# Evaluating the acceptance level of the papillomavirus vaccine using a neutrosophic linguistic model

**Melba Esperanza Narváez Jaramillo[1], Mayra Alejandra Guerrero Ayala[2], Dannya Aracelly Flores Jurado[3] and Olga Mireya Alonzo Pico[4]**

[1]Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: ut.melbanarvaez@uniandes.edu.ec
[2] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: ut.mayraguerrero@uniandes.edu.ec
[3] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: et.dannyaafj25@uniandes.edu.ec
[4] Professor,Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: ut.olgaalonzo@uniandes.edu.ec

**Abstract**. Human Papilloma Virus is a health problem for paying attention to. This is due to the consequences it can bring to infected peoples and the society. Thus, it is a privilege to have the vaccine that prevents children to get such disease. Particularly we propose in this paper to carry out a study of the approval level of the Human Papilloma Virus vaccine in the fiscal school "Bolívar" sited in Tulcán city, Ecuador. To achieve greater accuracy in this study it is applied the method of 2-tuples linguistic neutrosophic model, which is part of the Computing with Words. This tool allows obtaining results from the evaluation of the satisfaction of the respondents by means of linguistic terms, which is the most natural way of evaluation compared with the numerical one. There is also a numeric element that measures the accuracy of the result. The incorporation of neutrosophy allows the explicit inclusion of indeterminacy within what is evaluated, that results in a greater accuracy in the model with respect to the 2-tuples linguistic fuzzy method.

**Keywords:** Human Papilloma Virus, 2-tuple linguistic neutrosophic number, Computing with Words, linguistic model.

## 1 Introduction

According to the World Health Organization (WHO) the Human Papilloma Virus (HPV) is one of the most important causes of human morbidity and mortality, and is associated with sexual activity. HPV causes cervical cancer, ranks fourth among the most common cancers affecting women, with an estimated 266,000 deaths and some 528,000 new cases in 2012. The vast majority (about 85%) of these deaths occurred in the less developed regions, where it accounts for nearly 12% of all female cancers. Some countries have begun to vaccinate children, as the vaccine prevents different types of genital cancer in both men and women; in addition, one of the two available vaccines also prevents genital warts in both sexes. WHO recommends that girls between the ages of 9 and 13 be vaccinated, as this is the most cost-effective public health measure against this kind of disease, see [1-2].

MINSA-Peru, the Peruvian Ministry of Health ([3]) in the study report "Summary of Experience and Evaluation of the HPV Vaccine Test Project in Peru" evaluated acceptability through case studies to determine the conditions and contexts surrounding the decision to vaccinate and the determinants of HPV vaccine approval. The decision-making processes of parents and girls regarding HPV vaccination were diverse and complex in the cases studied during the program evaluation. The cases suggest that decision-making is not necessarily a linear process, but rather a process that varies in response to concerns and doubts about the effects and objectives of the HPV vaccine.

The case studies highlighted two stages in the decision regarding HPV vaccination. Parents refuse HPV vaccination because of concerns regarding the signed authorization requirement and adverse effects on girls. Educational efforts by teachers and health personnel, and information independently collected by parents and girls, resulted in most parents and girls accepting HPV vaccination.

Some studies have been found that the acceptability of the vaccine varies in relation to the socio-cultural and educational context, and promoting the vaccine to prevent a sexually transmitted infection in very young girls (<12 years) may create obstacles to its acceptability, it is recommended that it be promoted for the prevention of cervical cancer.

The purpose of this investigation is to identify the level of approval of the HPV vaccine by the parents of girls between 9 and 11 years old in the fiscal school "Bolívar" of the Tulcán city in Ecuador, and to generate information that will contribute to orient actions to achieve a greater coverage of vaccination and to protect through immunization a greater population against this disease and consequently to contribute to improve the conditions of health of the population.

This paper deal with decision support models based on neutrosophy ([4-6]), providing linguistic results that are easily interpretable. To this end, it is proposed that information be represented with linguistic values and operated on a 2-tuples linguistic model [7-10]. Thus, the mental models obtained are closer to the way of thinking of decision-makers.

