	[0; 1]	[1 ; 3]	[0; 0]	[0; 1]
7	[3 ; 4]	[3 ; 6]	[1 ; 5]	[2 ; 2]	[2 ; 3]
8	[0; 1]	[4 ; 4]	[4 ; 6]	[3 ; 4]	[0; 3]
9	[3 ; 5]	[4 ; 7]	[3 ; 8]	[1 ; 3]	[3 ; 6]
10	[1 ; 4]	[0; 4]	[1 ; 1]	[1 ; 2]	[2 ; 3]
11	[1 ; 1]	[0; 3]	[1 ; 4]	[3 ; 5]	[0; 3]
12	[3 ; 5]	[1 ; 2]	[4 ; 6]	[3 ; 5]	[2 ; 5]
13	[1 ; 3]	[3 ; 4]	[4 ; 4]	[3 ; 5]	[2 ; 3]
14	[3 ; 5]	[2 ; 6]	[0; 2]	[3 ; 3]	[2 ; 5]
15	[3 ; 6]	[3 ; 4]	[3 ; 3]	[3 ; 3]	[2 ; 3]
16	[3 ; 4]	[4 ; 6]	[4 ; 8]	[1 ; 1]	[2 ; 5]
17	[3 ; 3]	[1 ; 1]	[4 ; 8]	[2 ; 3]	[2 ; 5]
18	[0; 2]	[0; 2]	[4 ; 8]	[3 ; 4]	[2 ; 4]
19	[2 ; 2]	[1 ; 2]	[4 ; 7]	[2 ; 3]	[3 ; 3]
20	[0; 0]	[3 ; 4]	[1 ; 4]	[2 ; 5]	[1 ; 1]
0-110	[163; 332]	[217; 410]	[256; 557]	[181; 351]	[169; 335]

Table 3. Neutrosophic frequencies of factors

The neutrosophic frequencies of occurrence of the determining factors in the process control system for the oil refining plant were analyzed, in 110 days, with an occurrence level of [0; 8] for each factor per day and a total indeterminacy level of l = 169, m = 193, n = 301, ñ = 170, o = 166, and a level of representativeness of [47.07%; 54.04%], on the days in which there were 8 effects per factor, with an incidence of more than 50% in terms of variations in crude oil quality. It should be noted an increase in the reports of SI linked to the refining process of crude oil refining (table 3).

The results provided by the IS (from the industrial sensors, recording of the quality parameters, and the machine control room) of the effects that affect the process (table 4) can be understood as the factor implied by a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$. The values of the neutrosophic means and the level of variations of the activated sensors in the event of possible damage or breakage, which constitute a danger for the development of the process, are calculated. Depending on the level of affectations, the neutrosophic standard deviation is used and which affectation requires a greater incidence in oil refining, the values are calculated.

Factors	$\bar{\mathbf{x}}_{\mathbf{N}}$	**YN**	**CVN**
Decrease in income	[1,482; 3,018]	[0.741; 2,189]	[0.5; 0.725]
Low production performance	[1,973; 3,727]	[1,094; 2.63]	[0.554; 0.706]
Variations in the quality of crude oil	[2,327; 5,064]	[1,633; 3,424]	[0.702; 0.676]
Increase in maintenance	[1,645; 3,191]	[0.704; 2,155]	[0.428; 0.675]
Increased breakage	[1,536; 3,045]	[0.718; 2,181]	[0.467; 0.716]

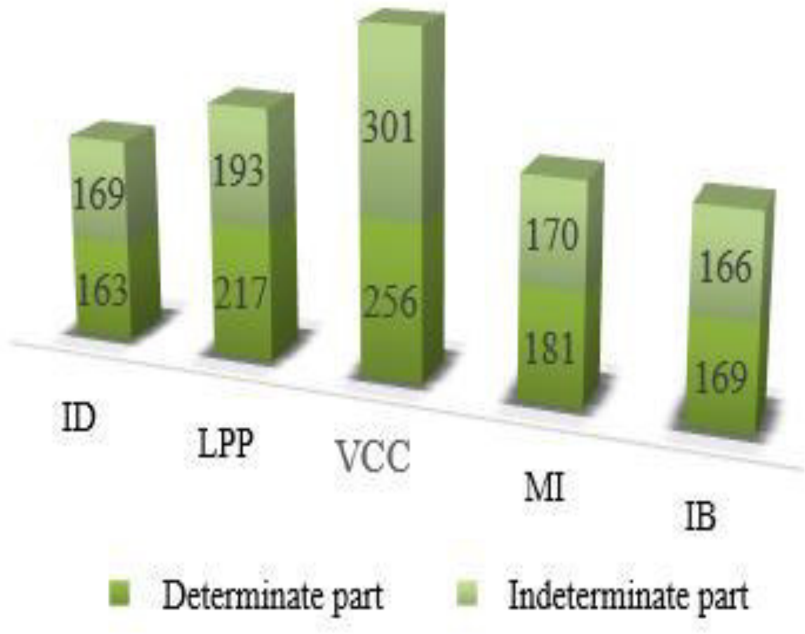

Table 4. Neutrosophic statistical analysis of incidents in the oil refining process

Figure 6. Neutrosophic bar graph of the incidents in crude oil production.

In table 4, it was determined that the factors, *Variations in crude oil quality* and *Low production Performance*, constitute an average of greater incidence on the other factors. This means that the VCC and LPP factors are the ones that most affect the refining process, while the value of CV_{NIM} in the increase in maintenance is lower than the rest. This means that the result of the MI factor has a more consistent, coherent, and precise impact when evaluating the indeterminacy in the possible breaks (Figure 5).

Comparative analysis

ID

To calculate the associated referent indeterminacy measure for the form of neutrosophic numbers (Table 5), the results show that the values range from $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U] CV_N \in [CV_L ; CV_U] CV_N 0.675$ to 0.725 with the 36.6% indeterminacy measure generating an increase in maintenance at the refinery associated with the effects of the remaining factors.

Factors	$\bar{x}_N$	**YN**	**CVN**
DI	1,482; 3,018 I;I $\in [0; 0.50]$	0.741 + 2.189 I; I $\in [0; 0.66]$	0.5 + 0.725 I; I $\in [0; 0.31]$
LPP	1,973; 3,727 I;I $\in [0; 0.47]$	1,094 + 2.63 I; I $\in [0; 0.58]$	0.554 + 0.706 I; I $\in [0; 0.21]$
VCC	2,327; 5,064 I;I $\in [0; 0.54]$	1,633 + 3,424 I; I $\in [0; 0.52]$	0.702 + 0.676 I; I $\in [0; 0.38]$
MI	1,645; 3,191 I;I $\in [0; 0.48]$	0.704 + 2.155 I; I $\in [0; 0.67]$	0.428 + 0.675 I; I $\in [0; 0.36]$
IB	1,536; 3,045 I;I $\in [0; 0.49]$	0.718 + 2.181 I; I $\in [0; 0.67]$	0.467 + 0.716 I; I $\in [0; 0.34]$

Table 5. Neutrosophic forms with the measure of indeterminacy

Discussion

In this investigation, it was determined that high-quality devices are of vital importance, as these will affect the production system. The quality of the devices, as well as the periodic tests of accuracy, are the key so that the data obtained in the measurements can remain reliable. Chips, like sensors, play a fundamental role in the prediction and prevention of numerous aspects, satisfying the needs of many diagnostic applications, which is why it is important to make the best decisions in the search for the best results. The efficiency of industrial processes always guarantees competitive differences and good productive and economic results and gains efficiency and safety.

Conclusions

Nowadays, information systems make business more accessible, since with the characteristics of the software operations are facilitated and in this way all processes are simplified, costs are lowered and there is more security in transactions. In a process control system, the functionality and review of the technical state of the chips according to the expiration date is important, since these are the ones that will determine any failure in the production process. Advances in electronics, computing, and robotics will facilitate this exhaustive monitoring of the process. With the analysis of the neutrosophic statistics, it was determined that the variable in the oil refining process is affected by the increase in maintenance and the continuous stoppage of production, with a level of indeterminacy of 36.6%, so that, If the equipment is replaced, the breakages and with it the maintenance will decrease, proportionally affecting the reduction of the remaining factors. The neutrosophic statistical analysis shows the increase in maintenance with a lower CV value, as a determining factor to improve the production process. Based on this result, it was concluded that with the use of quality sensors, advantages can be obtained over the competition and thus the expansion of the business.

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Neutrosophic Analytic Hierarchy Process for the Analysis of Innovation in Latin America

Rosa Evelyn Chuga Quemac[1], Manases Esaud Gaspar Santos[2], Laura Alicia Colcha Ramos[3], Cinthya Paulina Cisneros Zúñiga[4]

[1] Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. E-mail: ut.rosachuga@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. The rivers. Ecuador Email: uq.mancesgaspar@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes (UNIANDES). Lizarzaburu Avenue. Riobamba, Chimborazo. Email: ur.lauracolcha@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes (UNIANDES). Teniente Hugo Ortiz Street, Puyo. Pastaza. Ecuador Email: up.cinthyacisneros@uniandes.edu.ec

Abstract. This paper analyzes the factors that are influencing the stagnation of innovation indicators in the Latin American region. To do this, an analysis is carried out to explore the existence of different groups of countries characterized by different levels of technological capacity and innovation. The elements to be analyzed during the study are obtained through the indicators evaluated in the Global Innovation Index, its 2020 edition, and the Analytic Hierarchy Process. The results show the existence of three groups of countries characterized by a different capacity for technological innovation, both in terms of technology policy and generation of technology and innovation, and technological preparation of society.

Keywords: Innovation, Latin America, WIPO

1 Introduction

Today, innovation is considered an imperative strategy to achieve economic development and is the best option to face the challenges of the future. You can innovate in products, processes, markets, or organizations [1]. [2] Defines innovation as having an idea about a process or a tool as new, but with relevant and substantial improvements. [3] Defines it as a solution of technological advance, achieved through cutting-edge technology. According to [4], it is: "the introduction of a new or significantly improved product (good or service), a new marketing method or a new organizational method, in internal company practices, workplace organization or external relations". Finally, [5] defines, in general terms, that innovation is the commercial application of an idea, which flows through three important stages: the idea, the development, and the introduction to the market.

There is a widely accepted belief that technological innovation is a fundamental variable to explain aspects such as competitiveness, growth rate, productivity, job creation, and well-being [6]. Different levels of technological development characterize countries and this is the main factor that reveals their different competitive patterns and their long-term economic divergence [7].

One of the most important references in this matter is the *Global Innovation Index* (GII). This report provides detailed values on innovation performance in various world economies. Its 80 indicators provide a broad vision of innovation, including the political environment, education, infrastructure, and market sophistication [1].

In recent years, there has been a strong political determination to foster innovation, including developing countries; it is a relatively new and promising trend towards democratization beyond a select number of economies and poles of competitiveness [8]. Unfortunately, Latin America remains stagnant relative to the average performance of global economies. The data provided by the Data Center for Intellectual Property Statistics of the World Intellectual Property Organization (WIPO) shows that from 2015 to 2019 there has been a decrease of 13% in patent applications from the Latin American region and the Caribbean. The crisis generated by the coronavirus disease (COVID-19) pandemic is expected to make this situation even worse.

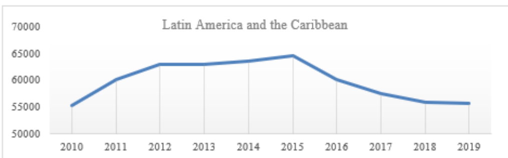

Figure 1: Indicator: Total patent applications. Region: Latin America and the Caribbean. Source: Intellectual Property Statistics Data Center of the World Intellectual Property Organization (WIPO)

The objective of this study is to analyze the factors that are influencing the stagnation of innovation indicators in the Latin American region. To do this, it is intended to carry out an empirical analysis that explores the existence of different groups of countries characterized by different levels of technological and innovation capacity, examining their main differences.

The study has been carried out using the data published in the Global Innovation Index (GII) in its 2020 edition, which contains a series of indicators that quantify the different aspects related to the technological innovation capacity of more than 130 countries. This work analyzes these data through two stages. The first consists of reducing a large number of indicators through the *Analytic Hierarchy Process* (AHP) to determine a reduced set of indicators based on which the different countries will subsequently be evaluated. Second, the selected indicators will be used to identify different groups of countries by analyzing these indicators.

Accordingly, the work has been organized as follows. In section 2, the indicators used to measure the technological innovation capacity of the different countries of the region are defined, while at the same time justifying their selection using the method described. Section 3 shows the analysis using the selected indicators and their result.

2 Case study

The capacity for technological innovation is related to different aspects such as the infrastructures that support industrial production and innovation activities, the formation of human resources, and the ability of nations to create, imitate, and manage a complex reserve of knowledge. advanced technology [9]. In this article, a series of indicators will be used that directly measure different relevant aspects of the technological innovation capacity of the Latin American countries included in the GII 2020. The advantage of using a battery of indicators is that it is thus possible to define the situation of each country, providing an easier understanding of the differences between them.

Professor Dutta launched the Global Innovation Index (GII) project in 2007 during his tenure at the European Institute of Business Administration (INSEAD). The objective was to find and determine metrics and methods that could better capture the richness of innovation in society, going beyond traditional measures of innovation such as the number of research articles and the level of expenditure on research and development (R&D) [10]. GII is not intended to be the final and definitive ranking of economies concerning innovation. Measuring the results of innovation and its impact remains difficult, so great emphasis is placed on measuring the climate and infrastructure for innovation and evaluating the related results [11].

The GII is based on two sub-indexes, the Innovation Input Sub-index and the Innovation Output Sub-index, each built around a total of 7 pillars. Each pillar is divided into three sub-pillars, which, in turn, are made up of several individual indicators.

Innovation Input Sub-index	Institutions
	Human resources and research
	Infraestructure
	Market sophistication
	Business sophistication
Innovation Products Sub-index	Knowledge and technology outputs
	Creative outputs

Figure 2: Global Innovation Index 2020. Source: Global Innovation Index Database, Cornell, INSEAD and WIPO, 2020

So the initial selection of the indicators to be evaluated is shown below:

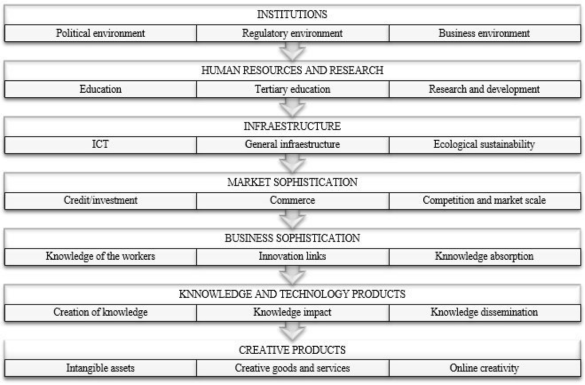

Figure 3. Innovation indicators to evaluate

Pillar 1: Institutions: captures the institutional framework of an economy.

- The political environment sub-pillar includes the political, legal, operational, or security risk index and the quality of public and civil services, the formulation and implementation of policies.
- The Regulatory Environment sub-pillar is based on two indexes intended to capture perceptions of the government's ability to formulate and implement cohesive policies that promote private sector development and to assess the extent to which the rule of law prevails.
- The Business Environment sub-pillar evaluates the cost of dismissal due to dismissal as the sum, in weeks of salary, of the cost of the notice requirements added to the severance payments due when dismissing a worker.

Pillar 2: Human resources and research: This pillar attempts to measure the human resources of economies.

- The first sub-pillar includes a combination of indicators aimed at capturing achievement at the primary and secondary education levels.
- The tertiary education sub-pillar aims to capture coverage (tertiary enrollment); Priority is given to sectors traditionally associated with innovation and the entry and mobility of tertiary education students.
- The sub-pillar on R&D measures the level and quality of R&D activities.

Pillar 3: Infrastructure:

- The ICT sub-pillar includes four indices, each on access, use, government online service, and citizens' online participation of ICT.
- The general infrastructure sub-pillar includes the average electricity production in GWh per capita; a composite indicator on logistics performance; and gross capital formation.
- The sub-pillar on ecological sustainability includes three indicators: it attempts to measure the environmental performance of the economies according to various criteria.

Pillar 4: Market sophistication: measures the availability of credit and the existence of an environment that supports investment

- The Credit sub-pillar includes a measure on the ease of obtaining credit
- The Investment sub-pillar includes the minority investor protection facility index. They analyze whether the market size corresponds to the dynamism of the market and provide a metric of concrete data on venture capital deals.
- The last sub-pillar addresses trade, competition, and market scale.

Pillar 5: Business sophistication - Try to assess how conducive innovation activities are.

- The first sub-pillar includes four quantitative indicators of workers' knowledge.
- The Innovation Links sub-pillar is based on both qualitative and quantitative data on collaboration between companies and universities in R&D, the prevalence of well-developed and deep clusters, the gross R&D expenditure promised by abroad as a percentage of GDP, and the number of agreements on joint ventures and strategic alliances.
- The sub-pillar on the absorption of knowledge will reveal how good economies are at absorbing and disseminating knowledge.

Pillar 6: Knowledge and technology products: This pillar covers all those variables that are traditionally believed to be the result of inventions and/or innovations.

- The first sub-pillar refers to the creation of knowledge. It includes accurate indicators that are the result of inventive and innovative activities: patent applications filed by residents both in the national patent office and internationally through the PCT; utility model applications submitted by residents at the national office; scientific and technical articles published in peer-reviewed journals; and the number of articles (H) of an economy that has received at least H citations.
- The second sub-pillar, on the impact of knowledge, includes statistics that represent the impact of innovation activities at the micro and macroeconomic levels.
- The third sub-pillar, on the dissemination of knowledge, includes statistics related to sectors with high-tech content or that are key to innovation.

Pillar 7: Creative Products

- The first sub-pillar on intangible assets includes statistics on trademark applications by residents and which economies have the most valuable brands.
- The second sub-pillar on creative goods and services includes powers to arrive at the creativity and creative outcomes of an economy.
- The third sub-pillar attempts to measure how innovation, production, and trade in digitized creative products and services are evolving in an innovation-based economy.

3 Conceptual framework of the neutrosophic AHP method

Before conducting the empirical study, it is convenient to reduce the set of indicators to a smaller number of dimensions. For this, the AHP method has been used in its neutrosophic variant since this method is designed to solve complex multi-criteria problems based on subjective assessments. Through its use, the indicators that best analyze the distribution of technological innovation among Latin American countries are identified, taking into account the region's particularities. In other words, those that best discriminate the level of technological innovation in these countries.

The result of the AHP is a hierarchy with priorities that show a global preference for each of the decision alternatives, so it will be used to prioritize the indicators that have the greatest impact on the problem under study. Below are the main definitions of neutrosophic logic and its application in the neutrosophic AHP.

Definition 1[12], [13]: The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A,and falsehood-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$,$F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$. Notice that, according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2 [12], [13]: The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{<x; T_A(x), I_A(x), F_A(x)>: x \in U\}$c, where $T_A:U \rightarrow [0, 1]$, $I_A:U \rightarrow [0, 1]$, and $F_A:U \rightarrow [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic Number* (SVNN) is represented by N = (t, i, f), such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3[12], [14], [15]**:** the *single-valued trapezoidal neutrosophic number*, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_1-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{otherwise} \end{cases} \tag{2}$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \tag{4}$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3 \leq a_4$.

