



# Neutrosophic Statistical Analysis of the Rehabilitation of Arterial Hypertension

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**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:

$$n = \frac{N * Z_{\alpha}^2 * p * q}{d^2 * (N - 1) + Z_{\alpha}^2 * p * q} \quad (1)$$

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 finally 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

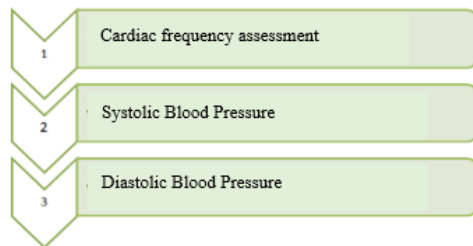
tombola technique.

The sample is distributed as follows: 11 male and 19 female patients, with a mean age of  $48.3 \pm 10.8$ , 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  $\alpha$  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  $H_0$  can be rejected.

The distinction between the classical P-value and the neutrosophic P-value is that the neutrosophic P-value is not a 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  $H_0$  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 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]

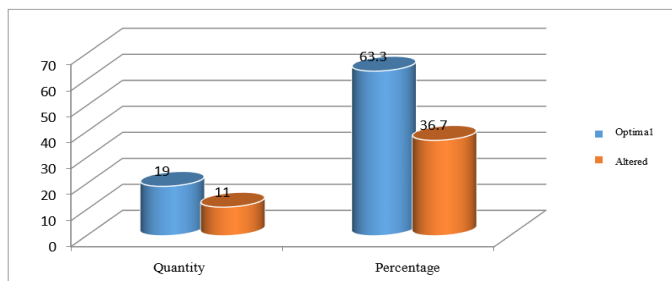
### 2.4 Statistical analysis

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

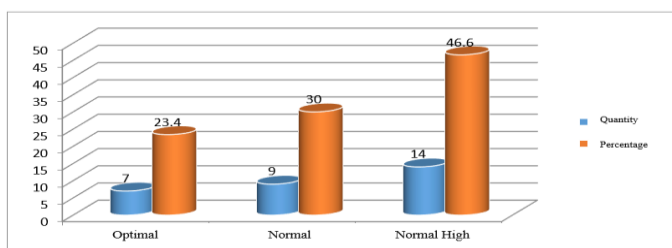
Graph 1 shows the results of the heart rate indicator, where it is observed that most of the patients in studies 19 for 63.3% of the study sample reached values that are considered optimal, this is indicative in favor of the rehabilitation. For their part, the remaining 11 for 36.7% did not reach the 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%.

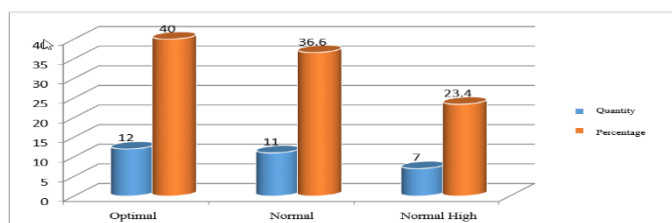
On the other hand, most are in the high normal ranges (14 to 46.6%), for which it is suggested that they should follow their SBP control for a longer period, and maintain a correct diet, do physical exercise and take the medication according to the doctor's prescription.



**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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