Computing with words (CWW) is a methodology that permits a computation and reasoning process using words belonging to the language instead of numbers. This methodology allows creating and enriching decision models in which vague and imprecise information is represented by linguistic variables using words belonging to a natural language instead of numbers, see [11-15].

These processes have been carried out in fuzzy decision making using different models:

Semantic Model: operations are performed using fuzzy or fuzzy arithmetic.

Symbolic Model: the operations are carried out on the indexes of the linguistic labels.

Model based on the linguistic 2-tuple: it operates in a domain of linguistic expression, treating it as a continuous universe, gaining precision in the results. The use of the model based on 2-tuples has made possible to tackle Decision Making problems defined in complex contexts that the classical models could not, due to their limitations.

A classic statistical method could be used to determine the degree of acceptance of this vaccine, however, the final result would be given in the form of the percentage of respondents who give a specific answer to each question. Although this method is the most widely used for conducting surveys, it lacks the interpretability of the linguistic scale. Statistics can be very suitable for health specialists, who must finally interpret the results so that educators express it to the students in the form of linguistic terms, which is a more effective way of explaining this health situation.

On the other hand, Neutrosophic Statistics is a generalization of classical statistics ([16-18]), where for example the distributions that depend on numerical parameters are replaced by interval of parameters, the population or sample sizes are considered in an indeterminate interval, and so on. However, this generalization also lacks of interpretability.

Other concepts that combine statistics in decision-making in the neutrosophic environment are probability multi-valued neutrosophic sets (PMVNSs) ([19]), which are designed to solve problems of Multi-criteria group decision-making, where multi-valued neutrosophic sets ([20]) are combined with multi-criteria decision methods, as in [19]. In [21] the Frank operator is studied to solve problems of Multi-criteria group decision-making from Normal Neutrosophic Sets, where the three membership functions of neutrosophic sets correspond to functions of normal distribution, which provide to it statistical properties.

In [22] measures on the Probabilistic Neutrosophic Hesitant Fuzzy Sets are studied, which reduce unnecessary evaluation processes in decision-making.

Other concepts are based on linguistic calculations, especially those which use the Linguistic Neutrosophic Numbers ([23, 24]).

With the proposed method, linguistic interpretation is carried out directly and automatically. Another advantage that can be highlighted is the possibility of converting this method into a standard method for carrying out this type of study, which can be automated by means of friendly software, where only linguistic terms are entered as data and linguistic conclusions are also obtained.

This method is more accurate in two ways. In one sense the processed 2-tuples contain both, a linguistic term and a numerical value that reflects the accuracy of this linguistic term, this advantage is inherited from the original fuzzy method. On the other hand, the neutrosophic 2-tuples overcome the fuzzy ones in that not only one linguistic term, but three are taken into account, which makes the reached conclusion more accurate.

This paper have the following structure, section 2 contains the concepts and definitions essential to understand the results of this research. Section 3 presents the results obtained in the research. The last section is devoted to conclusions.

## 2 Basic Concepts

This section explains the main concepts related to 2-tuples linguistic models.

The 2-tuple linguistic representation model allows computation processes with words without loss of information, based on the concept of symbolic translation.

Let $S = \{s_0, s_1, \ldots, s_g\}$ be a set of linguistic terms and $\beta \epsilon [0, g]$ a value in the granularity interval of S.

**Definition 1.** ([7-9]) The Symbolic Translation of a linguistic term$s_i$ is a number valued in the interval [-0.5, 0.5) which expresses the difference of information between a quantity of information expressed by the value $\beta \epsilon$ [0,g], obtained in a symbolic operation and the nearest integer value, $i \in \{0, \ldots, g\}$ which indicates the index of the nearest linguistic label ($s_i$) in S.

Based on this concept, a new model for the representation of linguistic information was developed, which makes use of a pair of values or 2-tuples. This representation model defines a set of functions that facilitate operations on 2-tuples.