Definition 4 [12], [14], [15]**:** given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (5)
3. Inversion: $\tilde{a}^{-1} = \langle (a_4{}^{-1}, a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.

Definitions 3 and 4 refer to the *single-valued triangular neutrosophic number* when the condition $a_2 = a_3$, [16]–[18]. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in [19]. The analytic hierarchy process was proposed by Thomas Saaty in 1980 [20]. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [21][22]. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [22][24]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level, the decision options are understood [13]. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6) [25].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \quad (6)$$

We can find in [17] the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying neutrosophic AHP or NAHP for short. Moreover, equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\widetilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (7)$$

Matrix $\widetilde{A}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4. To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in [19]. They are the so-called score and accuracy indexes, respectively, see Equations 8 and 9:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (8)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (9)$$

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [26]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 7.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i, j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 10 and 11. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = 1/S(\tilde{a}_{ij}) \quad (10)$$

$$A(\tilde{a}_{ji}) = 1/A(\tilde{a}_{ij}) \quad (11)$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (12)$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

4 Application of the method

Following the logic of the method, we determined that the indicators whose behavior will be analyzed for their importance are: Regulatory environment, Business environment, Third cycle education, R&D, ICT, Credit, Creation of knowledge, and Knowledge Impact.

Pillars	Weighing	Indicators	Weight	Global
P1 Institutions	0.18	Political environment	0.162	0.029
		Regulatory environment	0.540	0.097
		Business environment	0.298	0.054
P2 Human Resources	0.15	First and second cycle education	0.168	0.025
		Third cycle education	0.416	0.062
		R&D	0.416	0.062
P3 Infrastructure	0.09	ICT	0.564	0.051
		General infrastructure	0.218	0.020
		Ecological sustainability	0.218	0.020
P4 Market sophistication	0.10	Credit	0.564	0.056
		Investment	0.218	0.022
		Trade, competition and market scale	0.218	0.022
P5 Business sophistication	0.07	Knowledge of workers	0.333	0.023
		Innovation Links	0.333	0.023
		Knowledge absorption	0.333	0.023
P6 Knowledge and technology products	0.32	Knowledge creation	0.416	0.133
		Knowledge impact	0.416	0.133
		Dissemination of knowledge	0.168	0.054
P7 Creative Products	0.08	Intangible assets	0.564	0.045
		Creative goods and services	0.218	0.017
		Online creativity	0.218	0.017

Table 2: Summary of the global evaluations of the evaluated indicators

5 Analysis of the results

In this section, an analysis of the innovation capacity of Latin American countries is carried out according to the indicators determined in the previous section.

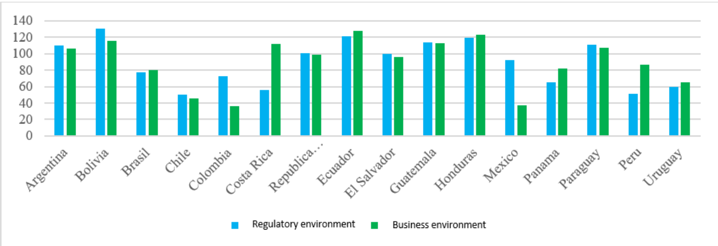

Figure 4. Behavior (ranking) of the P1 indicators in Latin American countries.

As can be seen in Figure 4, both indicators have very similar behavior in the countries analyzed. It is observed that only three are located among the top 60 worldwide concerning the regulatory environment indicator. With regard to the business environment, only Chile, Colombia, and Mexico are among the top 60, which offers a measure of the lack of ease that exists among the rest of Latin American countries to start a business and to resolve insolvency.

In general, the region has institutional frameworks that are weakly focused on achieving adequate levels of protection and incentives for innovation.

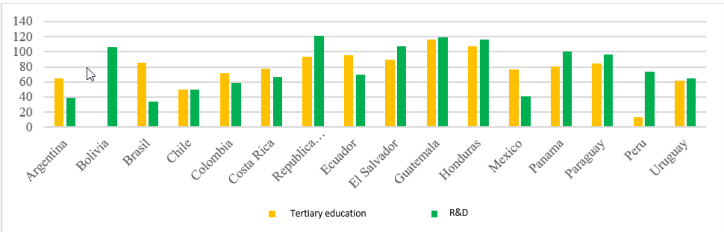

Figure 5: Behavior (ranking) of the P2 indicators in Latin American countries.

Regarding coverage (tertiary enrollment) in sectors traditionally associated with innovation, only Chile and Peru are in favorable positions; the rest are between the average, except for Guatemala and Honduras, which are in positions above 100. It is noteworthy that even though few countries in the region are among the top 60 with respect to tertiary education, the quality of R&D activities in several countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Uruguay) allow locations in the ranking below 80. Only the Dominican Republic, El Salvador, Guatemala, and Honduras are in positions above 100.

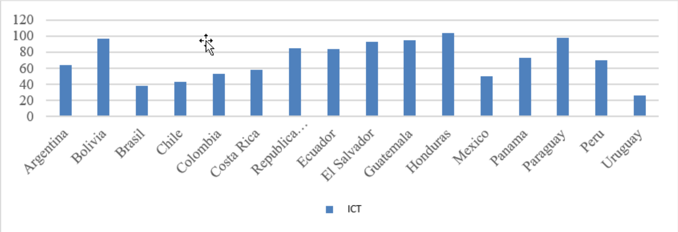

Figure 6. Behavior (ranking) of the ICT indicator in Latin American countries.

In general, access to ICTs, their use, the government's online service, and the online participation of citizens in the region are highly variable. Countries such as Brazil, Chile, Colombia, Mexico, and Uruguay have better results in this regard than other Latin American countries. On the other hand, it is generally observed in the region that it is relatively easy to obtain credits for innovations. The cases of Peru, Panama, and Colombia are noteworthy, which are among the top 40 in the world in terms of this indicator.

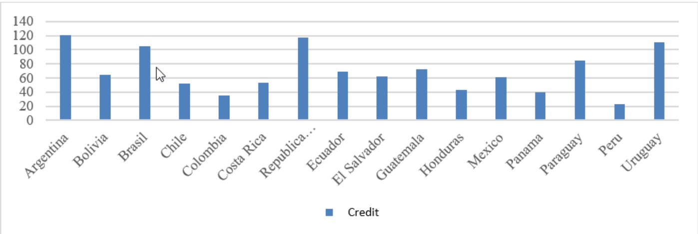

Figure 7. Behavior (ranking) of the Credit indicator in Latin American countries.

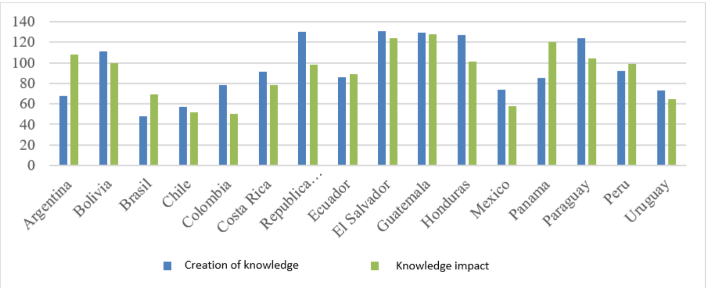

Figure 8. Behavior (ranking) of the P6 indicators in Latin American countries.

In the period analyzed, patent applications filed by residents both in the national patent office and internationally through the PCT, utility model applications filed by residents in the national office, scientific and technical articles published in peer-reviewed journals have made Brazil and Chile stand out from the rest by being located among the top 60 worldwide. However, in general, this indicator did not perform well in the region. The Knowledge impact made it possible to obtain slightly better results, but the impact of innovation activities at the micro and macroeconomic levels is still insufficient to position the countries of the region favorably.

In general, it can be verified that the region is characterized by scarce investments in R&D, an incipient use of IP systems is observed, and the disconnection between the public and private sectors in prioritizing R&D and innovation. The deficient and bureaucratic regulatory framework, the existence of poorly financed public administrations and without resources, the low levels of education and consequently the low number of scientific publications, the Latin American model of staying with small companies and the incipient culture to promote the use of trademarks do not favor innovation activity. Only a few countries in the region exceed the average: Brazil, for example, has an R&D intensity comparable to some European economies, such as Portugal and Spain. Chile, Uruguay, and Brazil, on the other hand, are high producers of scientific papers.

Finally, and according to what has been analyzed, it can be concluded that the innovation performance of the region can be divided into three groups: First, the regional leaders: Chile, which is the most innovative economy in the region, 54 of the world ranking, followed by Mexico (55) and Costa Rica (56). Second, an intermediate group of six economies, mostly from South America and upper-middle-income, except for Uruguay and Panama with high incomes: Brazil (62), Colombia (68), Uruguay (69), Panama (73), Peru (76), and Argentina (80). The third group is made up of 7 economies that are in the top 110.

Conclusions

Carrying out this work allowed the development of an investigation on the differences in the capacity for technological innovation between Latin American countries. The results show the existence of 3 groups characterized by different levels of technological innovation. The differences shown between them were determined from 8 indicators obtained from the GII 2020:

- Regulatory environment,
- Business environment,
- Tertiary education,
- R&D,
- ICT,
- Credit,
- Creation of knowledge and Knowledge Impact.

The versatility of the neutrosophic AHP method can be verified as an effective tool in the discrimination of information to rank these indicators.

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Assessment of the Relevance of Intercultural Medical Care. Neutrosophic sampling

María Gabriela González Chico[1], Neyda Hernández Bandera[2], Saihrys Herrera Lazo[3] and Nelson Laica Sailema[4]

[1] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.mariagonzalez@uniandes.edu.ec
[2] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.neydahernandez@uniandes.edu.ec
[3] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.saihrysherrera@uniandes.edu.ec
[4] Docente de la carrera de Medicina. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.nelsonlaica@uniandes.edu.ec

Abstract. The research addresses aspects related to intercultural medical care, considering that methodological limitations affect the performance of medical care in Ecuador. The objective of this study was to carry out a diagnosis on the level of relevance of medical care personnel regarding interculturality in health, with a sample calculated using neutrosophic statistics , which covered different specialties. The research uses methods of a theoretical order (analytical-synthetic, inductive-deductive, and systemic) and the empirical level (the survey) and mathematical statistics. The information was submitted to the corresponding statistical processing. The results obtained in the practical validation of the assessment of the relevance of intercultural medical care, since through the Pearson correlation test, it was confirmed the existence of significance.

Keywords: healthcare, medicine, intercultural, diagnosis, neutrosophic statistics

1 Introduction

Culture is considered a continuous process of production, reproduction, creation, and exchange of human work with its multiple manifestations. It is a process where man embodies his essential being and (…) projects the future, based on the recognition of the possibilities and limits in which his creative energy is deployed (…)". That is why the sociocultural term is related today, mostly, with various cultural, intellectual, and social products [1].

Following the above-mentioned, it can be approached that the term culture and its different ramifications can be used in different fields of knowledge. Therefore, this research will delve into one of the derivations of this, in a specific context such as the case of health.

The relationship of different cultures in a given context of power implies considering different levels: the interpersonal, the group, and the structural. That is why there must be a direct relationship between interculturality and health. Well, the current ways of approaching treatments present a scientific perspective. However, it should not be forgotten that until recently, the ancestral and traditional forms of treatment were the only ways to cure the diseases of many indigenous communities. That is why health systems personnel must seek a link or awareness of why the treatment is required.

Within this science, the intercultural concept is not sufficiently incorporated into the tasks of the different health systems of the Latin American region, it has a rich history and culture in the traditions of its ways of treating different diseases. This diversity translates into the ever-increasing employment of traditional health agents with knowledge inherited over generations, and with a very high level of use by patients treated in the National Health Systems.

According to the World Health Organization, the definition of Intercultural Health is related to the universality of some processes in countries belonging to the Far East or Africa and is understood from respect for different cultures and the interaction with agents of traditional medicine [2].

From the perspective of several knowledgeable researchers on the subject, they suggest that intercultural health is a fact, it is necessary for the real and non-supervised participation of the true social actors of the communities. What must also go hand in hand with scientific and systematized knowledge in medical care.

A special look requires that in several Latin American countries, traditional medicine has a great presence and is used by a vast majority of the population that had in this knowledge a single health resource until not long ago, as argued by Bautista Vangehuchten, & Duque, 2017. Hence the importance and timeliness of deepening studies of this nature [3].

In the Republic of Ecuador, in 2008 it was possible to approve and apply the constitutional regulations that recognize the struggle of groups historically segregated by the socio-political and until then mono-cultural system of the State, empowering social participation and interculturality. Different areas of public management where health is involved.

Most of the authors consulted because the elderly are the main age group that still maintains knowledge about medicinal plants, rituals, and traditional healing methods. Many of them also have experience as midwives and healers. However, it is common to hear their concern that the intergenerational transmission of this knowledge is lost, because currently few young people are interested in learning and practicing them [4].

In contrast, it is observed that traditional practices are not sufficiently valued by rural doctors or by other professionals hired by the Ministry of Public Health, since medical procedures and the use of drugs are prioritized over the application of traditional methods in minor illnesses [4].

The policies, plans and actions that are projected by medical care, go through several essential factors, these are disease and health as a universal right. Which are decisive for the success or failure of the treatment. For the first to be achieved, it is necessary to assess the two essential actors. The healthcare professional and the patient receiving the care.

Due to the characteristics of the Ecuadorian geography, health personnel must move long distances or go to places with difficult access, to provide comprehensive care to users of the health service. That is why ancestral knowledge and interculturality can be used to achieve an articulation between both pieces of knowledge [5].

It is an unequivocal example of the importance of promoting research on interculturality in health. Well, it allows overlapping of knowledge to achieve a better quality of life for the Ecuadorian population.

According to what was previously discussed in this work, it is intended to make a diagnosis of intercultural medical care. For which an exploratory diagnosis was made.

These results make it possible to identify the current prevailing scenario and the following problematic situation: how to identify the level of relevance of medical care personnel regarding interculturality in health?

That is why the present work has the objective: to make a diagnosis on the level of relevance of medical care personnel on interculturality in health.

Therefore, the following hypothesis is raised: knowledge about the assessment of the relevance of intercultural medical care will allow the medical treatment of various diseases to be carried out more effectively.

2 Materials and Methods

2.1 Subjects under study

Neutrosophic statistics were used to calculate the population. As the total population is known, it is calculated using the following expression:

$$n = \frac{N * Z_\alpha^2 p * q}{d^2 *(N-1) + Z_\alpha^2 * p * q} \quad (1)$$

Where p = means the approximate proportion of the phenomenon under study in the reference population, while q = represents the proportion of the reference population that does not present the phenomenon under study (1 -p). The desired confidence level is indicated by the letter (Z). These, in turn, refer to the degree of confidence that the true value of the parameter in the population will be found in the calculated sample, while the absolute precision is (d). Which is nothing more than the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points). N is population size.

In this case, you want a confidence level of 95%, z = 1.96, d = 0.05 and p = 0.44, N =[30, 36].

Calculations on the neutrosophic sample were made on Google Collaboratory using python interval arithmetic library.

The result that we call the neutrosophic sample n = [27.46, 33.44] indicates that the sample must be in values between 27 and 33 individuals. This value is de-neutrosophicated using:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} = \frac{27+33}{2} = 30 \quad (2)$$

Being consistent with the formulas of neutrosophic statistics for the population calculation, in this research, a total of 30 professionals from different branches of the health sciences are studied. Table 1 shows these and the amount for each of them, the sex and the average age of the sample under study. A simple random sampling was used for its selection, using the technique of selection by random numbers.

Specialty (N)	Male gender	Female gender	Age (mean ± SD)
Medicine (16)	7	9	39.1 ± 11.6
Nursing (7)	5	2	44.7 ± 11.2
Laboratory workers (4)	1	3	42.6 ± 10.1
Rehabilitators (2)	1	1	46.5 ± 9.2
TOTAL (30)	15	15	44.3 ± 10.8

Table 1. Characteristics of the sample studied by medical specialty, sex and age. **Source**: results of the sample study.

2.2 Type of investigation

A quantitative and cross-sectional pilot study was carried out. It is based on non-experimental research since there was no manipulation of the variables. The data are interpreted as they were revealed in the context of the application, a question that allows a photographic assessment of it.

2.3 Instruments

For the development of the study, a set of methods were used, both theoretical and empirical. Their grouping was carried out under the criteria issued by Hernández [6].

- *Analytical-synthetic*, allowed us to carry out a study on the theoretical and methodological foundations on which the assessment of the relevance of intercultural medical care is based. In addition, it facilitated the processing of the information offered by the different instruments applied to diagnose the current state of the problem and the drawing of conclusions.
- *Inductive-deductive*, made it possible to make inferences and generalizations about the assessment of the relevance of intercultural medical care, through the use of the neutrosophic linguistic scale, from which new logical conclusions are deduced.
- Systemic**:** It was used in understanding the interactions that occur between each of the questions designed in the survey, this was verified with the Pearson correlation test.
- *Survey***:** It was applied to obtain information that would allow characterizing the assessment of the relevance of intercultural medical care, for its tabulation a neutrosophic linguistic Likert scale is used.

Questions contained in the survey:

- Question 1. Do you assess the importance of medical treatments based on interculturality?
- Question 2. How do you assess the benefits of using medicine based on interculturality?
- Question 3. What is your assessment regarding the inclusion of intercultural medicine techniques in Ecuador in current medical care?

2.4 Neutrosophic method used

For the development of the research the following steps are used [7]:

- Step 1 Identify the problem
- Step 2 Choice of method and type of scale
- Step 3 Collect the information
- Step 4 Data interpretation
- Step 5 Study validation

Neutrosophic evaluative scale:

A neutrosophic Likert scale was used to determine the relevance, where the values under consideration are composed of PA (x), IA (x), NA (x), where PA (x) denotes a positive membership, IA (x) is indeterminate, and NA (x) is negative. The health sciences professional can evaluate whether their satisfaction criteria belong to the five sets. This scale used single value neutrosophic numbers (SVNN) [8,9,10]. An SVNS is an object with the following form [11,12,13].

Definition 1: Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (3)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate, and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

The interval represents the true, indeterminate, and false memberships of x in A, respectively. For convenience, an SVN number will be expressed as A, where a, b, c [0, 1], y + b + c ≤ 3

Linguistic term	SVN numbers
Very Relevant (VR)	(1,0,0)
Relevant (R)	(0.70,0.25,0.30)
Medium Relevant (MR)	(0.50,0.50,0.50)
Something Relevant (SP)	(0.30,0.75,0.70)
Not Relevant (NR)	(0,1,1)

Table 2. Linguistic terms of the scale[14, 15].

Let A = (T, I, F) be a single-valued neutrosophic number, a scoring function S related to a single-valued neutrosophic value, based on the degree of belonging to the truth, the degree of belonging to indeterminacy and the degree of belonging to falsehood is defined by [16,17]:

$$\boldsymbol{s(V_i) = 2 + T_i - F_i - I_j} \qquad (3)$$

The scoring function for single-valued neutrosophic sets is proposed to make the distinction between the numbers [18].

