



# Neutrosophic Analysis of the Educational Orientation to the Diabetic Patient that reflects its impact on the Quality of Life

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**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 mmol/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  $< 2.7$  mmol/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  $x \in X$ .  $u_A(x)$ ,  $r_A(x)$  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:** ([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  $u_A, r_A, v_A : X \rightarrow [0,1]$ , 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  $0 \leq a + b + c \leq 3$ .

*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  $N_1 = a_1 + b_1I$  and  $N_2 = a_2 + b_2I$  two neutrosophic numbers, some operations between them are defined as follows, [13]:

$$N_1 + N_2 = a_1 + a_2 + (b_1 + b_2)I \text{ (Addition),}$$

$$N_1 - N_2 = a_1 - a_2 + (b_1 - b_2)I \text{ (Difference),}$$

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

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

Additionally, given  $I_1 = [a_1, b_1]$  and  $I_2 = [a_2, b_2]$  we have the following operations between them ([13]):

$$1. \quad I_1 \leq I_2 \text{ if and only if } a_1 \leq a_2 \text{ and } b_1 \leq b_2.$$

$$2. \quad I_1 + I_2 = [a_1 + a_2, b_1 + b_2] \text{ (Addition);}$$

$$3. \quad I_1 - I_2 = [a_1 - b_2, b_1 - a_2] \text{ (Subtraction),}$$

$$4. \quad I_1 \cdot I_2 = [\min\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}, \max\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}] \text{ (Product),}$$

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

$$5. \quad \sqrt{I} = [\sqrt{a}, \sqrt{b}], \text{ always that } a \geq 0 \text{ (Square root).}$$

$$6. \quad I^n = \underbrace{I \cdot I \cdot \dots \cdot I \cdot I}_{n \text{ times}}$$

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:

### Questionnaire Questions:

- 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  $\geq 55$  we consider it is YES,
- If the answer is  $\geq 45$  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  $MD \leq MA$ , 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 <sup>b</sup>	-4,021 <sup>b</sup>	-3,742 <sup>b</sup>	-3,771 <sup>b</sup>	-4,413 <sup>b</sup>	-3,945 <sup>b</sup>	-3,755 <sup>b</sup>
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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