**Definition 2.** ([7-9]) Let $S = \{s_0, s_1, \dots, s_g\}$ be a set of linguistic terms and $\beta \epsilon [0, g]$ a value that represents the result of a symbolic operation, then the linguistic 2-tuple that expresses the information equivalent to β, is obtained using the following function:

$$\Delta: [0, g] \rightarrow S \times [-0.5, 0.5)$$

$$\Delta(\beta) = (s_i, \alpha) \quad (1)$$

Where $s_i$ is such that $i = \text{round}(\beta)$ and $\alpha = \beta - i, \quad \alpha \in [-0.5, 0.5)$ and “round” is the usual rounding operator, $s_i$ is the index label closest to β and α is the value of the symbolic translation.

It should be noted that $\Delta^{-1}: \langle S \rangle \rightarrow [0, g]$ is defined as $\Delta^{-1}(s_i, \alpha) = i + \alpha$. Thus, a linguistic 2-tuple $\langle S \rangle$ is identified with its numeric value in $[0, g]$.

In [10] the concept of 2-Tuple Linguistic Neutrosophic Number (2TLNN) is proposed to solve problems based on Single-Valued Neutrosophic Sets and 2-tuples linguistic sets (2TLSs).

A 2TLNN is defined as follows [10]:

Suppose that $S = \{s_0, \dots, s_g\}$ is a 2TLSs with odd cardinality t+1. It is defined for $(s_T, a), (s_I, b), (s_F, c) \in L$ and a, b, c ∈[0, t], where $(s_T, a), (s_I, b), (s_F, c) \in L$ independently express the degree of truthfulness, indeterminacy, and falsehood by 2TLSs, then 2TLNN is defined as follows:

$$l_j = \left\{(s_{T_j}, a), (s_{I_j}, b), (s_{F_j}, c)\right\} \quad (2)$$

Where $0 \leq \Delta^{-1}(s_{T_j}, a) \leq t$, $0 \leq \Delta^{-1}(s_{I_j}, b) \leq t$,$0 \leq \Delta^{-1}(s_{F_j}, c) \leq t$, and$0 \leq \Delta^{-1}\left(s_{T_j}, a\right) + \Delta^{-1}\left(s_{I_j}, b\right) + \Delta^{-1}(s_{F_j}, c) \leq 3t$.

The scoring and accuracy functions allow us to rank 2TLNN [10].

Let$l_1 = \{(s_{T_1}, a), (s_{I_1}, b), (s_{F_1}, c)\}$be a 2TLNN in L, the scoring and accuracy functions in $l_1$are defined as follows, respectively:

$$S(l_1) = \Delta\left\{\frac{2t + \Delta^{-1}(s_{T_1}, a) - \Delta^{-1}(s_{I_1}, b) - \Delta^{-1}(s_{F_1}, c)}{3}\right\},\ \Delta^{-1}(S(l_1)) \in [0, t] \quad (3)$$

$$H(l_1) = \Delta\left\{\frac{t + \Delta^{-1}(s_{T_1}, a) - \Delta^{-1}(s_{F_1}, c)}{2}\right\},\ \Delta^{-1}(H(l_1)) \in [0, t] \quad (4)$$

**Definition 3.**Given a 2TLNN, $l_j = \langle (s_{T_j}, a_j), (s_{I_j}, b_j), (s_{F_j}, c_j) \rangle$ (j = 1, 2,…, n) with vector of weights $w_i = (w_1, w_2, \dots, w_n)^T$ which satisfies the conditions $w_i \in [0, 1]$ and $\sum_{i=1}^{n} w_i = 1$, then the following two aggregation operators are defined, which are the Linguistic Neutrosophic Number-weighted arithmetic averaging (LNNWAA) and the Linguistic Neutrosophic Number-weighted geometric averaging (LNNWGA), respectively, [25]:

$$\text{LNNWAA}(l_1, l_2, \dots, l_n) = \sum_{j=1}^{n} w_j l_j = \langle s_{t - t\prod_{j=1}^{n}\left(1 - \frac{T_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{I_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{F_j}{t}\right)^{w_j}} \rangle \quad (5)$$

$$\text{LNNWGA}(l_1, l_2, \dots, l_n) = \prod_{j=1}^{n} l_j^{w_j} = \langle s_{t\prod_{j=1}^{n}\left(\frac{T_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}} \rangle \quad (6)$$