2.5 Statistical analysis used

Statistical analyzes were performed with SPSS v. 20 (SPSS Inc., Chicago, IL, United States). The data relating to descriptive statistics will be presented below through the distribution of frequencies, while the Pearson correlation test was used to identify whether or not there were coincidences in the responses of health science professionals to the survey questions.

3 Results

Answer to question 1

When looking at graph 1, you can see the results of question 1 of health professionals regarding the importance of medical treatments based on interculturality. Where it can be seen that only 3 of them for 10.1% of the total sample considered that these are very relevant, for their part 2 for 6.7% consider that they are relevant and 7 for 23.3% evaluate it of averagely pertinent.

It is noteworthy that the majority of respondents 11 to 36.6% consider that they are something relevant and that they can still be used but always as an alternative treatment. The remaining 7 for 23.3% considered it not relevant and stated that with advances in science and technology they do not believe that they are already useful to current medicine.

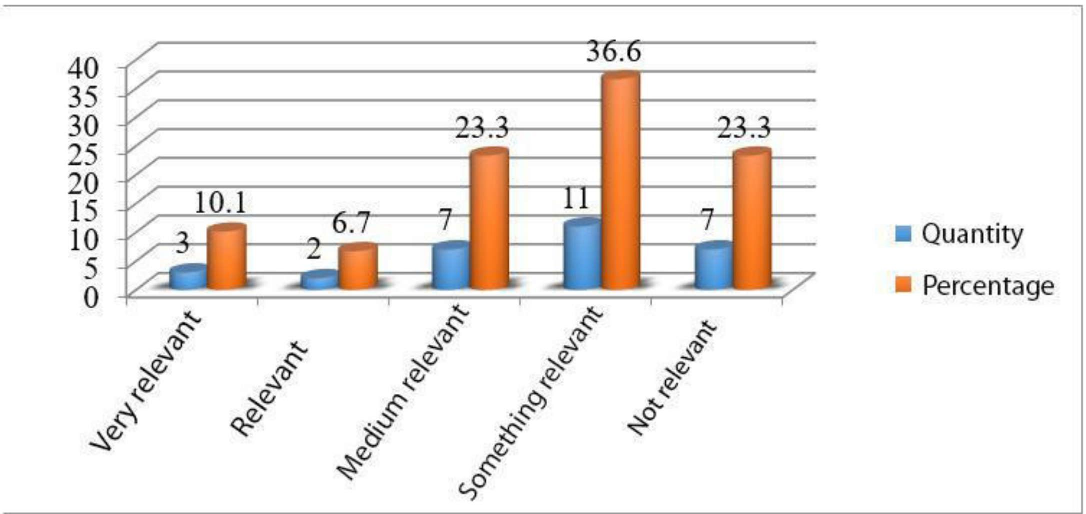

Figure 1. Results obtained in question 1. **Source**: Microsoft Excel for Windows processing results.

Answer to question 2

Figure 2 shows the results of question 2 of the survey, where 4 professionals for 13.3% consider that the benefits of the use of medicine based on interculturality are still very relevant today. On the other hand, 3 for 10% of the sample considers that they are pertinent.

On one hand, the majority of the investigated subjects 11 for 36.7% consider that they are moderately pertinent and that accompanied by other scientifically proven techniques they give positive results. The Something relevant category was indicated by 9 professionals for 30% and the rest of the investigated 3 for 10% considered that they are not relevant.

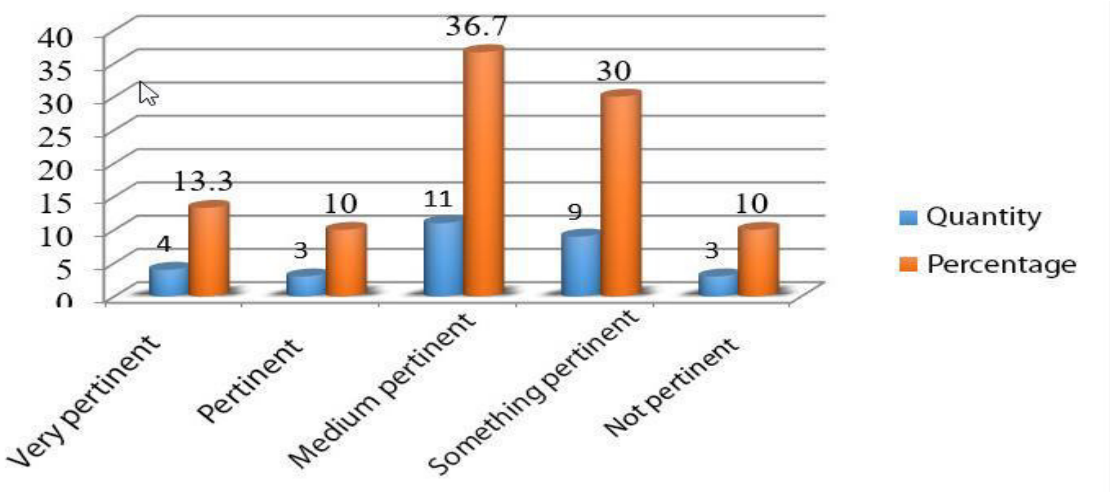

Figure 2. Results obtained in question 2. **Source**: Microsoft Excel for Windows processing results.

Answer question 3

The results of this question are illustrated in graph number 3. Where 5 of the professionals surveyed for 16.6% consider that the inclusion in current medical care techniques of intercultural medicine in Ecuador is very pertinent, always in conjunction with the traditional one. While 4 for 13.4% value its inclusion as pertinent.

Most of the professionals in the study (12 for 40%) valued that their inclusion is moderately relevant, they also reflected in the qualitative assessment of the survey that it is possible as an alternative. The category of something pertinent obtained 6 professionals for 20%, while the remaining 3 study subjects for 10% considered that it is not pertinent.

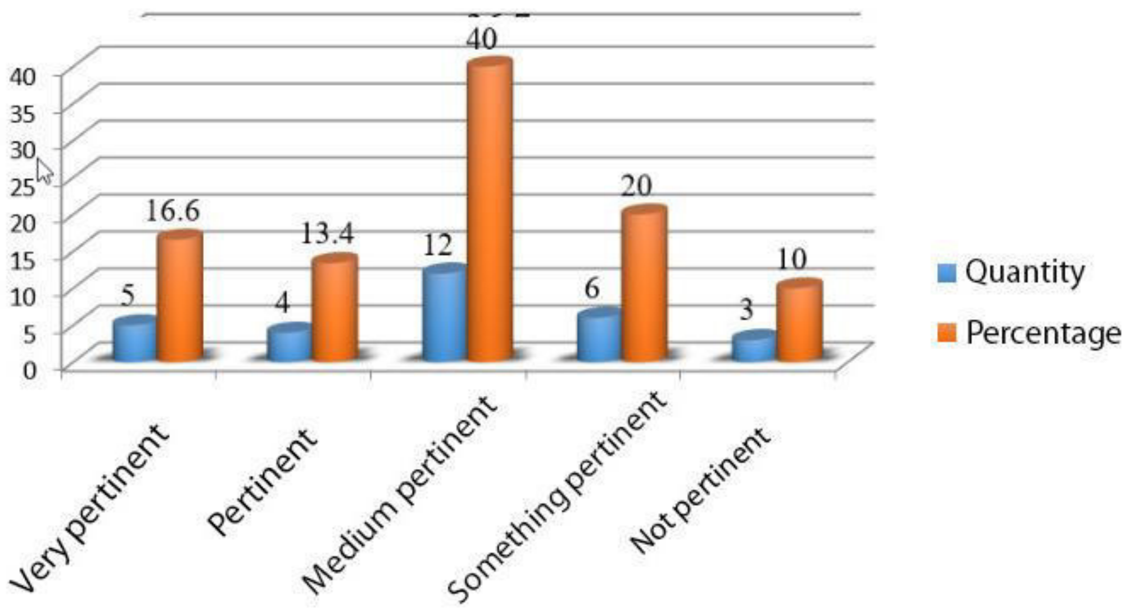

Figure 3. Results obtained in question 3. **Source**: Microsoft Excel for Windows processing results.

Study validation

To deepen the validity of the results, a correlation study was carried out, since this type of statistical analysis allows the assessment of the relationships between 2 or more variables, that is, the degree of possibility that they coincide. Table 3 shows the correlation matrix between the variables corresponding to the three questions of the survey that were applied to health professionals. Correlation coefficients have been calculated in all possible pairs of study variables.

The interpretation of the results of the Pearson test carried out by SPSS 20.0 for Windows, makes it evident that they are significant, since r, (p <0.005). In this sense, it can be seen that the responses to the content of the survey questions correlate with each other. All of the above makes evident the level of assessment of the relevance of intercultural medical care. A question that accepts the hypothesis raised.

Correlations

		Importance	Profits	Inclusion
Importance	Pearson's correlation	1	.912 **	.918 **
	Sig. (Bilateral)	-	, 000	, 000
	N	30	30	30
Profits	Pearson's correlation	.912 **	1	.941 **
	Sig. (Bilateral)	, 000	-	, 000
	N	30	30	30
Inclusion	Pearson's correlation	.918 **	.941 **	1
	Sig. (Bilateral)	, 000	, 000	-
	N	30	30	30

Table 3. Correlation matrix between the responses of health science professionals. **Source**: SPSS 20.0 processing for Windows
**. The correlation is significant at the 0.01 level (bilateral).

Conclusion

The analysis of the theoretical and methodological references on Assessment of the relevance of intercultural medical care shows the existence of different bibliographic sources on the subject, however, tools are required to promote a current assessment of this problem.

The methodological logic followed was based on the general methods of science for the statistical analysis of the assessment of the relevance of intercultural medical care.

The interpretation of the results offers validity to the research carried out since employing statistical analysis, particularly the Pearson correlation test, allowed the validation of the instruments used in the research with a significance level of p 000.

It is important to study in-depth in future works the construction of the computer tool and the use of the Neutrosophic Compensatory Logic are considered since the latter provides linguistic models that express through logical propositions the translation of ambiguous phrases into the colloquial style as they refer.

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Neutrosophic Statistics in the Analysis of the Causes of Tax Evasion

Denisse Elizabeth Huera Castro[1], Marcelo Raúl Dávila Castillo[2], Eugenio Javier Escobar Gonzáles[3] and Milton Rodrigo Hidalgo Ruiz[4]

[1] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador Email: ua.denissehuera@uniandes.edu.ec
[2] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.marcelodavila@uniandes.edu.ec
[3] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.eugenioescobar@uniandes.edu.ec
[4] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.miltonhidalgo@uniandes.edu.ec

Abstract. In Ecuador, taxes have become one of the main sources of public income after the fall in oil prices. That is why it is important to integrate tax policies and tax compliance with the taxpayer since it is considered essential in the State's development plans. On the other hand, the payment of taxes constitutes one of the main mechanisms to maintain and strengthen the government fiscal policy and, in some cases, the main source of economic resources that allow the State to conserve and improve the levels of public funds. Unfortunately, citizens have difficulty filing taxes, and that is due to the lack of tax culture. This paper is developed through a neutrosophic statistical analysis to determine the possible causes of non-compliance with tax obligations. Currently, the breach of formal duties continues to be part of the usual procedure of taxpayers for which it is necessary to analyze its causes. It is a process that involves indeterminacy; hence it will be better treated with a neutrosophic approach.

Keywords: public revenue, taxpayer, taxes, neutrosophic statistics.

1 Introduction

"Tax evasion is any elimination or reduction of a tax amount produced within the scope of a country, by those who are legally obliged to pay it and who achieve such result through fraudulent, omission or violation of legal provisions" [1]. Tax evasion is a fact that worries all countries of the world due to the effects it has produced [2]. It corresponds to commissive events of the taxpayer that contravenes and violates the fiscal norm and by which a taxable wealth is totally or partially subtracted from the payment of the tax provided by law [3].

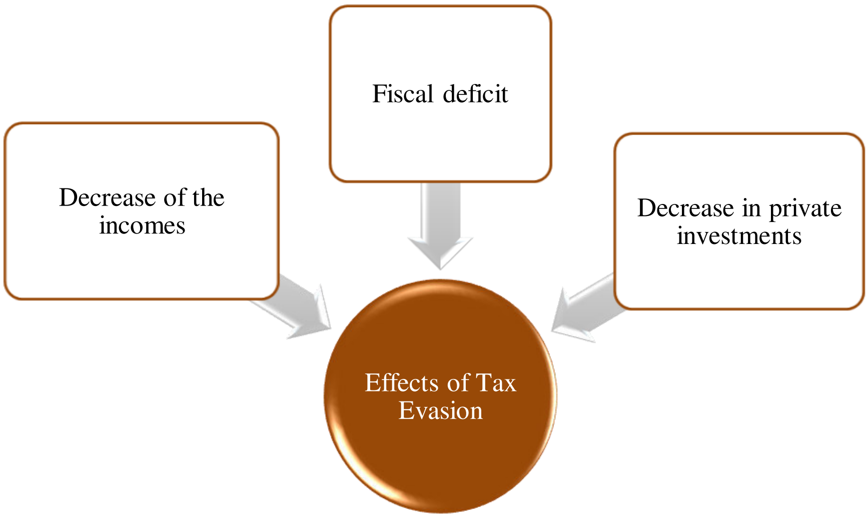

Figure 1. Effects of tax evasion.

Taxes are incomes that the State and other public sector entities receive from taxpayers in the form of taxes, fees, special contributions to finance public services, and the execution of programs that help sustain the country's welfare state [4]. These taxes generate greater strengthening of public services, which is why their collection is essential because this satisfies the basic needs of society.

To demonstrate the main causes and their impact on the development of the Ecuadorian economy, The Tax Administration has been directed with a coercive approach, but both theory and numerous studies have shown that it is important to consider the taxpayer's perception of the fairness of the tax system, as well as its morality [5].

[6] indicates that "tax evasion or fiscal evasion is an illegal act that consists of hiding assets or income to pay fewer taxes, and nowadays there are many ways used by taxpayers to evade taxes; in fact, some are very well elaborated, sophisticated, and others, on the other hand, surprise for their simplicity, for how simple and effective they are, but it is not easy to know them all.

Tax policy promotes redistribution and stimulates employment, the production of goods and services, and responsible ecological, social, and economic behaviors" [7]. For this reason, it is necessary to make theoretical contributions to support state policy. At present, it is important to generate a reference framework for tax education, since the commitment depends on it, in such a way that in the social structure it complies with each of the redistribution principles [8].

Ecuador needs to continue applying increasingly efficient tax policies, which discourage tax evasion, by taxpayers, through the implementation of different mechanisms of coercion, education and culturalization, since ignorance of tax obligations does not exempt the taxpayer from responsibilities [9-11].

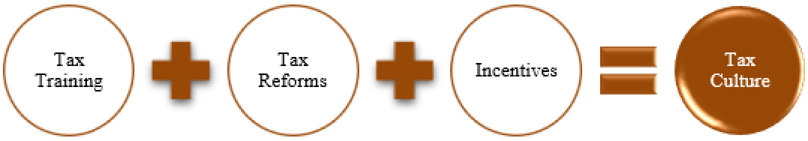

Figure 2. Support mechanisms to increase the tax culture.

The person who simulates, hides, omits, falsifies, or deceives in the determination of the tax obligation, to stop paying the taxes in whole or in part, will be punished with a custodial sentence of 1 to 10 years, depending on the type of tax fraud committed [12] and to detect the evader, the decision is left to the taxpayer as well as the probability of being detected and captured; the taxpayer intuits the control carried out by the collecting entity and the handling of incomplete and imperfect information to decide to fall into tax evasion [13].

Despite the efforts made by the Internal Revenue Service (IRS) to strengthen controls to reduce the level of evasion and to enhance the processes aimed at increasing collection, such objectives have not yet been achieved [13, 14].

There will always be tax evasion and the non-compliance with the tax payment means that the country stops moving forward to achieve the millennium goals such as: minimize extreme hunger and unemployment, achieve schooling for children, reduce infant mortality, improve the health of the dispossessed, fight disease and ensure the conservation of the environment [5, 15].

This study defines the problem situation as non-compliance with the tax payment for the analysis of tax evasion. From this, the main objective is to analyze the causes of tax evasion and the specific objectives are:

- Determine the causes that influence non-compliance with the tax payment
- Carry out the measurement and modeling of the variable
- Project viable alternatives based on the strategy

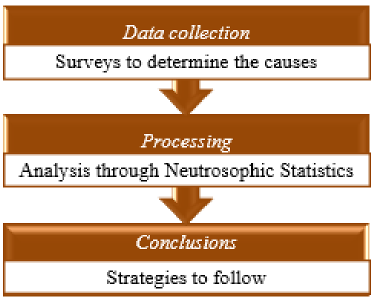

Figure 3. Development of the study of non-compliance with the tax payment.

2 Materials and methods

Whereas Classical Statistics deals with determinate data and determinate inference methods, Neutrosophic Statistics deals with indeterminate data. That is, data that has some degree of indeterminacy (unclear, vague, partially unknown, contradictory, incomplete, etc.), and from indeterminate inference methods that also contain degrees of indeterminacy (for example, instead of arguments and crisp values for probability distributions, graphs, diagrams, algorithms, functions, etc. inaccurate or ambiguous arguments and values may be present) [16-22].

Neutrosophic Statistics was founded by Prof. Dr. Florentin Smarandache [23], from the University of New Mexico, United States, in 1998, who developed it in 2014 by introducing the Neutrosophic Descriptive Statistics (NDS). Later, Prof. Dr. Muhammad Aslam from King Abdulaziz University, Saudi Arabia, founded in 2018 the Neutrosophic Inferential Statistics (NIS), the Neutrosophic Applied Statistics (NAS), and the Neutrosophic Statistical Quality Control (NSQC).

The Neutrosophic Statistics is also a generalization of the Interval Statistics, due, among other things, to the fact that while the Interval Statistics is based on the Interval Analysis, the Neutrosophic Statistics is based on the Analysis of Sets (understanding by such all set types, not just intervals).

If all the data and inference methods are determined, then the Neutrosophic Statistics coincide with Classical Statistics. As the world has more indeterminate data than determined, neutrosophic statistical procedures are more needed than classical ones.

Neutrosophic Numbers of form N = a + bI have been defined by WB Vasantha Kandasamy and F. Smarandache in 2003 [24], and were interpreted as "a" is the determinate part of the number N, and "bI" as the indeterminate part of the number N by F. Smarandache in 2014 [16]. Neutrosophic probabilities and statistics[25], are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the joint probability that event E occurs, the probability that event E does not occur, and the probability of not knowing whether event E occurs or not [26]. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)), \quad (1)$$

T (x) represents the probability that the value x occurs, F (x) the probability that the value x does not occur, and I (x) the indeterminate/unknown probability of the value x.

3 Results

Data collection

A Neutrosophic Frequency Distribution is a table showing absolute and relative frequencies, partial or total indeterminacies. Indeterminacies mainly occur due to imprecise, unknown or incomplete data related to absolute frequencies. The relative frequencies then become imprecise, incomplete or may even become unknown, an example of this is the following distribution of neutrosophic frequencies associated with the analysis of the causes of tax evasion.

