Neutrosophic Model for Sentiment Data Analysis

Ned Vıto Quevedo Arnaız [1, *], Genaro Vınıcıo Jordan Naranjo[2], Diego Xavier Chamorro Valencia[3], Joffre Joffre Paladines Rodríguez[4], Anna Mixaylovna Aripova[5]

[1]Regional Autonomous University of the Andes Riobamba. Ecuador
[2]Regional Autonomous University of the Andes Ambato. Ecuador
[3]Regional Autonomous University of Los Andes Ibarra. Ecuador
[4]Universidad de la Habana, La Habana, Cuba
[5]Tashkent State University of Economics, Uzbekistan

Emails: us.nedquevedo@uniandes.edu.ec , ua.genarojordan@uniandes.edu.ec , ui.diegochamorro@uniandes.edu.ec, joffre_paladines@hotmail.com, anna-aripova-1990@mail.ru

Abstract

Sentiment analysis has recently become popular in social, political and health related fields, but it has a common limitation of capturing the subjectivity involved in multiple human expressions. In this study, we tackle this concern by presenting a model that is constructed using neutrosophic logic which can incorporate indeterminacy in the evaluation of perceptions. Although some answers may be provided by the traditional methods, they fail to contain the uncertainties and contradictions which are characteristic of natural language, making them difficult to implement in complicated situations. In this methodological gap, the neutrosophic model is presented as a tool capable of overcoming these limitations by explicitly treating uncertainty and balancing definite, indeterminate, and contradictory elements. The integration of machine learning algorithms with neutrosophic techniques helps classify and visualize sentiments embedded in big volume of text data. The findings suggest that this methodology not only enhances the precision in the identification of emotional subtleties but also provides a hybrid platform for integrating imprecise information. His credits are based on the development of a theoretical model which advances the field of sentiment analysis and the development of real-life applications in customer services for example, political analytics and strategic decision making. This methodological advance demonstrates that incorporating neutrosophic logic into sentiment data analysis opens up new possibilities for understanding and modeling the complexities of human perceptions.

Keywords: Neutrosophic model; Sentiment analysis; Human perception; Subjectivity; Ambiguity; Uncertainty; Contradictions; Neutrosophic logic; Natural language; Machine learning

1. Introduction

The concept of State, represented as an abstract entity resulting from the collective will of society, arises as a political construction intended to promote human progress and the advancement of general prosperity, as expressed in [1]. Within this framework, the State assumes the obligation to satisfy the needs of the community, ensure compliance with the principles and rights stipulated in the Constitution and promote citizen participation in decisions that affect the economic, political, administrative and cultural spheres of the nation. In addition, the State has the duty to safeguard national sovereignty, preserve territorial integrity and maintain harmonious coexistence based on justice, in accordance with the ideas of [2].

One of the main objectives of the State is the protection of workers and their families, particularly in cases where a member of the family unit is pregnant, as highlighted by [3]. Occupational safety is interpreted in a comprehensive manner, covering both internal and external dimensions, which include the well-being of citizens and the safeguarding of the integrity of workers within a democratic environment free of corruption, as postulated by [4,22].

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

The issue of occupational safety, being an integral facet of workers' fundamental rights, assumes utmost importance in protecting vulnerable segments of the work environment. Vulnerable cohorts, characterized by a greater susceptibility to situations of inequity and bias, require specific attention in matters of occupational safety to ensure parity and preservation of their rights, as emphasized by [3]. In this context, pregnant women, as well as children and adolescents, require special consideration due to their unique circumstances and stages of development. In the area of occupational safety, there is a call to establish mechanisms that effectively protect these demographic segments, not only by ensuring their physical well-being but also by defending their honor and fundamental rights, as articulated by [5].