Decision-making is a discipline that has been approached from different perspectives, from the most classical such as philosophy, statistics, mathematics and economics, to the most recent ones such as artificial intelligence. The solution to a decision-making problem consists in the following steps:

- Defining the problem of decision making.
- Analyze the problem and identify the solution alternatives: $X = \{x_1, x_2, \dots, x_n\}$(n≥2).
- Establish the evaluation criteria.
- Select experts.
- Evaluate alternatives.
- Sort and select the best alternative.
- Implement and follow up.

When the number of criteria satisfies $C = \{c_1, c_2, \dots, c_m\}$ $(m \geq 2)$, it is considered a multi-criteria decision-making problem. When the number of experts is such that $K = \{k_1, k_1, \dots, k_n\}$ (n≥2) it is considered a group decision problem.

In this paper we propose a method to measure the acceptance of the papilloma virus vaccine. This is basically a multicriteria decision making solution to process linguistically the responses of the interviewed. In the following we describe what are the steps forming the proposed method.

**Step 1.** The respondents will be selected to conduct the assessment of their satisfaction with respect to the human papilloma virus vaccine. They are denoted by: $K = \{k_1, k_1, \ldots, k_n\}$ ($n \geq 2$). It is recommendable they are selected statistically, were a random sampling is used.

**Step 2.** Specify the scale of linguistic terms that will be used for evaluation. Every scale depends on the kind of answer. It is important that the set of possible answers have an odd cardinality, and we recommend including an indeterminate response, like "I don't know", "I don't care" or "Indifference". Specifically, here we propose the following questionnaire and linguistic scales:

- $Q_1$: Do you know about HPV infection?

Measured with the linguistic scale $S_1$ = {$s_{10}$ = "Nothing", $s_{11}$ = "Very little", $s_{12}$ = "Little", $s_{13}$ = "More or less", $s_{14}$ = "Much"}.

- $Q_2$: Do you know what the HPV vaccine protects against?

Measured with the linguistic scale $S_2$ = {$s_{20}$ = "Nothing", $s_{21}$ = "Very little", $s_{22}$ = "Little", $s_{23}$ = "More or less", $s_{24}$ = "Very much"}.

- $Q_3$: Do you know if HPV is related to cervical cancer?

Measured with the linguistic scale $S_3$ = {$s_{30}$ = "No", $s_{31}$ = "Not sure", $s_{42}$ = "Yes"}.

- $Q_4$: Education level of the interviewed

Measured with the linguistic scale $S_4$ = {$s_{40}$ = "Low", $s_{41}$ = "Middle", $s_{42}$ = "High"}.

- $Q_5$: Do you authorize the administration of the HPV vaccine to your daughter or tutored?

Measured with the linguistic scale $S_5$ = {$s_{50}$ = "No", $s_{51}$ = "Not sure", $s_{52}$ = "Yes"}.

**Step 3.** Aggregate the result for each criterion and all respondents, using Equation 7 with weights allotted equal to 1/n. This weight could vary if the sample is partitioned and some interviewed responses are considered more important than the others, nevertheless, in this research we judge everybody have the same weight.

$$\mathrm{WAO}(l_1, l_2, \ldots, l_n) = \langle s_{\sum_{j=1}^{n} w_j T_j}, s_{\sum_{j=1}^{n} w_j I_j}, s_{\sum_{j=1}^{n} w_j F_j} \rangle \quad (7)$$

This operator corresponds to the arithmetic mean ([7]). We used WAO instead of LNNWAA or LNNWGA, because this is associated with the statistic mean, taking into account we are calculating the result of review of a random sampling.

**Step 4.** Either the scoring or the accuracy functions are applied to evaluate the results, obtaining a unique 2-tuple value.