Nr	Cause	Neutrosophic absolute frequency	Neutrosophic relative frequency
1	Unawareness	15	[0.179, 0.214]
2	Trust third parties.	[20,30]	[0.238, 0.429]
3	Lack of liquidity	25	[0.298, 0.357]
4	Loss of documentation	[10.14]	[0.119, 0.2]
		[70.84]	[0.833, 1.2]

Table 1. Causes of tax evasion.

As can be seen, for the cases of Unawareness and Lack of liquidity, the number of individuals who present this cause of non-payment of taxes is known precisely (15 and 25 times, respectively). However, it is not possible to specify the number of times that the causes have been observed to be Trusting third parties and Loss of documentation.

From the table, we can see that, for the case of 2, this has happened between 20 and 30 times, but the exact information is not available, the same for the figure of Loss of documentation. This indicates the existence of indeterminacies related to frequencies. The last column reveals the neutrosophic relative frequencies associated with each event.

As there is imprecise information, it is necessary to calculate the extremes (min and max) of the absolute or estimated frequencies.

$$min_{fn} = 15 + 20 + 25 + 10 = 70$$

$$max_{fn} = 15 + 30 + 25 + 24 = 84$$

Subsequently, to calculate the relative frequencies, the minimum and maximum values of these must be calculated for each of the results tabulated as individuals who report that cause of non-compliance. For this, the following formula will be applied:

$$min_{fnri} = \frac{min_{fni}}{max_{fn}}, \text{ and}$$

$$max_{fnri} = \frac{max_{fni}}{min_{fn}}$$

In the case of frequencies that do not present indeterminacy, it is true that:

$$min_{fni} = max_{fni} = fni$$

Therefore:

$$min_{fnr0} = \frac{min_{fn0}}{max_{fn}} = \frac{15}{84} = 0.179$$

$$max_{fnr0} = \frac{max_{fn0}}{min_{fn}} = \frac{15}{70} = 0.214$$

$$min_{fnr15} = \frac{min_{fn15}}{max_{fn}} = \frac{20}{84} = 0.238$$

$$max_{fnr15} = \frac{max_{fn15}}{min_{fn}} = \frac{30}{70} = 0.429$$

$$min_{fnr20} = \frac{min_{fn20}}{max_{fn}} = \frac{25}{84} = 0.298$$

$$max_{fnr20} = \frac{max_{fn15}}{min_{fn}} = \frac{25}{70} = 0.357$$

$$min_{fnr30} = \frac{min_{fn20}}{max_{fn}} = \frac{10}{84} = 0.119$$

and

$$max_{fnr30} = \frac{max_{fn15}}{min_{fn}} = \frac{14}{70} = 0.2$$

The value of the accumulated neutrosophic relative frequency was then obtained through the sum of the reported neutrosophic relative frequencies.

$$Frna = [0.179\,, 0.214] + [0.238\,, 0.429] + [0.298\,, 0.357] + [0.119\,, 0.2] = [0.833\,, 1.2]$$

Neutrosophic statistical analysis

To visually show the neutrosophic absolute frequencies, different types of graphs can be used, which must contain and differentiate the determined and the indeterminate part of the analyzed data.

The frequency of recording the causes of non-compliance can be represented by a column chart as shown in the figure.

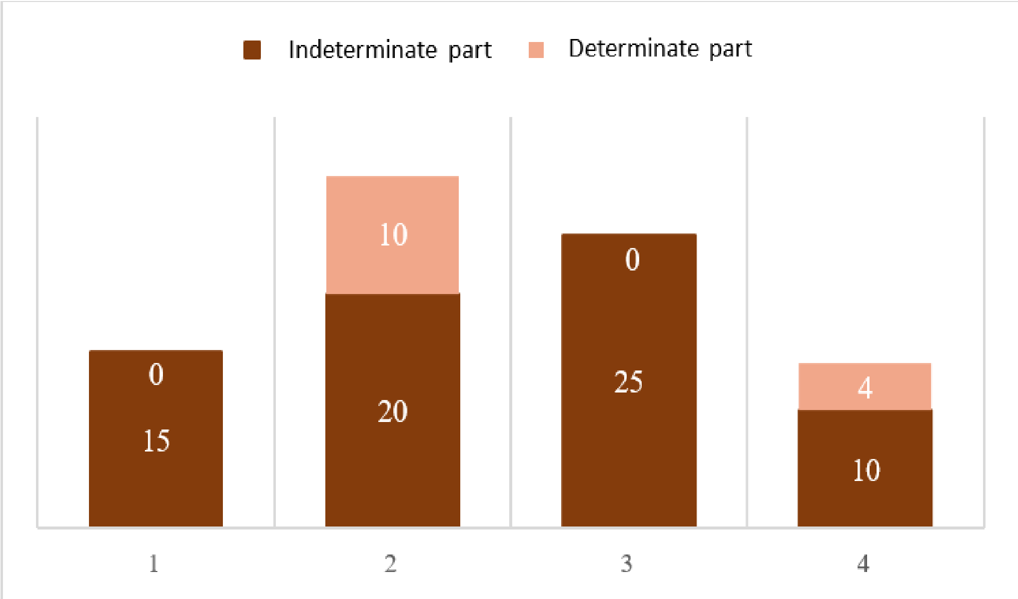

Figure 4. Neutrosophic column chart.

It can be seen that the frequencies related to causes 2 and 3 are indeterminate with indeterminacy values of 10 and 4, respectively.

Chapter conclusion

In this case, 15 specialists are selected from the neutrosophic sample and the possible causes of tax evasion are analyzed and modeled using a neutrosophic cognitive map. Indeterminacy is expressed with the question mark (?). The identified causes are:

Node	Cause
N1	Unawareness
N2	Trust third parties.
N3	Lack of liquidity
N4	Loss of Documentation

Table 2. Causes and nodes identified

"N0" represents on the map the causes of tax evasion

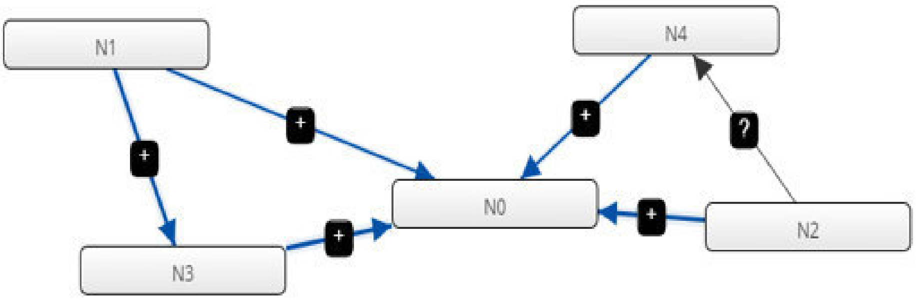

Figure 5. NCM graphic representation of the causes of non-payment.

	N0	N1	N2	N3	N4
N0	0	0	0	0	0
N1	0.75	0	0.25	0	0
N2	0.5	0	0	0	I
N3	0.75	0	0	0	0
N4	0.25	0	0	I	0

Table 3. Neutrosophic adjacency matrix

The nodes are subsequently classified. The following measures are used in the proposed model based on the absolute values of the adjacency matrix.

- Outdegree $od(v_i)$is the sum of the rows in the neutrosophic adjacency matrix. It reflects the strength of the relations (c_{ij}) salient of the variable.

$$od(v_i) = \sum_{i=1}^{N} c_{ij} \tag{2}$$

- Indegree is the sum of the columns that Reflects the Strength of the salient relations (c_{ij}) of the variable.

$$id(v_i) = \sum_{i=1}^{N} c_{ji} \tag{3}$$

- Total centrality (total degree), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \tag{4}$$

The measures of centralities are calculated. Outdegree and Indegree measurements are presented in Table 4.

Node	Outdegree	Indegree
N0	0	*2.25*
N1	1	*0*
N2	0.5 + I	*0.25*
N3	0.75	*0*
N4	0.25	*I*

Table 4. Centrality measures

The nodes are classified according to the following rules:

- **The Transmitting variables:** They have positive or indeterminate outdegree and zero indegree.
- **The receiving variables:** They have an indeterminate or positive indegree and zero outdegree.
- **The ordinary variables:** They have a degree of indegree and outdegree other than zero.

The nodes are classified below:

In this case, nodes P1, E1, and T2 are transmitters, S1 is a receiver, and T1 is ordinary.

	Transmitter	**Receiver**	**Ordinary**
N0		X	
N1	X		
N2			X
N3	X		
N4			X

Table 5. Classification of nodes

The total grade was calculated (Equation 5.3). The results are shown in Table 6.

	td
N0	2.25
N1	1
N2	0.75 + I
N3	0.75
N4	0.25 + I

Table 6. Total degree

Static analysis in NCM initially results in neutrosophic numbers of the form (a + bI), where I = indeterminacy). That is why a neutralization process is required, as proposed by Salmerón and Smarandache. I ∈ [0, 1] is replaced by its maximum and minimum values.

N0	*2.25*
N1	1
N2	[0.75, 1.75]
N3	0.75
N4	[0.25, 1.25]

Table 7. De-neutrosophication of centrality values

The total grade was calculated (Equation 5.4). Finally, we work with the average of the extreme values to obtain a single value:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{5}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{6}$$

The results are shown in Table 8.

	Td
N0	2.25
N1	1
N2	1.25
N3	0.75
N4	0.75

Table 8. Centrality using the mean of the extreme values

The order obtained is: $\mathbf{N_0} \succ \mathbf{N_2} \succ \mathbf{N_1} \succ \mathbf{N_3} \sim N_4$. where the nodes *Trusting on third parties* and *Unawareness* are the main factors.

Strategies to consider

The Tax Administration should minimize the adverse effects of trusting third parties and ignorance, such as the main nodes that activate the neutrosophic network in non-compliance with the tax payment. Therefore, the strategy to consider will be: the tax policy should be aimed at improving the perception that taxpayers have about the fulfillment of their tax obligations, through the expansion of the sanctioning part of the current tax legal framework, the increase in tax rates penalization for tax non-compliance, optimization of information systems and increase in educational campaigns, to make taxpayers understand that for the development of a country the commitment of all its citizens is necessary.

Conclusions

- The government and SRI should focus on improving the efficiency of the collection to eliminate the public deficit, implementing mechanisms from constant educational training, and implementing applications and web pages.
- The neutrosophic statistical analysis and the neutrosophic statistics can determine the possible causes and non-compliance with tax obligations. Currently, the breach of formal duties continues to be part of the usual procedure of taxpayers, which is why it is necessary to analyze using a tool that includes indeterminacy.
- After application in this case study, the model is found to be practical to use. The NCM provides great flexibility and considers the interdependencies of the analysis of the causes of tax evasion.

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Management of Indeterminacy in the Analysis of Knowledge about Reproductive Tract Infections in Women

Julio Morillo Cano[1], Melba Esperanza Narváez Jaramillo[2], Adisnay Rodríguez Placencia[3] and Olger Efraín Velastegui Naranjo[4]

[1] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.juliomorillo@uniandes.edu.ec
[2] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Troncal de la Sierra, Tulcán. Carchi. Ecuador. Email: ut.melbanarvaez@uniandes.edu.ec
[3] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.adisnayrodriguez@uniandes.edu.ec
[4] Docente de la carrera de Enfermería. Universidad Regional Autónoma de los Andes (UNIANDES). Km 5 ½ vía a Baños. Ambato. Tungurahua. Ecuador. Email: ua.olgervelastegui@uniandes.edu.ec

Abstract. The research aims to assess the level of knowledge about reproductive tract infections among women to apply statistical analysis of the probability of indeterminacy. The main methods and techniques used were: theoretical, analytical-synthetic, and inductive-deductive, while within the empirical are the survey, measurement, and statistical-mathematical. The sample was calculated using neutrosophic statistics and python interval arithmetic library. The results achieved are evaluated quantitatively and qualitatively, where the validity of the same was demonstrated since there was a level of significance equal to or less than p 0.05.

Keywords: analysis, indeterminacy, infections, reproductive tract, neutrosophic sampling

1 Introduction

Infections of the female genital tract, in addition to the physical and emotional problems that they cause in patients, constitute an economic loss of appreciable proportions to the health system, both in women in industrialized countries and the female population of developing countries [1], [2]. On the other hand, female genital tract infections are an important health problem in medicine and one of the main reasons for consultation in Primary Health Care in women of reproductive age [1],[2].

Factors that may explain the higher frequency of these infections include induced abortion, which in developing countries is an important cause of serious and fatal infectious diseases; the increase in gynecological and obstetric diagnostic examinations, fostered by advances in health systems these days.

This condition can be associated with the invasion and multiplication of pathogenic microorganisms in the vagina from external or internal sources. The germs that are part of the normal microbiota intervene, which by different factors modify the acidic pH of the vagina, which normally remains between 3.5 and 4.5.

The alteration of the pH produces the imbalance of the vaginal microenvironment, with the consequent decrease or disappearance of the protective effect of the lactobacillary microbiota. The change produced facilitates the rapid and uncontrolled growth of harmful biological agents and the formation of metabolic wastes such as flow, inflammation, and irritation of the vaginal walls. The changes produced are frequently associated with bacterial vaginosis, trichomoniasis, and vaginal candidiasis [2], [3].

A study by the World Health Organization shows that more than 90% of deaths are concentrated in low- and middle-income countries, where access to timely detection and treatment services is very limited [4]. That is why it becomes a serious health problem.

The clinical manifestations of female genital tract infections are many and varied, from simple vaginitis to septic shock, with a series of intermediate and progressive conditions such as endometritis, salpingitis, Tubo-ovarian abscesses, pelvic peritonitis, and peritonitis, as well as complications during pregnancy, postpartum and the puerperium [1], [2].

The importance of personal hygiene in women is indisputable since contact with urine, sweat, and vaginal secretion, in addition to the poor ventilation in that area, favor that the humidity generated does not evaporate completely, reasons for which they make the vagina more susceptible to infections [5], [6]

Several researchers agree that the lack of sexual hygiene can be the cause of sexually transmitted infections and when these are repeated, cause cervical cancer (CCU) [7], [8]. This pathology is the main cause of death from gynecological cancer in Ecuador. That is why there is a need to enhance knowledge among females of different reproductive ages.

Bacterial vaginosis (BV) is a polymicrobial clinical entity resulting from the replacement of the normal vaginal microbiota of Lactobacilli spp. Producers of hydrogen peroxide due to high concentrations of anaerobic bacteria such as Prevotella spp., Mobiluncus spp., Bacteroides spp., Peptoestreptococcus spp., Peptococcus spp., Gardnerella vaginalis, and Mycoplasma hominis. In women with BV, the concentration of G. vaginalis is 100 to 1 000 times higher than in women without this disease and is considered its main causative agent.

Another vaginal infection is trichomoniasis. This condition is among one of the most common sexually transmitted STIs. Its causative agent is Trichomonas vaginalis, a flagellated protozoan parasite that infects the male and female urogenital tracts. Risk factors involved include having multiple sexual partners and having unprotected sexual contact. [9]

There are numerous investigations carried out on this subject, among them the following stand out: Cutié and collaborators in their study obtained a positivity of 49.2% in the samples taken at best with some type of symptom of reproductive tract infections. [1]

On the other hand, Ortiz et al. identified 50.3% [10], while Gallardo and others did it for 87% [11]. A question that denotes that the positivity of samples in women with some reproductive tract infection is increasing every day.

Authors such as Ortiz and Martínez applied a group of surveys and managed to identify that the average age of the patients with vaginal infections was 35 years, with a range of 17 to 74 years and the average age of initiation of the first sexual relations was of 17 years with a range of 12 to 36 years, which coincides with some authors who state that these clinical entities are more frequent in women who are fully sexually active [11], [12].

According to the bibliography consulted, during pregnancy, infection is more frequent in the third trimester of pregnancy. In this physiological period, high levels of estrogens and glucocorticoids are produced, which results in a reduction of vaginal defense mechanisms and a relationship between vaginal infection by Candidas spp., and early pregnancy complications such as the low birth weight fetus and prematurity [3].

On the other hand, the early initiation of sexual intercourse, use of intrauterine devices and vaginal douches, promiscuous sexual behavior, pregnancy, hormonal treatments, and suffering from diseases, such as decompensated diabetes mellitus or others that cause depression of the immune system, are factors that predispose women to vaginal infections; In this study, there was a relationship between the risk factors explored and the frequency of these clinical entities [13].

As can be seen in the researches consulted, reproductive tract infections in women are a serious health problem both personally and for a certain country. Within the fundamental perspectives of the different health systems (prevention, education, and treatment of diseases), it is undoubtedly the first two important pillars.

That is why tools are required to identify the level of knowledge about reproductive tract infections among women. Neutrosophic statistics, and especially neutrosophic probabilities, are used for this purpose. Which starts from the event E, has the probability that event E occurs, the probability that event E does not occur and the probability of indeterminacy (not knowing whether event E occurs or not). For example, in classical probability nsup ≤ 1, while in neutrosophic probability nsup ≤ 3 + [14].

Therefore, the objective of this work was to apply statistical analysis of the probability of indeterminacy in the assessment of the level of knowledge about reproductive tract infections among women.

2 Materials and Methods

2.1 Subjects under study

Neutrosophic statistics were used to calculate the population. As the total population that participates in the research is known, it is calculated using the following expression p = approximate proportion of the phenomenon under study in the reference population q = proportion of the reference population that does not present the phenomenon under study (1 -p).

The desired confidence level (Z). It is an expression that makes evident the degree of confidence that will be had that the true value of the parameter in the population found in the calculated sample. The absolute precision (d). It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points). N is population size.

In this case, data for calculation are: a confidence level of 90% ,$z = 1.645$, $d = 0.1$ and $p = 0.4$, $N = [20,36]$.

Calculations on the neutrosophic sample were made on Google Collaboratory online using python interval arithmetic library (Fig 1.)

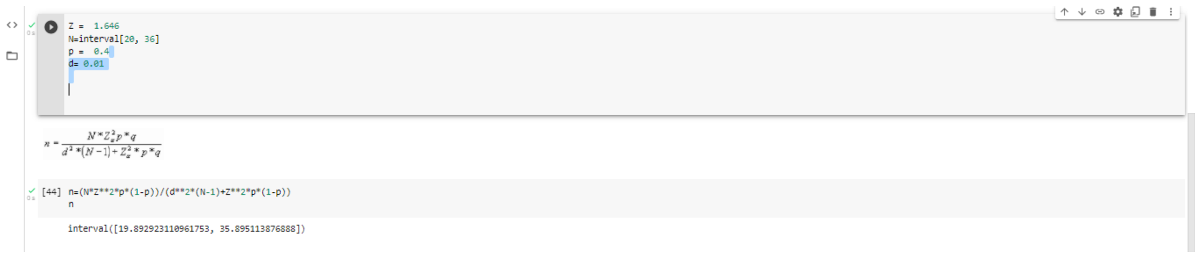

Figure 1. Neutrosophic sample calculation in Google Collaboratory

The result of the neutrosophic sample is n = [20, 36] indicates that the sample must be in values between 20 and 36 patients.

In the current study, participated 28 women of childbearing age, ranging in age from 22 to 40 with an average age of 33.6. They were all from the Guayas province of the Republic of Ecuador. Simple random sampling was performed using the random number technique.