Pregnant women face a number of additional obstacles in the workplace. The state of pregnancy involves a number of physiological and emotional transformations that may make certain work tasks unsafe or unsuitable for them. Consequently, labor regulations should incorporate specific provisions to ensure the health and well-being of pregnant women. These measures may include modifying work responsibilities, providing adequate rest periods and the option to request leave when deemed necessary, as highlighted by [6,23].

Children and adolescents represent another particularly vulnerable demographic group in both the workplace and society. Given their stage of development and limited capacity to understand and defend their rights, it is imperative to have protection mechanisms in place to actively safeguard them. The International Convention on the Rights of the Child underlines the importance of ensuring children's rights to protection from all forms of exploitation, as well as to education and play, as noted [6].

A fundamental component of the Constitution of the Republic of Ecuador addresses the rights inherent to persons in the process of development who have not yet been born, known as *nasciturus.* This legal provision explicitly protects life during pregnancy, paying special attention to unborn children and adolescents, who possess rights common to all humanity, in addition to the rights specific to their phase of development [7,24]. According to this article, the State undertakes to recognize and preserve life from the moment of conception, in addition to providing the necessary care and protection [8]. Despite the Civil Code's assertion that the legal existence of a person begins with birth, that is, the total separation from the mother's body, this perspective is oriented toward the defense and respect of the fundamental rights of entities that develop in the mother's womb. This interpretation is aligned with the principle of guaranteeing the safeguarding and recognition of life from its earliest stages, ensuring its continuation in subsequent vital phases [8].

In this context, the economic, social and labor security of parents plays a fundamental role in the comprehensive protection of the fetus. Ecuadorian legislation guarantees the labor stability of pregnant women by prohibiting unforeseen dismissals during pregnancy and up to three months after delivery [3]. However, this protective measure focuses predominantly on the pregnant mother, without considering the circumstances of the working father, who also contributes significantly to the well-being of the family and the future development of the fetus [4].

The lack of protection of the rights of the fetus when the father is dismissed, especially if the father is the sole breadwinner of the family, presents a normative discord that requires in-depth examination from both a legal and social perspective. This issue highlights the complexity of balancing the protection of the fetus with the employment situation of the parents and emphasizes the need for a comprehensive analysis of the situation. The precarious employment situation of the parents can directly affect the family unit, in particular the well-being of the future child, highlighting the intricate interaction between job stability and family well-being [5,9]. Within the framework of the Ecuadorian Constitution, emphasis is placed on the protection of life and the integral development of the fetus [7, 8].

This research delves into the field of protection of pregnant working women, focusing on the legal and social landscape of Ecuador. The study explores the legal framework, constitutional principles, and labor protection policies that affect employees with pregnant partners. This research aims to determine a model based on natural language processing with neutrosophic linguistic labels that explains the factors that influence the well-being of pregnant spouses. Additionally, it seeks to investigate through natural language processing the feelings of these pregnant women regarding their well-being at work, exposing how positive or negative this can be regarding the treatment they receive in their workplace.

2. Related work.

2.1. Neutrosophic Sets

The concept of neutrosophic sets, introduced by Florentin Smarandache, is an advanced mathematical framework designed to deal with the complexity and ambiguity inherent in real-world problems. Unlike traditional set theories

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

that operate on binary logic (true or false), neutrosophic sets embrace the notions of truth, falsity, and indeterminacy. This allows for a richer and more nuanced approach to modeling and solving problems characterized by uncertainty, vagueness, and incomplete information.

To begin, let's dig into the basic structure of a neutrosophic set. A neutrosophic set A in a universe of discourse X is characterized by three membership functions: T_A(x), I_A(x), and F_A(x). These functions represent the degree of truth, indeterminacy, and falsity, respectively, for each element x in X. Each membership value ranges between 0 and 1, inclusive, allowing for a flexible representation where an element can simultaneously belong to multiple degrees of truth, falsity, and indeterminacy.