## 3 Results

This section summarizes the results of applying the survey to the parents of girls respect to the approval level of the HPV vaccine. We substituted the classical statistical analysis by a decision making approach where a linguistic terms scale is used.

With this investigation we prefer obtaining linguistic results from linguistic input values rather than numeric ones because natural language is more effective to express person's opinions. Additionally, neutrosophy permits more accurate calculations.

The questionnaire was applied to the parents of girls in the fiscal school "Bolívar" according to the details given in Table 1.

| Respondent | Quantity | Percent |
|---|---|---|
| Mother | 70 | 81 |
| Father | 12 | 14 |
| Others | 4 | 5 |
| Total | 86 | 100 |

**Table 1:** Respondents to the questionnaire.

The questionnaire to measure the criteria is the following:

Let us note that second indexes of every $S_i$ elements are those used for calculation. We asked for the truthfulness, indeterminacy, and falseness of the answers in form of linguistic terms.

The final results are summarized in Tables 2-6.

| Linguistic term | Number of answers for the first component | Number of answers for the second component | Number of answers for the third component |
|---|---|---|---|
| $s_{10}$ | 62 | 0 | 5 |
| $s_{11}$ | 8 | 60 | 9 |
| $s_{12}$ | 2 | 12 | 0 |
| $s_{13}$ | 10 | 3 | 53 |

| | | | |
|---|---|---|---|
| $s_{14}$ | 4 | 11 | 19 |

**Table 2:** Responses to the questionnaire for $Q_1$.

| Linguistic term | Number of answers for the first component | Number of answers for the second component | Number of answers for the third component |
|---|---|---|---|
| $s_{20}$ | 72 | 0 | 3 |
| $s_{21}$ | 0 | 72 | 11 |
| $s_{22}$ | 0 | 0 | 0 |
| $s_{23}$ | 10 | 4 | 72 |
| $s_{24}$ | 4 | 10 | 0 |

**Table 3:** Responses to the questionnaire for $Q_2$.

| Linguistic term | Number of answers for the first component | Number of answers for the second component | Number of answers for the third component |
|---|---|---|---|
| $s_{30}$ | 68 | 0 | 18 |
| $s_{31}$ | 0 | 0 | 0 |
| $s_{22}$ | 18 | 0 | 68 |

**Table 4:** Responses to the questionnaire for $Q_3$.

| Linguistic term | Number of individuals | Percent |
|---|---|---|
| $s_{40}$ | 36 | 42 |
| $s_{41}$ | 42 | 49 |
| $s_{42}$ | 8 | 9 |

**Table 5:** Responses to the questionnaire for $Q_4$.

| Linguistic term | Number of answers for the first component | Number of answers for the second component | Number of answers for the third component |
|---|---|---|---|
| $s_{30}$ | 74 | 11 | 10 |
| $s_{31}$ | 3 | 0 | 0 |
| $s_{22}$ | 9 | 75 | 76 |

**Table 6:** Responses to the questionnaire for $Q_5$.

Table 7 summarizes the result to aggregate the person's opinions for questions 1, 2, 3, and 5, using formula 75.

| Question | Aggregated 2 –tuples corresponding to the first component | Aggregated 2 –tuples corresponding to the second component | Aggregated 2 –tuples corresponding to the third component |
|---|---|---|---|
| $Q_1$ | ($s_{11}$, -0.32558) | ($s_{12}$, -0.40698) | ($s_{13}$, -0.16279) |
| $Q_2$ | ($s_{21}$, -0.46512) | ($s_{21}$, 0.44186) | ($s_{23}$, -0.36047) |
| $Q_3$ | ($s_{30}$, 0.11111) | - | ($s_{32}$, -0.41860) |
| $Q_5$ | ($s_{50}$, 0.24419) | ($s_{52}$, -0.25581) | ($s_{52}$, -0.23256) |

**Table 7:** Results of aggregating opinion's for questions 1, 2, 3, and 5.

Let us remark that in the proposed method, the arithmetic mean is used as an aggregation operator ([7]), which is an unbiased statistic used in classical statistics. In this investigation, a survey is carried out on 100% of the population of parents or guardians of the Fiscal Educational Unit "Bolívar" of the city of Tulcán, therefore it is sufficient to process the data within the descriptive statistics. For this reason, the arithmetic mean is used as the linguistic aggregation operator, instead of the LNNWAA and LNNWGA ([25]).