2.2 Type of investigation

A descriptive cross-sectional study was carried out. The study complies with the postulates of the Declaration of Helsinki, where all patients signed informed consent. Where the data were tabulated and interpreted exactly as the members of the sample expressed them.

2.3 Instruments

The investigative logic was guided by the use of methods and techniques that are described below:

Analytical-synthetic: allowed to carry out a study about the theoretical and methodological foundations that support the management of indeterminacy in the analysis of knowledge about reproductive tract infections in women. It was used for the systematization, generalization, and specification of the processed information. It was useful in interpreting the empirical information obtained, as well as in preparing the proposal.

Inductive-deductive: it allowed to make inferences and generalizations about the management of indeterminacy in the analysis of knowledge about reproductive tract infections in women, as well as the interpretation of the data obtained, from which new logical conclusions are deduced.

Measurement: it was used to identify the transformations that occurred in the selected sample by using the survey applied to the women involved in the study.

Survey: It was carried out on 100% of the members of the study sample, as this was the instrument used to assess the women involved in the research regarding their level of knowledge about reproductive tract infections in women.

Questions:

1- Do you know which are the main reproductive tract infections in women?

2- What are its symptoms and signs?

3- What are the ways to prevent reproductive tract infections in women?

4- Do you know the complications that reproductive tract infections can cause among women?

Neutrosophic method used:

For the neutrosophic statistical analysis developed, the workflow of 5 activities was taken into account. Statistical analysis is based on a neutrosophic environment to model uncertainty. Therefore, the steps described above are presented below.

Step 1 Identification of the problem situation to be investigated

Step 2 Selection and development of instruments

Step 3 Application of the instruments

Step 4 Data analysis and interpretation

Step 5 Validation of the results

For the analysis of the behavior of the sample, we used the level of neutrosophic significance [15], [16], [17]. The level of neutrosophic significance α can be a set, not necessarily a crisp number as in classical statistics [18], [19]. A P Neutrosophic value is defined in the same way as in classical statistics: the smallest significance level at which a null hypothesis H0 can be rejected.

The distinction between the classical P-value and the neutrosophic P-value is that the neutrosophic P-value is not a crisp number as in classical statistics, but a set (in many applications it is an interval).

Neutrosophic P value = P z > z critical value when H0 is true where P (*) means classical probability calculated assuming that H0 is true, the probability of observing a test statistical value is more extreme than what was obtained.

2. 4 Statistical analysis used

Statistical analyzes were performed with SPSS v. 20 (SPSS Inc., Chicago, IL, United States). The data relating to descriptive statistics will be presented through the distribution of frequencies, while inferential statistics were used, particularly the non-parametric Chi-square test with Yates correction.

3 Results

When tabulating the results of the survey applied to the women who are part of this study, the results described below are corroborated by questions.

Figure 2 illustrates the results of question 1. Where it can be noticed that only a minority of 9 women for 32.2% stated that they knew about the main reproductive tract infections. On the other hand, the majority of the study sample considered the opposite, that is, no, this was reflected in 17 of them for 60.7% of the total women investigated. In contrast, 2 of them (for 7.1%) decided not to talk about it. As shown, there is ignorance of the majority of the investigated women about the main infections.

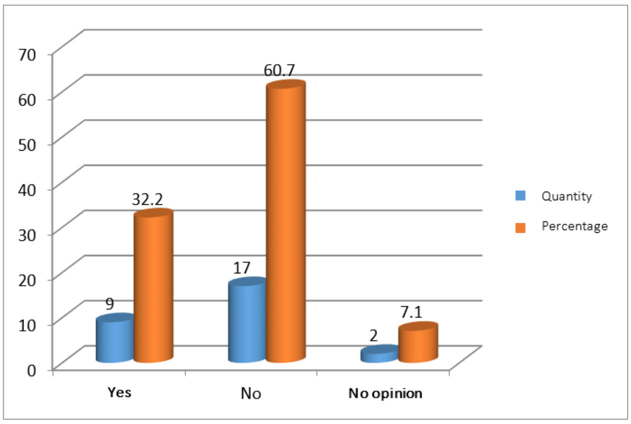

Figure 2. Results obtained in question 1 Source: Microsoft Excel for Windows processing results.

Figure 3 shows the results of question 2 on the content of women's knowledge about the symptoms and signs of reproductive tract diseases. Where, like the previous question, the minority of the sample under study knows the main signs and symptoms (8 for 28.5). Most of the women said they did not know them (18 for 64.4). While 2 for 7.1% did not have an opinion.

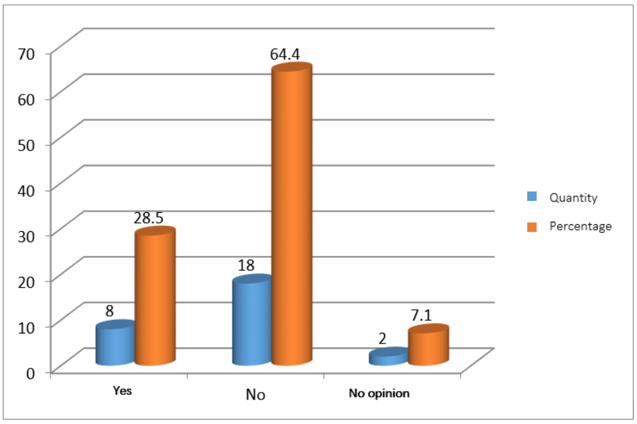

Figure 3. Results obtained in question 2. Source: Microsoft Excel for Windows processing results.

Figure 4 makes it evident that once again the minority of the women in the study are those who know the ways to prevent reproductive tract infections. This is reflected in that 10 of them for 34.7% indicated the *yes* option in the applied survey. While most of them 16 for a 57.1% consider not knowing them, this is an aspect that should be deepened in future research because the best treatment to deal with these diseases is prevention. On the other hand, only 2 women for 7.1% decided not to give their opinion and left the questionnaire blank.

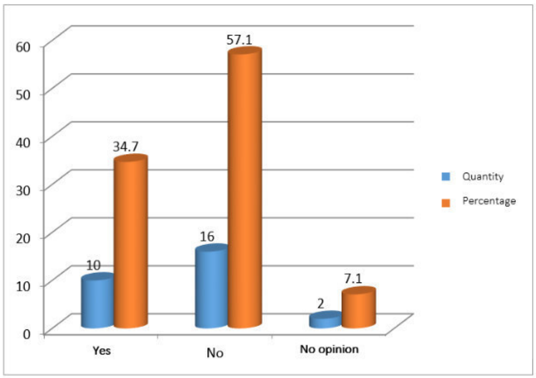

Figure 4. Results obtained in question 3. Source: Microsoft Excel for Windows processing results.

The last question of the survey (4) is represented in figure 5, where it is revealed that only 5 women for 17.9% of the total under study showed knowledge of the complications that reproductive tract infections may cause. While they *did not know about this,* the majority of the sample (21 for 75%) and only 2 for 7.1 did not have an opinion on the subject.

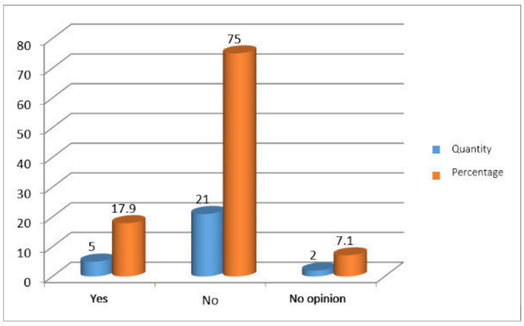

Figure 5. Results obtained in question 4 Source: Microsoft Excel for Windows processing results.

Results shown in each of the questions in the survey make it clear that intervention type research is required to enhance the knowledge of women regarding this topic. That is why it is suggested to develop brochures that illustrate the basic contents of reproductive tract diseases, to increase health education for this population group.

Study validation

For the validation of the study, three specific moments were taken into account, the first one directed to the hypothesis statement, the second to the application of the Chi-square test, and the third to the confirmation or not of the hypothesis.

Moment 1. State the statistical hypotheses that respond to the proposed objectives

Statistical hypothesis: H0: $\mu = \mu 0$

H0: Women do know about reproductive tract infections

H1: $\mu \neq \mu 0$

Ha: Women don't know about reproductive tract infections

Moment 2

The results obtained are shown in table 1. For which the data were processed with the statistical package SPSS v. 20 (SPSS Inc., Chicago, IL, United States). The results obtained through this are presented below.

Contrast statistics				
	Main infections	Symptoms and	Ways to	Complications
Chi-square	12,071[a]	14,000[th]	10,571[a]	22,357[a]
gl	2	2	2	2
Next asympt.	, 002	.001	, 005	, 000
a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.3.				

Table 1. Results obtained with the application of the nonparametric test of chi-square with Yates correction. Source: results of the processing of the SPSS statistical package v.20

Moment 3

The analysis of frequency, carried out through the Chi-square test with Yates correction, shows the existence of a significant difference. Well, as shown in table 1, in the content of the four questions of the survey, values equal to or less than 0.05 were obtained. Which denotes that the null hypothesis (Ho) is rejected.

Conclusion

The analysis of the theoretical and methodological references on the level of knowledge about reproductive tract infections in women shows the existence of different bibliographic sources on the subject, however, tools that promote a current assessment of this problem are required.

The methodological logic followed was based on the general methods of science for the statistical analysis of the level of knowledge about reproductive tract infections in women. Neutrosophic sampling was calculated using python

The interpretation of the results offers validity to the research carried out, since using statistical analysis, particularly the non-parametric Chi-square test with Yates correction, which allowed the validation of the results obtained in this study.

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Neutrosophic Statistical Analysis of the Rehabilitation of Arterial Hypertension

Lester Wong Vázquez[1], María Fernanda Orozco Noboa[2], Francisco Xavier Poveda Paredes[3] and Jorge Marcelo Quintana Yánez[4]

[1]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.lesterwong@uniandes.edu.ec
[2]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.mariaorozco@uniandes.edu.ec
[3]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.franciscopoveda@uniandes.edu.ec
[4]Regional Autonomous University of the Andes (UNIANDES), Km 5 ½ road to Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.jorgequintana@uniandes.edu.ec

Abstract. The present research addresses the subject of a neutrosophic statistical analysis of the rehabilitation of arterial hypertension. Through the consultation of the literature referring to the research topic, that necessary to cover the scientific path and the preparation of the report, the systematized investigative experiences, the use of methods of the theoretical, empirical, statistical, and mathematical level, as well as investigative techniques; it was possible to show that there are shortcomings that weigh down the subject studied. That is the reason why this analysis is carried out. Through which, after processing the information, it is evident that the results correlate with each other, and that grants validity to the tests executed.

Keywords: neutrosophic statistics, rehabilitation, arterial hypertension

1 Introduction

Various researchers consider Hypertension (HT) is not only a pathology but also a cardiovascular risk factor. Because its alteration can cause heart disease, cerebrovascular accidents, kidney failure, mortality, and premature disability; its prevalence increases with age. All of this coincides with what has been declared by numerous authors in the scientific community [1-4].

Due to the aforementioned arguments, this disease is considered one of the most important factors that influence mortality from cardiovascular diseases (CVD). Well, it has been proven by various means and sources that the alteration of blood pressure (BP), (whether elevated or decreased), is one of the risk factors for dissimilar diseases of the cardiovascular system. That is why it can be argued that it affects any age group.

That is why an investigation developed by the Joint Committee of the Association of Life Insurance Medical Directors of America has shown that scores above 140/90 mm Hg are pathological in any population group. In such cases, the diagnosis of hypertension is justified [5].

It is known that more than 90% of the cases of HT are within the so-called essential or primary HT, and in 80 to 90% of these, the responsible mechanisms are unknown. Among the most common causes of secondary HT are renal, pheochromocytoma, increased secretion of corticosteroids, and primary hyperaldosteronism. [6].

There are different approaches to what the reference values are to know if a patient has AHT. But undoubtedly, what was raised by the American Heart Association (AHA) and the American College of Cardiology (ACC) in 2014, agreed to form a panel of 21 members to draw up new guidelines for the diagnosis and management of HT. [7]

On the other hand, the Latin American scientific community suggests that hypertension is defined as the persistent elevation of BP above the limits considered normal. In adults, hypertension is considered when levels are equal to or greater than 140/90 mm Hg [6]

Hypertensive patients are now considered to be all those with diastolic blood pressure numbers of 80 mm Hg or higher, rather than 90 mm Hg and higher. Therefore, in these guidelines, the pre-hypertension category disappears, which was between 120 and 139 of SBP and between 80 and 89 of DBP [8], [9].

In the world, about 700 million people are suffering from arterial hypertension (AHT), 15 million die from diseases of circulatory origin, more than 7 million due to coronary heart disease, and 4.5 million die from encephalic vascular diseases, and hypertension is present in all of these people. [10].

According to researchers, older people have a higher cardiovascular risk than younger ones, for any level of blood pressure, thus patients between 65 and 94 with a diastolic blood pressure of 95 mm Hg have 3-4 times more cardiovascular risk than those between 35 and 64 years, with the same blood pressure [6], [10].

When analyzing the pathophysiological bases of HPA, it can be argued that the cardio-circulatory system is functionally a closed circuit. The heart, acting as a muscular pump, pumps blood through a network of blood vessels, which gradually become narrower until they become small capillaries, to then resume a larger caliber on its return to the starting point, with This process fulfills the vital function of feeding and oxygenating each of the cells of the body.

In this sense, the impulsion of the blood requires the power and energy of a contractile system capable of generating the necessary pressure so that said fluid, which is somewhat thick, remains in continuous movement. This pressure, when the entire structure functions correctly fluctuate between 80 and 120 mmHg. Strangely, a good number of adults experience a hemodynamic disorder over time in which the pressure in the system rises and remains permanently high

It is worth highlighting the evaluations that associate that cardiovascular risk began more than 50 years ago with the Framingham study, which allowed identifying the risk factors that favor the development of cardiovascular diseases (CVD) such as hypertension, dyslipidemia, smoking, obesity, diabetes, and physical inactivity. [11]

For this reason, AHT promotes atherogenesis by different mechanisms. Endothelial dysfunction has been observed in recent-onset hypertensive patients; this dysfunction can be evidenced by an attenuated response to vasodilator substances, such as acetylcholine, by an increase in vascular permeability to macromolecules, including lipoproteins, by an increase in endothelin production and an increase in leukocyte adherence.

HT induces arterial remodeling that results in a decrease in light in the small vessels with an increase in resistance to flow and, on the contrary, a dilation in the large arteries that favors the development of atherosclerotic disease. [12]

At present, two main treatment schemes for patients with AHT are recognized; these are pharmacological and non-pharmacological treatment. The first includes drugs that keep the patient stable in blood pressure; this should always be done with a prescription. While the second includes a diet low in salt and saturated fat, reducing or eliminating alcohol and caffeine consumption, increasing potassium intake, not smoking, psycho-relaxation therapy, control of body weight, and controlled and dosed exercise.

The topicality, novelty, and relevance of these studies are recognized, however, they are aimed at rehabilitating patients with this disease. Nevertheless, a study is required to follow up with the patients after they have finished the non-pharmacological treatment. That is why in the present study, an intervention is carried out in patients who have not undergone any rehabilitation program for more than six months.

For this, a neutrosophic statistical analysis of the most selected indicators in the rehabilitation programs is carried out. When reviewing the bibliography some limitations appear, for example:

- Few cross-sectional studies analyze hypertensive patients who have completed the rehabilitation process.
- The use of neutrosophy for the evaluation of indicators of arterial hypertension is scarce.

On these arguments, it is declared as a scientific problem: how to perform a neutrosophic statistical analysis of arterial hypertension in patients who have completed their rehabilitation process?

The objective of the research is to perform a neutrosophic statistical analysis of arterial hypertension in patients who have completed their rehabilitation process.

2 Materials and Methods

2.1 Subjects under study

Neutrosophic statistics were used to calculate the population. Since the total population is known, let us calculate it using the following expression:

$$n = \frac{N * Z_\alpha^2 p * q}{d^2 * (N-1) + Z_\alpha^2 * p * q} \qquad (1)$$

p = approximate proportion of the subject studied in the reference population q = proportion of the reference population that does not present the subject under study (1 -p). The desired confidence level (Z). It indicates the degree of confidence that the true value of the parameter will be reached in the population found in the calculated sample and finaly absolute precision (d).

It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points). N is the population size

In this case, you want a confidence level between 95 and 99%, z = [1.645, 1.96], d = [0.05, 0.1] and p = [0.4, 0.44], N = 40. The result that we call the neutrosophic sample n = [10.1, 30.6] indicates that the sample must be between 10 and 31 individuals.

For the study, we selected a sample of 30 patients who participated in different rehabilitation programs for hypertensive patients and who had not received their effect for a year. Give that what we want is to monitor how the main AHT indicators work. It was selected using simple random sampling, particularly randomization by the tombola technique.

The sample is distributed as follows: 11 male and 19 female patients, with a mean age of 48.3 ± 10.8, these belong to the Pastaza Canton, in the province of the same name in Ecuador. All received the medical authorization to participate in the study and the patients signed the informed consent.

2.2 Instruments
Neutrosophic method

For the neutrosophic statistical analysis developed, the workflow of three activities was taken into account. Statistical analysis bases its operation on a neutrosophic environment to model uncertainty. The analysis is based on a neutrosophic statistical scheme that can address criteria of a different nature in a neutrosophic environment [15][18, 19]. Figure 1 shows a diagram with the activities that support the analysis.

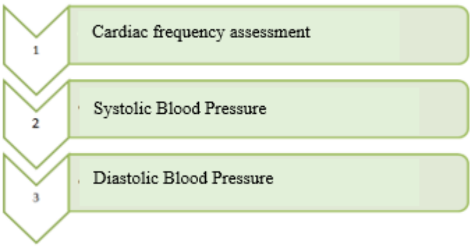

Figure 1. Scheme with the activities that support the analysis

The statistical analysis method is designed to check the correlation of the three fundamental indicators of the AHT. The different activities of the analysis are described below:

Step 1. Explanation of the test to be applied
Step 2. Verification and calibration of the means and implements to be used
Step 3. Adopt the indicated position to start the test
Step 4. Performing the test
Step 5. Analysis and interpretation of the results

For the analysis of the behavior of the sample, the level of neutrosophic significance was used [13], [14], [15]. The level of neutrosophic significance α can be a set, not necessarily a c number as in classical statistics [16], [17]. A neutrosophic P-value is defined in the same way as in classical statistics: the smallest level of significance at which a null hypothesis H0 can be rejected.

The distinction between the classical P-value and the neutrosophic P-value is that the neutrosophic P-value is not a crisp number as in classical statistics, but a set (in many applications it is an interval).

Neutrosophic P-value = P z> z critical value when H0 is true where P (*) means classical probability calculated assuming that H0 is true, the probability of observing a test statistical value is more extreme than what was actually obtained.

2.3 Tests applied in the study

1- Heart rate (HR): taken in the sitting position with a digital pulse meter, the patient is given a time of 15 minutes when arriving at the place where the test is performed.