The inclusion of an indeterminacy component (I_A(x)) is what differentiates neutrosophic sets from other set theories, such as fuzzy sets and intuitionistic fuzzy sets. This third component recognizes that in many real-world scenarios, information is incomplete or ambiguous, and is neither completely true nor completely false. This makes neutrosophic sets particularly useful in fields such as artificial intelligence, decision making, and systems engineering, where uncertainty and incomplete information are common.

One of the primary applications of neutrosophic sets is in decision-making processes. Consider a scenario where a company must decide whether to launch a new product. Traditional binary decision models may struggle with the ambiguity and incomplete data that are often present in such situations. By employing neutrosophic sets, the company can assess the potential success of the product by considering degrees of truth (e.g., positive market feedback), falsity (e.g., negative reviews), and indeterminacy (e.g., uncertain market trends). This comprehensive approach allows for more informed and nuanced decision-making

In the realm of artificial intelligence, neutrosophic sets have shown promise in improving machine learning algorithms. Traditional algorithms often face challenges when dealing with ambiguous or incomplete data. By incorporating neutrosophic sets, these algorithms can better handle uncertainty, leading to better learning outcomes and more accurate predictions. For example, in natural language processing, where the meaning of words can be context-dependent and ambiguous, neutrosophic sets enable more sophisticated models that capture these subtleties more effectively.

Another important application of neutrosophic sets is in the field of medical diagnostics. Medical data is often imprecise and incomplete, making it difficult to draw definitive conclusions. Neutrosophic sets can model the degrees of truth, falsity, and indeterminacy associated with various diagnostic criteria, helping physicians make more accurate diagnoses. For example, symptoms and test results can be represented as neutrosophic sets, allowing for a more holistic view of a patient's health status.

Despite their advantages, neutrosophic sets are not without challenges. The complexity of managing three membership functions for each element can lead to computational difficulties, especially in large data sets. Furthermore, the interpretation of indeterminacy and its practical implications require further exploration and consensus within the scientific community. The development of efficient algorithms and computational methods for handling neutrosophic sets is an ongoing area of research.

Neutrosophic sets represent a significant advance in the mathematical modeling of uncertainty and indeterminacy. By integrating degrees of truth, falsity, and indeterminacy, they offer a powerful and flexible tool for a wide range of applications, from decision making and artificial intelligence to medical diagnostics. However, realizing the full potential of neutrosophic sets requires continued research into their theoretical foundations and the development of efficient computational techniques. As these efforts progress, neutrosophic sets are likely to become an increasingly important tool for addressing real-world complexities.

Neutrosophics is a new branch of philosophy that studies the origin, nature and scope of neutrosophic theories, created by Professor Florentin Smarandache. Its incorporation ensures that the uncertainty inherent in decision making is taken into account, including indeterminacies where experts will issue their judgments by evaluating linguistic rather than numerical terms, which constitutes the most natural form of measurement in humans [10,25] . Neutrosophic logic and sets, in turn, constitute a generalization of Zadeh's fuzzy logic and sets, and especially of Atanassov's intuitionistic logic, with multiple applications in the field of decision making and machine learning [10] .

The truth value in the neutrosophic set is the following [11] : Let $N = \{(T, I, F): T, I, F \subseteq [0,1]\}n$, be a neutrosophic evaluation of an application of a group of propositional formulas to N, and for each sentence p:

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

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

To facilitate practical application in real-world problems [12] , the use of Single Value Neutrosophic Sets (SVNS) was proposed, through which it is possible to use linguistic terms to obtain a greater interpretability of the results [13] . Let X be a universe of discourse, a SVNS A over X has the following form [12] :

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

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

With

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

The intervals $\boldsymbol{u_a(x), r_a(x)}$ **y** $\boldsymbol{v_a(x)}$denote the true, indeterminate and false-related memberships of x in A, respectively [10] . For convenience, a Single Valued Neutrosophic Number (SVN) is expressed as A = (a, b, c), where a, b, c ∈ [0.1] and 0 ≤ a + b + c ≤ 3 [12] .