Table 8 contains the results for applying formula 3 to the components obtained in $Q_1$, $Q_2$, and $Q_5$, whereas formula 4 is applied to $Q_3$. The last column contains the name of the linguistic terms associated with the symbols on the left.

| Question | Results of applying the score function or accuracy function | Linguistic term |
|---|---|---|
| $Q_1$ | $(s_{11}, 0.41473)$ | "Very Little" |
| $Q_2$ | $(s_{21}, 0.15116)$ | "Very Little" |
| $Q_3$ | $(s_{30}, -0.15676)$ | "No" |
| $Q_5$ | $(s_{50}, 0.24419)$ | "No" |

**Table 8:** Results for applying the score function in Questions 1, 2, 3, and 5.

Thus, the majority of the inquired persons are mothers, they know very little about HPV infection, know very little what the HPV vaccine protects against, do not know if HPV is related to cervical cancer, the educational level is low or medium, and do not authorize the administration of the HPV vaccine to their daughters.

## Conclusion

This paper was dedicated to study the evaluation of the parents and tutors' opinions about the use of the HPV vaccine to girls in the fiscal school "Bolívar" of the city of Tulcán in Ecuador. We used the 2-tuple linguistic neutrosophic model, hence, the input and output of the survey is evaluated on scales based on linguistic terms. Five questions were asked to 86 parents or tutors, most of them mothers. We can conclude that the results are negative, in general the parents and tutors consider not appropriate to vaccinate their girls, they do not know many important aspects of the HPV disease, and few of them have a high educational degree. We recommend increasing the educational work by the health personnel and teachers, [26, 27]. In future works we will take into account other operators described in the literature to carry out this type of study. However, with the proposed method, the main problem at hand was solved, which has a humanitarian and educational nature.

## References

[1] Pandhi, D. and Sonthalia, S. (2011). Human papilloma virus vaccines: Current scenario. *Indian Journal of sexually transmitted diseases, 32*(2), 75-85.
[2] Stanley, M. (2015). Human Papilloma Virus Vaccines. In *Medicines For Women* (pp. 271-289). Cham: Adis.
[3] MINSA (2010) Summary of Experience and Evaluation of the HPV Vaccine Test Project in Peru (Resumen de la experiencia y evaluación del proyecto piloto de la vacuna contra el virus del papiloma humano en Perú)(In Spanish). Available in: http://www.medicinasaludysociedad.com/site/images/stories/.
[4] Smarandache, F. (2002). *Neutrosophy, a new Branch of Philosophy*: Infinite Study.
[5] Smarandache, F. (2005). *A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrsophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability*: Infinite Study.
[6] Leyva-Vázquez, M. and Smarandache, F. (2018). *Neutrosophy: new advances in the treatment of uncertainty (Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre)(In Spanish)*. Brussels: Pons.
[7] Herrera, F. and Martínez, L. (2000). A 2-tuple fuzzy linguistic representation model for computing with words. *IEEE Transactions on Fuzzy Systems, 8*, 746-752.
[8] Herrera, F. and Martínez, L. (2000). An approach for combining linguistic and numerical information based on the 2-tuple fuzzy linguistic representation model in decision-making. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 8*, 539-562.
[9] Mata, F. (2006). *Models to Consensus Support Systems in problems of Group Decision Making defined in Multigranulars Linguistic Contexts (Modelos para Sistemas de Apoyo al Consenso en Problemas de Toma de Decisión en Grupo definidos en Contextos Lingüísticos Multigranulares)(In Spanish).* Doctoral Thesis, University of Jaen, Spain.
[10] Wang, J., Wei, G., and Yu, W. (2018). Models for Green Supplier Selection with Some 2-Tuple Linguistic Neutrosophic Number Bonferroni Mean Operators. *Symmetry, 10*(5), 131.
[11] Herrera, F., Alonso, S., Chiclana, F., and Herrera-Viedma, E. (2009). Computing with words in decision making: foundations, trends and prospects. *Fuzzy Optimization and Decision Making, 8*(4), 337-364.
[12] Martinez, L., Ruan, D., and Herrera, F. (2010). Computing with words in decision support systems: an overview on models and applications. *International Journal of Computational Intelligence Systems, 3*(4), 382-395.
[13] Rubin, S. H. (1999). Computing with words. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (*Cybernetics*), 29*(4), 518-524.
[14] Wang, P. P. (2001). *Computing with words*: John Wiley & Sons, Inc.
[15] Zadeh, L. A. (1999). From computing with numbers to computing with words. From manipulation of measurements to manipulation of perceptions. *IEEE Transactions on circuits and systems I: fundamental theory and applications, 46*(1), 105-119.
[16] Smarandache, F. (2014). *Introduction to Neutrosophic Statistics*. Craiova: Sitech & Education Publishing.
[17] Aslam, M., and Albassam, M. (2019). Inspection Plan Based on the Process Capability Index Using the Neutrosophic