Optimal: between 80 and 90 beats per minute
Altered: greater than these scoring ranges
2- Systolic blood pressure (SBP)
3- Diastolic blood pressure (DBP)

For both tests a digital ephemeral was used, patients were given between 15 and 20 minutes in a resting state before the test and this was performed in a sitting position. The table shows the values taken into account for the evaluation.

CATEGORY	PAS (mmHg)	DBP (mmHg)
Optimal	<120	<80
Normal	<130	<85
Normal High	130-139	85-89

Table 1: Reference values for the evaluation of PAS, PAD. Source: Hernández, R, Agramante, S and Aguilar [6]

2.4 Statistical analysis

Descriptive Statistics methods: they were used to describe the behavior of patients with AHT, both during the verification of the problem and in the process of evaluating and interpreting the results. We worked with bar graphs, mainly using quantity and percentage. In addition, the Pearson correlation coefficient was also applied. The latter was processed with the SPSS statistical package for Windows, V 20.

3 Results

Graph 1 shows the results of the heart rate indicator, where it is observed that most of the patients in studies 19 for 63.3% of the study sample reached values that are considered optimal, this is indicative in favor of the rehabilitation. For their part, the remaining 11 for 36.7% did not reach the normal score, so these results reflect that there are still patients who must continue to undergo some treatment to stabilize their pulsometry.

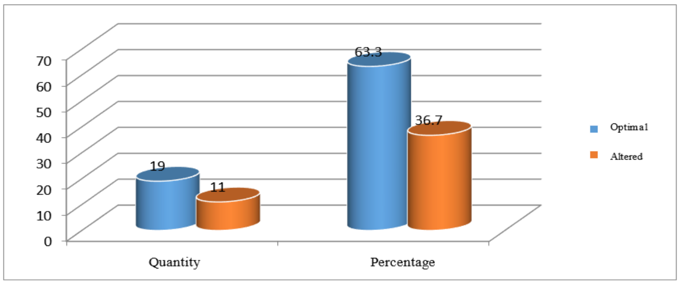

Figure 2. Heart rate results. **Source:** Microsoft Excel for Windows processing results

Graph 2 shows the results of the systolic blood pressure indicator, where it is observed that only 7 patients for 23.4% are in the optimal systolic blood pressure ranges, while 9 for a normal 30%.

On the other hand, most are in the high normal ranges (14 to 46.6%), for which it is suggested that they should follow their SBP control for a longer period, and maintain a correct diet, do physical exercise and take the medication according to the doctor's prescription.

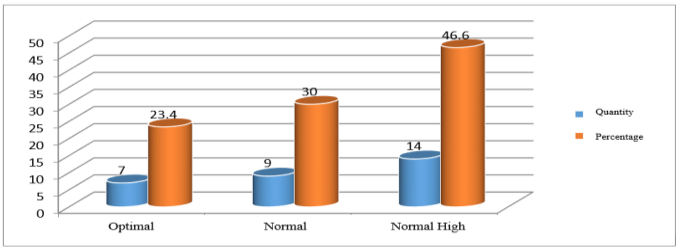

Figure 2: Systolic Blood Pressure Results. **Source:** Microsoft Excel for Windows processing results

Graph 3 shows the results of diastolic blood pressure, where 12 patients for 40% of the study sample were located in the evaluative category of optimal, while 11 for 36.6% obtained their parameters in the normal ranges.

On the other hand, a minority 7 for 23.4% were located in a risk zone due to their high normal blood pressure. As can be seen in this indicator, better results were evidenced. Therefore, it is shown that in the investigated cases the greatest alteration is present in the SBP.

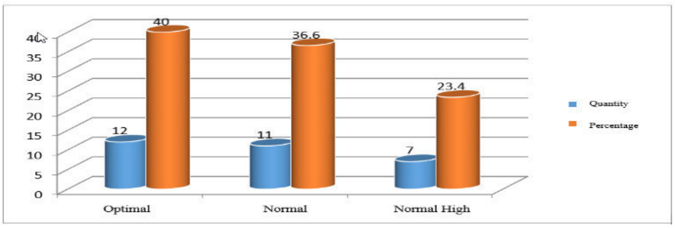

Figure 3. Diastolic blood pressure results. **Source**: Microsoft Excel for Windows processing results

To deepen the validity of the results, a correlation study was carried out, since it marks the relationships between 2 or more variables, that is, the degree of possibility that they have to coincide. Table number 2 shows the correlation matrix between the variables corresponding to the 5 tests carried out in the present study. Correlation coefficients have been calculated in all possible pairs of study variables.

This statistical analysis has been carried out from the Pearson test, where significant results were considered in r, (p <0.005). In this sense, it can be noticed that all the tests correlate with each other. Aspects that give a significant level of validity to the study, since p = 000 in all the assessed tests.

Correlations				
		FC	PAS	PAD
FC	Pearson's correlation	1	.679 **	.722 **
	Sig. (Bilateral)	-	, 000	, 000
	N	30	30	30
SBP	Pearson's correlation	.679 **	1	, 740 **
	Sig. (Bilateral)	, 000	-	, 000
	N	30	30	30
DBP	Pearson's correlation	.722 **	, 740 **	1
	Sig. (Bilateral)	, 000	, 000	-
	N	30	30	30
**. The correlation is significant at the 0.01 level (bilateral).				

Table 2. Correlation matrix between variables **Source**: Processing of the statistical package SPSS for Windows, V 20.

Conclusion

After the investigation was carried out, the following conclusions were reached:

1- The assessment of the theoretical and methodological references on the neutrosophic statistics of the rehabilitation of arterial hypertension shows the need to deepen in investigations that allow transforming the current state.

2- The assessment, analysis, and interpretation of the results, it was found that it is necessary to continue deepening in studies where computer tools and neutrosophic research methods are used since a high level of correlation between each of the tests was evidenced, which validates the results of this study.

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Neutrosophic Analysis of the Educational Orientation to the Diabetic Patient that reflects its impact on the Quality of Life

Ronelsys Martínez Martínez[1], Elizabeth Cristina Mayorga Aldaz[2], Olga Pampin Copa[3] and Kenia Peñafiel Jaramillo[4]

[1]Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.ronelsysmartinez@uniandes.edu.ec
[2]Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.elizabethmayorga@uniandes.edu.ec
[3]Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.olgapampin@uniandes.edu.ec
[4]Universidad Regional Autónoma de los Andes (UNIANDES), Km 5 ½ vía a Baños. Ambato, Tungurahua, Ecuador. E-mail: ua.keniapennafiel@uniandes.edu.ec

Abstract. This investigation is founded on the premise of the need to carry out a neutrosophic analysis of the educational orientation of the diabetic patient, which shows its impact on quality of life. To deal with the subject, it relies on an educational guide. We used a questionnaire consisting of seven questions to investigate the state of knowledge on diabetes in a sample of 210 diabetic patients. We defined a scale, where patients can answer in the form of intervals, such that we obtain as accurately as possible the patients' opinions. We processed the data utilizing Neutrosophic Statistics, which extends statistical methods to the interval-valued domain. The improvement after the patients passed the educational orientation is statistically significant.

Keywords: Neutrosophic Statistics, educational orientation, diabetes, quality of life.

1 Introduction

Diabetes mellitus is defined as a heterogeneous syndrome of multiple causes, characterized by chronic hyperglycemia, with alterations in carbohydrate, fat, and protein metabolism because of defects in insulin secretion, action, or both, [1]. The World Health Organization (WHO) considers that a patient is diabetic when he/she has more than once blood sugar levels above 7.8 mlmol/L. The Latin American Diabetes Association estimates that type 2 diabetes mellitus is one of the most prevalent diseases in adults globally, as it causes very high costs to individuals, families, and countries, [2].

Diabetes mellitus (DM), a chronic non-contagious disease, has been considered a serious health problem to be solved throughout the world. This disease has had a considerable increase in recent times, since from 30 million affected in 1995 to date it has risen to 347 million, with a tendency to increase, since it is estimated that in 2030 it will reach 366 million with the consequent economic and social impact that this brings, [3]. According to a report by this association, around 15 million people with diabetes mellitus in Latin America and this figure will reach 20 million in 10 years, much more than expected from a simple population increase, [2]. Diabetes manifests itself in several ways. Among them, there are insulin-dependent (IDDM) or Type I Diabetes, non-insulin-dependent (NIDDM) or Type II Diabetes, and gestation alone, [4].

IDDM is an autoimmune disease in which the body attacks itself and eventually destroys the insulin-producing beta cells. In addition to the genetic aspects, evidence suggests a viral infection as a trigger for the autoimmune process. This usually begins suddenly before the age of 30, with a clinical picture that is characterized by polyuria (excessive diuresis), polydipsia (excessive water intake), polyphagia (excessive food intake), weight loss, decay, dizziness, blurred vision, itching, cramps and injuries that do not heal.

The key element of NIDDM is partial insulin insufficiency due to insulin resistance, poor-quality insulin secretion, or insulin secretion defect. Insulin resistance is often associated with hypertension, dyslipidemia, and obesity, aside from genetic trends, diet, and obesity. It usually debut after the age of 30, in a sneaky way and with few symptoms. Gestational diabetes debuts in the stage of pregnancy and generally disappears after this, sometimes this presents with few symptoms but with great repercussions for the development and evolution of the fetus. The diabetic patient can present two glycemic states, such as Hypoglycemia < 2.7 mlmo/L or < 80 mg %, [4].

Treatment in diabetic patients is made up of four fundamental pillars, which must be related to each other, to obtain satisfactory results in terms of quality of life for diabetic patients. They are:

- Individual diet according to the activity of daily life that patient carries out,
- Insulin and oral hypoglycemic compounds,
- Physical exercises,

- Education about the disease.

The recommendations of recent years of the American Diabetes Association (ADA) highlight, among the main objectives, the early education of the patient and his/her family through compliance with a standardized program, in addition to establishing strict glycemic control criteria based on the figures glycated hemoglobin, at the desirable values of blood pressure control, lipid profile and stop smoking, [5].

The WHO considers that health education is the fundamental part of the treatment of diabetes and the only effective one for the control of the disease and the prevention of its complications, [6]. That is why educating the patient, with the characteristics of the disease and the fundamental pillars of treatment and the lifestyles that he/she must lead, is to prepare him/her with the knowledge and skills necessary to face the demands of the patient treatment.

The purpose of education is to inform and motivate the population to adopt and maintain healthy practices and lifestyles and promote environmental changes, directing the training of human resources and research in their field [7].

Educating the diabetic patient begins at the time of diagnosis, which once confirmed, lasts for life and will respond to the individual characteristics of each patient. That is why, as argued by several researchers on the subject, [8,9], an education program is necessary whose purpose is to improve the care and quality of life of the patient, as well as to reduce morbidity and mortality from diabetes and its complications, is a feasible way to counteract the complications of the disease.

In this regard, it is significant for this research that authors such as Fernández Vázquez et al suggest that participatory education involves the patient as a generator of their learning, establishing a link between theory and practice, which affects making decisions about healthy habits and lifestyles [7].

An essential role in continuing to study the subject in depth is what Sarrión Soro states. He states that diabetes education should be prioritized in psychological intervention and that among the topics to be developed are coping with the disease, improving adherence to treatment and glycemic control [10].

According to those above, we can observe that education about the disease is one of the important pillars to maintain an adequate quality of life in patients with this pathology. Based on these arguments, the present investigation will direct its gaze to this issue.

The educational orientation to the diabetic patient plays a preponderant role since it allows us maintaining the attention from this perspective to the patient. Therefore, it offers him/her specific knowledge of how to perform in different daily life situations. That is why an illustrative brochure on patient orientation is a viable tool to achieve a better quality of life in patients suffering from this disease.

For this purpose, a neutrosophic analysis is carried out on the educational orientation of the diabetic patient, for which a bibliographic review was conducted, educational strategy, and institutional programs of several countries were analyzed. Where we could observe the following regularities:

- The Neutrosophic analysis of the educational orientation to the diabetic patient that reveals its impact on the quality of life has been scarcely systematized.
- It is necessary to continue developing instruments that allow educational orientation in patients with diabetes.

The objective of the study is to apply an educational guide that allows us a neutrosophic analysis of the orientation to the diabetic patient that shows its impact on the quality of life. Neutrosophic Statistics extends the classical statistics theory to intervals. In this study, the answers to questionnaires are given in interval forms, so, the use of Neutrosophic methods is justified. Patients' knowledge of diabetes was assessed using this imprecise scale in two moments, before and after to pass the educational training. The imprecise data were converted into crisp values and processed using methods of classical statistics, like Wilcoxon's signed rank.

2 Materials and Methods

2.1 Neutrosophic Statistics

Neutrosophic statistics were used to process the data. Neutrosophic Statistics is based on classical Statistics, where the data, parameters, population's size, sample's size, etc., are interval rather than crisp values.

Definition 1: ([11]) Let X be a universe of discourse. Three membership functions characterize a Neutrosophic Set (NS), $u_A(x), r_A(x), v_A(x) : X \rightarrow\ ]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

Definition 2: ([11]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate, and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Neutrosophic Statistics extends the classical statistics, such that we deal with set values rather than crisp values, [12].

Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics.

Neutrosophic Inferential Statistics consists of methods that permit the generalization from a neutrosophic sampling to a population from which the sample was selected.

Neutrosophic Data is the data that contains some indeterminacy. Similarly to classical statistics, it can be classified as:

- *Discrete neutrosophic data*, if the values are isolated points.
- *Continuous neutrosophic data*, if the values form one or more intervals.

Another classification is the following:

- *Quantitative (numerical) neutrosophic data*; for example a number in the interval (we do not know exactly), 47, 52, 67, or 69 (we do not know exactly);
- *Qualitative (categorical) neutrosophic data*; for example: blue or red (we don't know exactly), white, black, green, or yellow (not knowing exactly).

The *univariate neutrosophic data* is a neutrosophic data that consists of observations on a neutrosophic single attribute.

Multivariable neutrosophic data is neutrosophic data that consists of observations on two or more attributes.

A *Neutrosophic Statistical Number* N has the form $N = d + I$, [12], where d is called *the determinate part and I is called indeterminate*.

A *Neutrosophic Frequency Distribution* is a table displaying the categories, frequencies, and relative frequencies with some indeterminacy. Most often, indeterminacies occur due to imprecise, incomplete or unknown data related to frequency. As a consequence, relative frequency becomes imprecise, incomplete, or unknown too.

Neutrosophic Survey Results are survey results that contain some indeterminacy.

A *Neutrosophic Population* is a population not well determined at the level of membership (i.e. not sure if some individuals belong or do not belong to the population).

A *simple random neutrosophic sample* of size n from a classical or neutrosophic population is a sample of n individuals such that at least one of them has some indeterminacy.

A *stratified random neutrosophic sampling* is the pollster groups of the (classical or neutrosophic) population by a stratum according to a classification; afterward, the pollster takes a random sample (of appropriate size according to a criterion) from each group. If there is some indeterminacy, we deal with neutrosophic sampling.

Additionally, we describe some concepts of interval calculus, which shall be useful in this paper.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as follows, [13]:

$N_1 + N_2 = a_1 + a_2 + (b_1 + b_2)I$ (Addition),

$N_1 - N_2 = a_1 - a_2 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

Additionally, given $I_1 = [a_1, b_1]$ and $I_2 = [a_2, b_2]$ we have the following operations between them ([13]):

1. $I_1 \leq I_2$ if and only if $a_1 \leq a_2$ and $b_1 \leq b_2$.
2. $I_1 + I_2 = [a_1 + a_2, b_1 + b_2]$ (Addition);
3. $I_1 - I_2 = [a_1 - b_2, b_1 - a_2]$ (Subtraction),
4. $I_1 \cdot I_2 = [\min\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}, \max\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}]$ (Product),

$\frac{I_1}{I_2} = \left[\frac{a_1}{b_1}, \frac{a_2}{b_2}\right]$, always that $0 \notin I_2$ (Division).

5. $\sqrt{I} = [\sqrt{a}, \sqrt{b}]$, always that $a \geq 0$ (Square root).

6. $\mathrm{I}^{\mathrm{n}} = \underbrace{\mathrm{I} \cdot \mathrm{I} \cdot \cdots \cdot \mathrm{I} \cdot \mathrm{I}}_{\text{n times}}$

As the size population that could participate in the research is known, it is calculated using the following expression:

- N: is the population size
- p = approximate proportion of the phenomenon under study in the reference population,
- q = proportion of the reference population that does not present the phenomenon under study (1 -p),
- The desired confidence level (Z).
- An expression that makes evident the degree of confidence that the true value of the parameter in the population is found in the calculated sample.
- The absolute precision (d). It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points).

In this case, we are looking for a confidence level between of 95%, so z = 1.96, d = 0.05 and p = q = 0.5, N = 462. The result is a sample of n = 210 randomly selected.

Thus, in the present study, 210 patients diagnosed with diabetes participated, aged between 35-59 years old, 143 are female and 67 are male, all from Cantón Urdaneta, Province of Los Ríos, Republic of Ecuador. A simple random sampling was carried out, using the selection procedure by letter.

2.2 The investigation

We carried out a pilot study of a quantitative, prospective, longitudinal, and comparative type of six months between each of the measurements. In which an educational orientation brochure was applied and its effect was finally assessed. The study complies with the postulates of the Declaration of Helsinki, where all patients signed informed consent.

The analytic-synthetic analysis was also used: which was aimed at the study of cognitive processes and allows the decomposition of the phenomenon or process of study. In this case, the educational orientation to the diabetic patient, the analysis of the main elements that make it up for determining their particularities, and then synthesis they are integrated to allow and discover relationships and general characteristics.

Within the empirical ones, the survey was used because it allowed obtaining information for characterizing the behavior of the educational orientation of the diabetic patient, its impact on the quality of life in the investigated canton.

For the tabulation, we used a questionnaire to be completed by the participants as a collection instrument, consisting of multiple-choice questions with simple answers. This was made up of 7 questions that encompassed the dimensions of the IMEVID questionnaire ([14]), which is used to measure lifestyle in patients with diabetes. The questionnaire is the following:

<u>Questionnaire Questions:</u>

1- Do you know details of the nutrition that a diabetic patient should take?

2- Do you practice physical activities systematically?

3- Do you know how harmful the consumption of tobacco or cigarettes is?

4- Do you know how harmful it is to consume any drink that contains alcohol?

5- Do you have information about diabetes?

6- Do you know how to handle emotions?

7- Do you comply with all treatment indications?

The used scale deserves a deepen explanation.

Each patient can respond in form of intervals. For example, patient A can answer question 1 for him/her is [98, 98.5]. This kind of answer seems difficult to achieve, however, with the correct explanation patients can complete this. The reason to use this scale is that patients can express their opinions more accurately.

2.3. Neutrosophic method used

For the developed neutrosophic analysis, the workflow of 8 logical steps considered to develop the research was taken into account. The analysis is based on the functioning of the neutrosophic environment to model the uncertainty. The analysis is based on a guide of logical steps with a neutrosophic approach that can address criteria of different nature in a neutrosophic environment, [15-26].

Step 1 Selection of the instruments to apply,

Step 2 Preparation of the personnel,

Step 3 Survey application,

Step 4 Tabulation of the results of the first measurement,

Step 5 Applying the educational orientation guide,

Step 6 Tabulation of the results of the second measurement,

Step 7 Interpretation of the results,
Step 8 Drafting the final investigation report.

Statistical analysis

Descriptive statistics were used, particularly the analysis of the frequency and percentages of each of the questions. In addition, inferential statistics were used, mainly the nonparametric Wilcoxon signed rank test. For which a confidence level of 95% and a maximum error of 5% were taken into account, considering a value of $p \leq 0.05$ as statistically significant. The collected data were analyzed using SPSS 20 software.

2.4 Main contentive aspects of the educational guide

For the elaboration of the guide, the criteria of several authors were taken into account. This in turn is structured as follows:

Introduction: where essential data on the disease, its incidence, prevalence, and main pillars of treatment are addressed.

Development: it contains a detailed explanation of the Nutrition that patients must take, the main bases of physical activity, the detrimental to the disease the consumption of tobacco and alcoholic beverages. It also offers information on diabetes, tells you how to manage emotions and details the main treatments and the need for compliance.

Bibliography: in this section, the classic and more accessible bibliography is offered to patients so that they continue to educate themselves about the disease.

3 Results

From a population of N = 462 patients, we selected a sample of n = 210. Each interval was converted into a crisp value calculating the middle point of the interval.

The answers were processed using the following criterion:

- If the answer is ≥ 55 we consider it is YES,
- If the answer is ≥ 45 and < 55 we consider it is INDETERMINATE,
- If the answer is < 45 it is NO.

Table 1 presents the results of the applied survey, where its content reflects the IMEVID questionnaire to find out if they present lifestyles in correspondence with the characteristics of the disease. A comparison is made between the two moments of the investigation: before the educational guide is applied and after its application.

In question 1 of the survey, with regard to nutrition, it is observed that at the initial moment, that is, before applying the educational guide, the patients had little perception of this aspect, since only 50 patients (24%) of the sample answered YES, which represents that they know details of the subject matter of this; the majority 101 (48%) answered not knowing this; and the rest 59 (28%) have an indeterminate answer, not claiming any cause for their position. The results were very different after the application of the guide, since the majority 193 patients (92%) of the sample considered to know about the nutrition that a diabetic patient should do, aspects that make evident the existence of a transformation towards the final moment, only 17 (8%) answer in an indeterminate range.

On the other hand, in question 2, referring to systematic physical activity, at the initial moment, only a minority performed it 42 or 20% of the sample, as this number indicated the option YES. While it was not the majority because 118 patients (56%) of the total of them indicated this option. On the other hand, only 50 (24%) did not indicate something. After applying the guide in this question, a transformation is also observed, since most of the patients investigated 193 (96%) stated whether to carry out physical activity systematically, an aspect that denotes that educational guidance is effective in this question, only 17 (4%) did not provide a clear answer.

Question 3 related to the harmfulness of tobacco or cigarette consumption, before applying the guide only a minority of 75 (36%) answered that they did know it, the majority said they did not know (118 or 56%) and the rest 13 or 8%, did not indicate either of the two previous options. After applying the guide, improvements in knowledge about this question are observed, since the majority 193 or 92% said they did know how harmful the consumption of this substance is. Only 17 or 8% did not respond clearly, so it can be argued that the effect of the guide on patients in this question has been positive.

The results of question 4 are associated with the knowledge about the negative effect of the consumption of any drink that contains alcohol for these patients. It is observed that before applying the guide, the majority, that is, 101 or 48% expressed knowledge about the question; on the other hand, 84 or 40% of the sample did not show up and only 25 or 12% did not answer clearly. While after the educational guide was applied, positive results were shown, since the majority 202 or 96% said they knew and 8 (4%) patients did not answer clearly.

Question 5 related to information about diabetes, at the beginning only 34 patients or 16% had information about diabetes. They stated that they had acquired it through the media and official internet sites in informal conversations with them. The majority did not have information 151 (72%), a question that is detrimental to correct quality of life despite having the disease. Only 25 or 8% have had an unclear response. A significant increase was obtained after applying the guide since 100% of the investigated patients stated that they had reliable information about the disease.

Question 6 on the management of emotions obtained similar results at the moment before the previous questions, since the minority 33 or 16% knew how to achieve an adequate management of emotions, however, the majority said they did not know, 160 or 76%, while only 17 did not answer clearly. There were improvements at the end of the research, since 18 or 72% of the study sample showed knowledge, in the same way, a minority, despite the indications included in guide 34 or 16% did not know how to control their emotions. It is important to state that this is the most difficult issue when knowing the diagnosis of a disease. On the other hand, 25 or 12% did not answer clearly any of the options.

Question 7 referred to the indications for treatment, at the initial moment of the investigation there was only a minority that knew the pillars of treatment of this disease (76 or 36%). Most of them were unaware of them (109 or 52%), while 25 or 12% did not issue any useful criteria. However, after the end of the investigation and in the second measurement of the longitudinal study, it is observed that 100% of the patients dominate the fundamental indications for treatment.

As has been observed in the descriptive analysis developed, it is shown that in all the questions, there have been increases at the end of the study. A matter that makes the educational orientation of patients evident and this affects their quality of life.

Subject of the question	Answers before applying the educational guide			Answers after applying the educational guide		
	Yes N (%)	No N (%)	Indeterminate N (%)	Yes N (%)	No N (%)	Indeterminate N (%)
Nutrition	50 (24%)	101 (48%)	59 (28%)	193 (92%)	0	17 (8%)
Systematic physical activity	42 (20%)	118 (56%)	50 (24%)	202 (96%)	0	8 (4%)
Tobacco use	75 (36%)	118 (56%)	17 (8%)	193 (92%)	0	17(8%)
Alcohol consumption	101 (48%)	84 (40%)	25 (12%)	202 (96%)	0	8 (4%)
Diabetes information	34 (16%)	151 (72%)	25 (12%)	210 (100%)	0	0
Managing emotions	33 (16%)	160 (76%)	17 (8%)	151 (72%)	34 (16%)	25 (12%)
Treatment indications	76 (36%)	109 (52%)	25 (12%)	210 (100%)	0	0

Table 1: Results of the application of the IMEVID questionnaire. **Source:** own elaboration.

To corroborate the validity of the results obtained, inferential statistics are used, particularly the Wilcoxon signed-rank nonparametric test. Where the results obtained are shown below.

Table 2 shows the results of the inferential statistics, where the ranges of signs show a level of statistical significance below 0.05 after comparing the results MD≤ MA, with 100% of the patients analyzed. This denotes that there was a change of sign in each of the cases studied when evaluating the Statistic Test (Z), it expresses a favorable position higher than the moment after the educational guide was applied, from a bilateral significance (Table 2), based in negative ranges, so the null hypothesis (H_0) is rejected. This leads to assert that the guide significantly contributed to the educational orientation of diabetic patients.

Aspects evaluated	Nutrition after - Nutrition before	A physics after - A physics before	Tobacco use after - Tobacco use before	Alcohol consumption after - Alcohol consumption before	Diabetes information after - Diabetes information before	Managing emotions after - Managing emotions before	Information after - Information before
Z	$-3,787^{b}$	$-4,021^{b}$	$-3,742^{b}$	$-3,771^{b}$	$-4,413^{b}$	$-3,945^{b}$	$-3,755^{b}$
Next asympt. (bilateral)	,000	,000	,000	,000	,000	,000	,000

Table 2: Wilcoxon signed-rank nonparametric test results. **Source:** Processing with SPSS 20 software.

Conclusion

In the research process on the educational orientation of the diabetic patient, its impact on the quality of life, the results obtained show that the qualitative and quantitative analysis allowed to corroborate the fulfillment of the proposed objective and reach the following conclusions:

1. The assessment of the theoretical and methodological references on educational orientation to diabetic patients and its impact on quality of life evidences the need to investigate this issue.

2. The interpretation of the results, using a descriptive and inferential analysis allows us asserting the educational guide contributed significantly to improve the educational orientation to the diabetic patient and therefore its impact on quality of life.
3. The neutrosophic perspective is present when we allow interval-valued answers to the questionnaire, which constitutes an imprecise approach, but undoubtedly a more accurate one because patients can express their opinions considering the imprecision of what they think.

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University of New Mexico

A New Model based on Subjective Logic and Neutrosophic Measure for Legal Reasoning

Eduardo Luciano Hernández Ramos[1], Francisco Alejo Guanoluisa Almache[2], Alba Rosa Pupo Kairuz[3] and Carlos Alberto Medina Riofrío[4]

[1] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Avenida Lizarzaburu. Riobamba, Chimborazo. Email: ur.eduardohernandez@uniandes.edu.ec
[2] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Juan de Salinas 612-500, Ibarra. Imbabura. Ecuador Email: ui.franciscoguanoluisa@uniandes.edu.ec
[3] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Transversal Central, Quevedo. Los Ríos. Ecuador Email: uq.albapupo@uniandes.edu.ec
[4] Docente de la carrera de Derecho. Universidad Regional Autónoma de los Andes (UNIANDES). Calle Teniente Hugo Ortiz, Puyo. Pastaza. Ecuador Email: up.carlosmedina@uniandes.edu.ec

Abstract. Legal sciences are the theoretical body of law. This branch of knowledge studies the rules and principles that govern the correct functioning of society. The proper administration of justice is essential for the satisfaction of the subjective and objective needs of citizens. It ensures that members of society fulfill their duties and can satisfy their rights before their families and other citizens. The purpose of this paper is the presentation of a neutrosophy-based model for representing decision-making within a trial, specifically concerning both, the sufficient proof and weighing of pieces of evidence. Concepts based on the neutrosophic measure are used to enrich an earlier model that used subjective logic. We follow the principle that neutrosophic theory allows for greater precision in legal reasoning because it makes it possible to explicitly differentiate and evaluate which parts are determined and known and which parts are indeterminate and unknown. Keeping in mind that a trial is plagued with unknown, imprecise, confusing, contradictory, and paradoxical elements; and these are the ones that must be clarified with proofs and pieces of evidence. This model can be the basis of a Decision Support System or an Expert System

Keywords: Legal reasoning, neutrosophic measure, neutrosophic probabilistic measure, neutrosophic belief function, subjective logic.

1 Introduction

Legal Sciences, also called Sciences of Law, are those that carry out the complex and constant study of the legal system and its application in society [1, 2]. Legal sciences make interpretations of the norm and it is through social phenomena, it is determined whether these functions are adequate or need to be reformed. The foundation of these sciences is the problem among humans. In a community of people, humans interact with each other and establish relationships, to set up the parameters on which these relationships are based, the laws must be fully complied with, otherwise, those who defend justice must act with discipline to enforce it.

The Legal Sciences advance along with society's advances, always trying to maintain a step forward to maintain control of the relationship between the people of the community and the foreigners with the inhabitants of the population. The history of Roman law shows us how was the life of that individual who wanted to conquer, dominate and expand his/her power throughout a region. The different stages of the Roman government (monarchy, republic, and empire) show us an interesting feature of the legal sciences in antiquity and when compared with what is understood today by law, it gives us to understand the relevance of the facts that were generated at that time [3, 4].

The greatest responsibility of the sciences of law is to integrate all humans into a rational system of laws that, although rooted in common law, must be maintained in conjunction with a standard of principles and values such as morality, equity, and justice. To maintain in society a balance between objective law (the established norm) and subjective law (the capacity of man/woman to decide his/her destiny) can be considered an art, it is a profession that is studied every day, as man/woman faces new situations. The Legal Sciences are studied by mankind in different ways, what gives so many nuances to the study of law are the cultures, customs, and traditions that man/woman carries with him/her in the community.

The object of Legal Science is the positive, perishable, and criminal law. That is to say, the validity in a given community and at a given time. The central nucleus of legal science is the norm or the set of norms that form the legal system, which is a datum for the legal scientist, aware that this positive law is situated in history and therefore is founded and evolves as a product of culture, which is a historical product.

As indicated above, matching what individuals think is right and moral with what the laws dictate is a challenge for the legal sciences in all modern societies. An example that shows us the complexity of this is the legalization of abortion. This is a thorny issue, since when abortion is performed, it is putting an end to a future life, yet some countries consider it legal. In some countries with strong religious traditions, it is considered legal but immoral. Some individuals consider the act of abortion to be immoral, although legal, and would not resort to these methods of termination of pregnancy, even if they had the best legal and medical guarantees that this would have no consequences. In other countries, due to specific circumstances, women wish to have an abortion, but the laws of their country prevent them from doing so and they resort to illegal mechanisms with few health guarantees, which can cost them their lives. This is why Deontology, or the Science of Morality ([5]), does not always coincide with what is permitted, which constitutes a challenge for the Legal Sciences.

Making a decision based on the law by a judge or jury to declare a defendant innocent or guilty is a great responsibility, since making one decision or another can in some cases change the life of a person and his/her family or society. In cases such as a simple brawl or driving a motor vehicle without a license can be resolved with a fine or community service. However, when that quarrel or the driving of the vehicle causes the death of one or more persons, it becomes a case for easy justice, only if it is serious enough, for example, if the one who provoked the quarrel or the one who was driving the car intended premeditatedly to kill the other person. However, when the event occurred under certain unclear circumstances, where the individual cannot be blamed 100% for what he or she did, the question arises as to how to categorize the event from a criminal point of view.

The guilt of the accused can be decided by a judge or jury in a trial that should be impartial, although on some occasions impartiality is a challenge for those judging because of the brutality of the act, or because there was a high degree of cruelty, or because the victim was a child, etc. Another challenge is the consideration of sufficient proof, which is when evidence is presented and it constitutes a key to clarify the circumstances in which the facts occurred and considerably diminishes the doubt that could have been had about the case.

For its part, taking into account that the trial is related to evidence, the weighing of pieces of evidence is considered crucial to admit that the presented facts are admissible and bring light on the case. However, not everything in the courts is clear. The course of the trial can be plagued by uncertainty, doubts, lack of knowledge, contradictions, inconsistencies, etc. The defendant may consciously or unconsciously try to manipulate the jury or the judge, or there may be key facts that are unclear and need to be clarified. It is assumed that during the trial a consensus will be reached as to what actually happened and the degree of guilt of the defendant as realistic as possible.

For all these reasons, we consider neutrosophy to be the logical-mathematical theory that can best model legal decision-making. This theory allows us representing more clearly than fuzzy logic theories and their generalizations the possible states of information or knowledge. According to neutrosophy, a concept, theory, idea, phenomenon, etc. denoted by A, could be separated into three components, which are <A> itself, <AntiA> which is what is opposed to A, and <NeutA> which is neither A nor AntiA, [6, 7].

This paper aims to generalize within the neutrosophic framework a model based on subjective logic, which is based on logic and probabilities [8]. The proposed model has the advantage that hybridizing it with neutrosophy will allow us to explicitly model what is indeterminate. This differentiation of what is indeterminate from what is known is crucial, because it allows those who judge to differentiate what is to be clarified and thus what is to be insisted upon in the judgment, and if a proof or piece of evidence sheds light on that indeterminate part, then that constitutes sufficient proof or a burden piece of evidence.

Mathematically speaking, this hybridization will be based on the neutrosophic measure theory, the neutrosophic probability measure, and the neutrosophic belief function, [6, 9]. Which extend the definitions of measure, probability measure, and belief function in the neutrosophic framework, respectively. It is not the first time that neutrosophy is used to model problems within the legal sciences. Some approaches can be found in [10-16]. However, none of them creates a new neutrosophic model for legal sciences, but only solves specific problems with the help of neutrosophic tools. One idea that seems interesting is the logical modeling of legal sciences with the use of deontic logic [17-24]. In some scientific articles, the problems of legal sciences are modeled with the help of fuzzy logic, [20, 25].

The present article has the following structure; section 2 is devoted to exposing the basic concepts of neutrosophic measure. Section 3 contains the details of the proposed model and one example. Finally, section 4 shows the conclusions of the paper.

2 Neutrosophic measure

This section contains the basic notions of neutrosophic measure, which is a necessary concept in the approach we propose in this paper, [6, 9, 26]. Let <A> be an item. <A> can be a notion, an attribute, an idea, a proposition, a theorem, a theory, etc. And let <antiA> be the opposite of <A>; while <neutA> be neither <A> nor <antiA> but the neutral (or indeterminacy, unknown) related to <A>. Let X be a neutrosophic space, and Σ be a σ-neutrosophic algebra over *X*. A *neutrosophic measure* ν is defined for neutrosophic set $A \in \Sigma$ by $\nu: X \to R^3$, such that:

$$\nu(A) = (m(A), m(neutA), m(antiA)) \quad (1)$$

with antiA := the opposite of A, and neutA := the neutral (indeterminacy) neither A nor antiA.

For any $A \subseteq X$ and $A \in \Sigma$:

1. $m(A)$ means *measure of the determinate* part of A;
2. $m(neutA)$ means *measure of indeterminate* part of A; and
3. $m(antiA)$ means *measure of the determinate part* of antiA.

Where ν is a function that satisfies the following two properties:

a) Null empty set: $\nu(\emptyset) = (0,0,0)$.
b) Countable additivity (or σ -additivity): For all countable collections $\{A_n\}_{n\in L}$ of disjoint neutrosophic sets in Σ, we have:

$$\nu(\cup_{n\in L} A_n) = \left(\sum_{n\in L} m(A_n), \sum_{n\in L} m(neutA_n), \sum_{n\in L} m(antiA_n) - (n-1)m(X)\right) \quad (2)$$

Where *X* is the whole neutrosophic space, and

$$\sum_{n\in L} m(antiA_n) - (n-1)m(X) = m(X) - \sum_{n\in L} m(A_n) = m\left((\cap_{n\in L} antiA_n)\right) \quad (3)$$

A *neutrosophic measure space* is a triplet (X, Σ, ν).

A *neutrosophic normalized measure* is $NN = (m(X), m(neutX), m(antiX))$, where $m(X), m(neutX), m(antiX) \geq 0$ and $m(X) + m(neutX) + m(antiX) = 1$.

Where *X* is the whole neutrosophic measure space.

A neutrosophic measure space (X, Σ, ν) is called *finite* if $\nu(X) = (a, b, c)$ such that all a, b, and c are finite (rather than infinite). A neutrosophic measure is called *σ-finite* if *X* can be decomposed into a countable union of neutrosophic measurable sets of fine neutrosophic measure. Analogously, a set A in *X* is said to have a *σ-finite neutrosophic measure* if it is a countable union of sets with finite neutrosophic measure.

The neutrosophic measure *ν* satisfies the *axiom of non-negativity*, if: $\forall A \in \Sigma$,

$$\nu(A) = (a_1, a_2, a_3) \geq 0 \quad (4)$$

If $a_1, a_2, a_3 \geq 0$.

While a neutrosophic measure ν, that satisfies only the null empty set and countable additivity axioms (hence not the non-negativity axiom), takes on at most one of the $\pm\infty$ values. The members of Σ are called *measurable neutrosophic sets*, while (X, Σ) is called a *measurable neutrosophic space*.