Statistical Method. *Mathematics*, *7*, 631.

[18] Aslam, M., Jeyadurga, P., Balamurali, S., and Hussein-AL-Marshadi, A. (2019). Time-Truncated Group Plan under a Weibull Distribution based on Neutrosophic Statistics. *Mathematics*, *7*, 905.

[19] Liu, P., Cheng, S., and Zhang, Y. (2018) An extended multi-criteria group decision-making PROMETHEE method based on probability multi-valued neutrosophic sets, *International journal of fuzzy systems 21*(2), 388–406.

[20] Peng, J.-J., Wang, J.-Q., Wu, X.-H., Wang, J., and Chen, X.-H. (2015) Multi-valued Neutrosophic Sets and Power Aggregation Operators with Their Applications in Multi-criteria Group Decision-making Problems, *International Journal of Computational Intelligence Systems*, *8*(2), 345-363.

[21] Liu, P., Wang, P., and Liu, J. (2017) Normal Neutrosophic Frank aggregation operators and their application in Multi-Attribute Group Decision Making, *International Journal of Machine Learning and Cybernetics*, *10*(5), 833-852.

[22] Shao, S., and Zhang, X. (2019). Measures of Probabilistic Neutrosophic Hesitant Fuzzy Sets and the Application in Reducing Unnecessary Evaluation Processes. *Mathematics*, *7*, 649.

[23] Fan, C., Feng, S., and Hu, K. (2019). Linguistic Neutrosophic Numbers Einstein Operator and Its Application in Decision Making. *Mathematics*, *7*, 389.

[24] Liu, P., and You, X. (2019) Improved TODIM Method Based on Linguistic Neutrosophic Numbers for Multicriteria Group Decision-Making, *International Journal of Computational Intelligence Systems*, *12*(2), 544 – 556.

[25] Fang, Z., and Ye, J. (2017) Multiple Attribute Group Decision-Making Method Based on Linguistic Neutrosophic Numbers, *Symmetry*, *9*, 111.

[26] Estupiñan Ricardo, J., Llumiguano Poma, M. E., Arguello Pazmiño, A. M., Albán Navarro, A. D., Martín Estévez, L., Batista Hernandez, N. (2019) Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. *Neutrosophic Sets & Systems*, 26, 55-61.

[27] Leyva Vázquez, M., Batista Hernandez, N., and Smarandache, F. (2018) *Multicriteria methods for determining the efectiveness of the public management and the analysis of the transparency* (*Métodos multicriterios para determinación de la efectividad de la gestión pública y el análisis de la transparencia)(In Spanish)*. Infinite Study.

Received: October 1st, 2019 Accepted: January 29rd, 2020