A function $f: (X, \Sigma_X) \to (Y, \Sigma_Y)$, mapping two measurable neutrosophic spaces, is called *neutrosophic measurable function* $\forall B \in \Sigma_Y, f^{-1}(B) \in \Sigma_X$ (the inverse image of a neutrosophic Y-measurable set is a neutrosophic X-measurable set). The properties of Neutrosophic measures are the following:

a) Monotonicity:

If A_1 and A_2 are neutrosophic measurable, with $A_1 \subseteq A_2$, where $\nu(A_1) = (m(A_1), m(neutA_1), m(antiA_1))$ and $\nu(A_2) = (m(A_2), m(neutA_2), m(antiA_2))$, then $m(A_1) \leq m(A_2)$, $m(neutA_1) \leq m(neutA_2)$, $m(antiA_1) \geq m(antiA_2)$.

b) Additivity:

If $A_1 \cap A_2 = \emptyset$, then $\nu(A_1 \cup A_2) = \nu(A_1) + \nu(A_2)$,

Where the sum of two measures is defined as follows:

$$(a_1, a_2, a_3) + (b_1, b_2, b_3) = \left(a_1 + b_1, a_2 + b_2, a_3 + b_3 - m(X)\right) \quad (5)$$

Where *X* is *the* whole neutrosophic space, and $a_3 + b_3 - m(X) = m(X) - m(A) - m(B) = m(X) - a_1 - a_2 = m(antiA \cap antiB)$.

The *neutrosophic probability measure* is a mapping:

$$NP: X \to [0,1]^3 \quad (6)$$

Where *X* is a neutrosophic sample space (i.e. *X* contains some indeterminacy),

$$NP(A) = \left(ch(A), ch(indetermA), ch(\underline{A})\right) \quad (7)$$

That is to say, it is decomposed into three components, the chance that A occurs, the chance that A is indeterminate, and the chance that A does not occur. By using another notation we have:

$$NP(A) = (ch(A), ch(NeutA), ch(AntiA)) \quad (8)$$

Which satisfies the condition, $-0 \leq ch(A), ch(indetermA), ch(\underline{A}) \leq 3^+$, that is to say, there exist probabilities such that $ch(A) + ch(indetermA) + ch(\underline{A})$ are equal to 1, <1 or >1.

The extension of the Kolmogorov axioms to the neutrosophic space is the following:

Let $(N\Omega, NF, NP)$ be a neutrosophic probability space, where $N\Omega$ is a neutrosophic sample space, NF is a neutrosophic event space, and NP is a neutrosophic probability measure.

1. The neutrosophic probability of event A is non-negative.

2. The neutrosophic probability of the sample space is between -0 and 3^+.
3. Neutrosophic σ-additivity:

$$NP(A_1 \cup A_2 \cup \cdots) = \left(\sum_{j=1}^{\infty} \quad ch(A_j), ch(indetermA_1 \cup A_2 \cup \cdots), ch\left(\underline{A_1 \cup A_2 \cup \cdots}\right)\right) \qquad (9)$$

Where $A_1, A_2, \cdots$ is a countable sequence of disjoint (or mutually exclusive) neutrosophic events.
If we relax the third axiom we get a *neutrosophic quasi-probability* distribution.

3 The model

This section contains the concepts of the proposed model, which is the generalization of the model in [8] to the neutrosophic framework. Firstly, the precedent model uses the term *frame of discernment* from the Dempster-Shafer belief model, [27]. This concept refers to a set of possible states of a given system. They choose the term "state" instead of "set" in the definition of frame of discernment in legal sciences, [8].

Definition 1 (*Neutrosophic mass assignment*) ([28]): A *neutrosophic mass assignment* is $m(\cdot) = \left(m_t(\cdot), m_i(\cdot), m_f(\cdot)\right)$; $m_t(\cdot), m_i(\cdot), m_f(\cdot): 2^\Theta \to]-0, 1^+[^3$ satisfying the following axioms for each dimension of the neutrosophic space:

$$\sum_{A\subset\Theta} \quad sup\left(m_t(A)\right) \geq 1 \qquad (10)$$

$$\sum_{A\subset\Theta} \quad inf\left(m_f(A)\right) \geq |\Theta| - 1 \qquad (11)$$

Where $|\Theta|$ represents the cardinality of the frame of discernment Θ.

Definition 2([28]): A *neutrosophic belief function* for all $A \subset \Theta$, $Bel(\cdot) = \left(Bel_T(\cdot), Bel_I(\cdot), Bel_F(\cdot)\right)$ is defined as:

$$Bel_T(A) = \sum_{B\subset A} \quad m_t(B) \qquad (12)$$

$$Bel_I(A) = \sum_{B\subset A} \quad m_i(B)$$

$$Bel_F(A) = \sum_{B\subset A} \quad m_f(B)$$

Definition 3: A *neutrosophic disbelief function* for all $A \subset \Theta$, $d(\cdot) = \left(d_T(\cdot), d_I(\cdot), d_F(\cdot)\right)$ is defined as:

$$d_T(A) = \sum_{A\cap B=\emptyset} \quad m_t(B) \qquad (13)$$

$$d_I(A) = \sum_{A\cap B=\emptyset} \quad m_i(B)$$

$$d_F(A) = \sum_{A\cap B=\emptyset} \quad m_f(B)$$

Definition 4: A *neutrosophic uncertainty function* for all $A \subset \Theta$, $u(\cdot) = \left(u_T(\cdot), u_I(\cdot), u_F(\cdot)\right)$ is defined as:

$$u_T(A) = \sum_{A\cap B\neq\emptyset\ B\not\subseteq A} \quad m_t(B) \qquad (14)$$

$$u_I(A) = \sum_{A\cap B\neq\emptyset\ B\not\subseteq A} \quad m_i(B)$$

$$u_F(A) = \sum_{A\cap B\neq\emptyset\ B\not\subseteq A} \quad m_f(B)$$

Definition 5: Let Θ be a frame of discernment and let $A, B \in 2^\Theta$. Then the *relative atomicity* of A to B is the function $a: 2^\Theta \to]-0, 1^+[$ defined by:

$$a(A/B) = \frac{|A\cap B|}{|B|} \qquad (15)$$

$A, B \in 2^\Theta$.

Let us observe that $A \cap B = \emptyset$ implies $a(A/B) = 0$, whereas $B \subseteq A$ implies $a(A/B) = 1$. $a(\cdot)$ measures the degree of overlap between A and B.

Definition 6: (*Neutrosophic Probability Expectation*) Let Θ be a frame of discernment with $m(\cdot)$ be the neutrosophic mass assignment, then the *neutrosophic probability expectation function* corresponding with $m(\cdot)$ is the function $E: 2^\Theta \to]-0, 1^+[^3$ defined by:

$$E_T(A) = \sum_B \quad m_t(B)a(A/B) \qquad (16)$$

$$E_I(A) = \sum_B \quad m_i(B)a(A/B)(1 - a(A/B))$$

$$E_F(A) = \sum_B \quad m_f(B)(1 - a(A/B))$$

$A, B \in 2^\Theta$.

Theorem 1: Given a frame of discernment Θ with $m(\cdot)$ be the neutrosophic mass assignment, the probability expectation function $E(\cdot)$ with domain 2^Θ satisfies:

1. $E(A) \geq 0$ for all $A \in 2^\Theta$,
2. If $A_1, A_2, \cdots, A_n \in 2^\Theta$ are pairwise disjoint then $E\left(\bigcup_{i=1}^n A_i\right) = \sum_{i=1}^n \quad E(A_i)$.

Proof.

1. It is a consequence of $m(\cdot)$ is non-negative.
2. Because of $A_1, A_2, \cdots, A_n \in 2^\Theta$ are pairwise disjoint, then we have $a(A/B) \neq 0$ only if $A = B$ and $a(A/A) = 1$, so the formula is true.□

Definition 7 (Opinion): Let Θ be a binary frame of discernment with 2 atomic states A and A, and let $m(\cdot)$ be a Neutrosophic mass assignment on Θ where $b(A)$, $d(A)$, $u(A)$, and $a(A)$ (i.e., $B = \Theta$ in $a(A) = a(A/\Theta)$) represent the belief, disbelief, uncertainty, and relative atomicity functions on A in Θ, respectively.

Then the opinion about A, denoted by ω_A, is the quadruple defined by:

$\omega_A \equiv (b(A), d(A), u(A), a(A))$ (17)

The expectation of the opinion ω_A is defined by using the following Equations:

$E_T(\omega_A) = b_T(A) + u_T(A)a(A)$ (18)

$E_I(\omega_A) = b_I(A) + u_I(A)a(A)(1 - a(A))$

$E_F(\omega_A) = b_F(A) + u_F(A)(1 - a(A))$

Definition 8 (Ordering of Opinions)([8]): Let ω_A and ω_B be two opinions. They can be ordered according to the following criteria by priority:

1. The greatest probability expectation gives the greatest opinion.
2. The least uncertainty gives the greatest opinion.
3. The least relative atomicity gives the greatest opinion.

Let us note that the order we referred to above is the neutrosophic order.

Definition 9: Let Θ_A and Θ_B be two distinct binary frames of discernment and let A and B be propositions about states in Θ_A and Θ_B, respectively. Let $\omega_A = (b(A), d(A), u(A), a(A))$ and $\omega_B = (b(B), d(B), u(B), a(B))$ be an agent's opinions about A and B, respectively. Let $\omega_{A\wedge B} = (b(A \wedge B), d(A \wedge B), u(A \wedge B), a(A \wedge B))$ be the opinion such that:

1. $b(A \wedge B) = b(A) \wedge_N b(B)$,
2. $d(A \wedge B) = d(A) \vee_N d(B)$,
3. $u(A \wedge B) = u(A) \vee_N u(B)$,
4. $a(A \wedge B) = a(A)a(B)$.

Where $\wedge_N$ is a neutrosophic norm or n-norm, and $\vee_N$ is a neutrosophic conorm or n-conorm, [29]. This is called the *Propositional Conjunction*.

Definition 10: Let Θ_A and Θ_B be two distinct binary frames of discernment and let A and B be propositions about states in Θ_A and Θ_B, respectively. Let $\omega_A = (b(A), d(A), u(A), a(A))$ and $\omega_B = (b(B), d(B), u(B), a(B))$ be an agent's opinions about A and B, respectively. Let $\omega_{A\vee B} = (b(A \vee B), d(A \vee B), u(A \vee B), a(A \vee B))$ be the opinion such that:

1. $b(A \vee B) = b(A) \vee_N b(B)$,
2. $d(A \vee B) = d(A) \wedge_N d(B)$,
3. $u(A \vee B) = u(A) \wedge_N u(B)$,
4. $a(A \vee B) = a(A) + a(B) - a(A) \cdot a(B)$.

This is called the *Propositional Conjunction*, which means the agent's opinion about A or B.

Definition 11: Let Θ_A and Θ_B be two distinct binary frames of discernment and let A and B be propositions about states in Θ_A and Θ_B, respectively. Let $\omega_A = (b(A), d(A), u(A), a(A))$ and $\omega_B = (b(B), d(B), u(B), a(B))$ be an agent's opinions about A and B, respectively. Let us define:

1. $E(\omega_{A\wedge B}) = E(\omega_A) \wedge_N E(\omega_B)$,
2. $E(\omega_{A\vee B}) = E(\omega_A) \vee_N E(\omega_B)$.

The negation of an opinion about proposition A represents the agent's opinion about A being false. It is defined as follows:

Definition 12: Let $\omega_A = (b(A), d(A), u(A), a(A))$ be an opinion about proposition A. Then, $\omega_A = (b(A), d(A), u(A), a(A))$ is the negation of A, defined as:

1. $b(A) = d(A)$,
2. $d(A) = b(A)$,
3. $u(A) = u(A)$,
4. $a(A) = 1 - a(A)$.

Definition 13: Let $\omega_A^\alpha = (b^\alpha(A), d^\alpha(A), u^\alpha(A), a^\alpha(A))$ and $\omega_A^\beta = (b^\beta(A), d^\beta(A), u^\beta(A), a^\beta(A))$, 〈`s and ®`s opinions about the same proposition A, respectively. $\omega_A^{\alpha,\beta} = (b^{\alpha,\beta}(A), d^{\alpha,\beta}(A), u^{\alpha,\beta}(A), a^{\alpha,\beta}(A))$ is the conjoint opinion and it is defined as follows:

1. $b^{\alpha,\beta}(A) = b^\alpha(A) \wedge_N b^\beta(A)$,
2. $d^{\alpha,\beta}(A) = d^\alpha(A) \vee_N d^\beta(A)$,
3. $u^{\alpha,\beta}(A) = u^\alpha(A) \vee_N u^\beta(A)$,
4. $a^{\alpha,\beta}(A) = a^\alpha(A)a^\beta(B)$.

Let us illustrate the method with an example:

Example 1 (Adapted from [30]): Mr. Jones has been murdered, and we know that the murderer was one of three notorious assassins, Peter, Paul, and Mary, so we have a set of hypotheses, i.e., frame of discernment $\Theta = \{Peter, Paul, Mary\}$. The only evidence we have is that one person (let us denote him by W_1) who saw the killer leaving is 80% sure that it was a man, 1% unsure, and 1% sure there was not a man. i.e., $P_{W_1}(man) = (0.8, 0.1, 0.1)$. Thus, we have the following $m_1(\cdot)$ for witness 1:

$m_1(\{Peter, Paul\}) = (0.8, 0.1, 0.1)$,
$m_1(\{Peter, Paul, Mary\}) = (0.016667, 0.1, 0.15)$,
$m_1(\{Mary\}) = (0.001, 0.1, 0.15)$,
$m_1(\{Peter\}) = (0.016667, 0.1, 0.15)$,
$m_1(\{Paul\}) = (0.016667, 0.1, 0.15)$,
$m_1(\{Peter, Mary\}) = (0.016667, 0.1, 0.15)$,
$m_1(\{Paul, Mary\}) = (0.016667, 0.1, 0.15)$, and, $m_1(\emptyset) = (0, 0, 0)$.

On the other hand, there is a second witness such that $m_2(\cdot)$ is the following:

$m_2(\{Peter, Paul\}) = (0.8, 0.1, 0.1)$,
$m_2(\{Peter, Paul, Mary\}) = (0.016667, 0.1, 0.15)$,
$m_2(\{Mary\}) = (0.016667, 0.1, 0.15)$,
$m_2(\{Peter\}) = (0.016667, 0.1, 0.15)$,
$m_2(\{Paul\}) = (0.02, 0.1, 0.15)$,
$m_2(\{Peter, Mary\}) = (0.016667, 0.1, 0.15)$,
$m_2(\{Paul, Mary\}) = (0.016667, 0.1, 0.15)$, and, $m_2(\emptyset) = (0, 0, 0)$.

So, W_1's belief that Paul murdered Mr. Jones vs. Paul did not murder him is $b_1(\{Paul\}) = (0.016667, 0.1, 0.15)$ and $b_1(\{Mary, Peter\}) = (0.016667, 0.1, 0.15) + (0.001, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.034334, 0.3, 0.45)$, respectively.

$d_1(\{Paul\}) = (0.016667, 0.1, 0.15) + (0.001, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.034334, 0.3, 0.45)$,
$u_1(\{Paul\}) = (0.8, 0.1, 0.1) + (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.83333, 0.3, 0.4)$,
$a_1(\{Paul\}) = \frac{1}{3}$.

W_2's belief that Paul murdered Mr. Jones vs. Paul did not murder Mr. Jones is $b_2(\{Paul\}) = (0.02, 0.1, 0.15)$ and $b_2(\{Mary, Peter\}) = (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.05, 0.300000, 0.45)$, respectively.

$d_2(\{Paul\}) = (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.05, 0.300000, 0.45)$,
$u_2(\{Paul\}) = (0.8, 0.1, 0.1) + (0.016667, 0.1, 0.15) + (0.016667, 0.1, 0.15) = (0.83333, 0.3, 0.4)$,
$a_2(\{Paul\}) = \frac{1}{3}$.

Let us note that $b_1(\{Paul\}) \prec b_2(\{Paul\})$, because witness 2 is more sure about Paul's guiltiness. Also, see m_i, b_i, d_i, and u_i, can be considered neutrosophic probability measures, this is because they can be either additive, subadditive or superadditive.

To calculate the conjoint W_1 and W_2's opinion we use the formula in Definition 13, and the n-norm and n-conorm, $(a_1, a_2, a_3) \wedge_N (b_1, b_2, b_3) = (min\{a_1, b_1\}, max\{a_2, b_2\}, max\{a_3, b_3\})$ and $(a_1, a_2, a_3) \vee_N (b_1, b_2, b_3) = (max\{a_1, b_1\}, min\{a_2, b_2\}, min\{a_3, b_3\})$, respectively.

Then, the conjoint opinion of the two witnesses is formed by $b^{W_1,W_2}(\{Paul\}) = (0.016667, 0.1, 0.15)$, $d^{W_1,W_2}(\{Paul\}) = (0.05, 0.300000, 0.45)$, $u^{W_1,W_2}(\{Paul\}) = (0.83333, 0.3, 0.4)$, and $a^{W_1,W_2}(\{Paul\}) = \frac{1}{9}$.

Conclusion

This paper introduced a neutrosophic model for legal reasoning. For this purpose, concepts not yet sufficiently explored in neutrosophy were used, such as the neutrosophic belief function, from which the neutrosophic disbelief function was defined. The model is based on evidence to deal with the aspects of sufficient proof and weighing of pieces of evidence, which are basic in criminal or civil court trials. The novelty of this model based on another model that appeared in [8], which uses subjective logic, lies in the extension of the previous model to the neutrosophic framework.

It is known that in criminal and civil courts one deals with arguments, information, and knowledge that can become contradictory, confusing, incoherent, vague, uncertain, malicious, indeterminate, paradoxical, unknown, and so on. Therefore, rather than fuzzy logic or subjective logic, neutrosophic logic is better suited to deal with indetermination because the explicitness of the areas of indeterminacy allows the judge and/or jury to determine in which areas the facts and the defendant's guilt need to be clarified. Therefore, this model is feasible to use in Legal Decision Support Systems and Expert Systems.

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Information about the journal

This special issue reflects the impact of neutrosophic theory in Latin America, especially after creating the Latin American Association of Neutrosofic Sciences. Among the areas of publication most addressed in the region are found in the interrelation of social sciences and neutrosophy, presenting outstanding results in these research areas.

The main objective of this special issue is to divulge the impact publication related to the Neutrosophic theory and explore new areas of research and application in the region. The SI reflects the influence of the neutrosophic publications in Latin America by opening new research areas mainly related to Neutrosophic Statistics, Plithogeny, and NeutroAlgebra.
Furthermore, it is worth mentioning the incorporation of authors from new countries in the region, such as Paraguay, Uruguay, and Panama, to have authors in total from 15 countries, 12 of them from the Latin American region.

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Prof. Dr. Florentin Smarandache, Postdoc, Mathematics Department, University of New Mexico, Gallup, NM 87301, USA, Email: smarand@unm.edu.
Dr. Mohamed Abdel-Basset, Faculty of Computers and Informatics, Zagazig University, Egypt,
Email: mohamed.abdelbasset@fci.zu.edu.eg.
Prof. Dr. Maikel Leyva Vazquez, Salesian Polytechnic University, Guayas, Ecuador, Email: mleyvaz@gmail.com.
Dr. Said Broumi, Laboratory of Information Processing, Faculty of Science Ben M'Sik, University of Hassan II, Casablanca, Morocco, Email: s.broumi@flbenmsik.ma.

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