Table 1: Linguistic terms used. Source: [13] .

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)
Average Good (AGG)	(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)

Let A = (a, b, c) be a single-valued neutrosophic number, a scoring function S is defined related to a single-valued neutrosophic value, based on the degree of belonging to truth, the degree of belonging to indeterminacy and the degree of belonging to falsehood [12] :

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

A survey is then designed for the study using the linguistic scale established in Table 1. The questions cover Ecuadorian labor legislation and are presented as follows:

- ❖ Workplace conditions: My workspace is comfortable and suited to my needs as a pregnant person.
- ❖ Flexible hours: I have flexible hours that allow me to meet my medical and wellness needs.
- ❖ Emotional support: I feel emotional support from my colleagues and superiors regarding my pregnancy.
- ❖ Professional support: My workplace offers resources or supportive policies to ensure my professional development during pregnancy.

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

❖ Workload: The workload is reasonable and fits my health status and capabilities during pregnancy.

❖ Access to Medical Facilities: I have easy access to medical facilities or assigned times for pregnancy-related medical consultations.

❖ Maternity policies: Maternity policies (maternity leave, return to work, etc.) are clear, fair and good enough.

❖ Discrimination and harassment: I feel free from discrimination and harassment at work because of my pregnancy.

❖ Information and communication: I receive all the necessary information and feel included in important communications during pregnancy.

❖ Work-life balance: I am able to maintain a healthy work-life balance during my pregnancy.

This survey covers various aspects of workplace wellbeing that may impact pregnant employees, allowing for sentiment analysis based on the scale provided. The results will help identify areas for improvement to create a more inclusive work environment and support pregnant employees.

3. Random Forest Algorithm

The discussion starts with tree-based models, as they are the fundamental building blocks of the random forest algorithm. In a tree-based model, the given dataset is recursively split into two subsets based on a specific criterion until a certain stopping point is reached. At the base of decision trees are so-called leaf nodes or leaves [13] . This involves a recursive splitting of a two-dimensional input space with axis-aligned boundaries, i.e. each split of the input space occurs in a direction parallel to an axis. The initial split was performed where $x_2 \geq a_2$. Subsequently, these two subspaces underwent a new division: The division on the left occurred where $x_1 \geq a_4$, while the correct division took place first where in $x_1 \geq a_1$, followed by a subdivision into one of its branches where $x_2 > a_3$ [14,26] .

Depending on how the partitioning and stopping criteria are set, decision trees can be designed for both classification tasks (categorical outcome, e.g. logistic regression) and regression tasks (continuous outcome). The random forest model is an ensemble tree-based learning algorithm; that is, the algorithm averages the predictions of many individual trees [14] . The individual trees are built on bootstrap samples rather than on the original sample. This is called bootstrap aggregation or simply bagging, and it reduces overfitting. The algorithm is as follows [14] .

```
for i ← 1 to B do
    Draw a bootstrap sample of size N from the training data;
    while node size != minimum node size do
        randomly select a subset of m predictor variables from total p;
        for j ← 1 to m do
            if jth predictor optimizes splitting criterion then
                split internal node into two child nodes;
                break;
            end
        end
    end
end
return the ensemble tree of all B subtrees generated in the outer for loop;
```

Figure 1. Random forest algorithm.

4. Processing in Orange and results

Several individuals from the groups of interest for the research in the Santo Domingo canton of Ecuador are selected as a study sample through completely random sampling, which are composed as shown in Table 2:

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

Table 2: Sample distribution for the study. Source: own elaboration.

Cluster	Amount	Description
First-time pregnant women (FTPW).	50	Women who work and become pregnant for the first time.
Women getting pregnant for the second time (WMC).	50	Women who become pregnant for the second time.
Women with more than two children (WCT).	50	Women who have been pregnant and have more than two children.
Women who have had health problems during pregnancy while working (WHHH).	50	Women who have had health problems while working.
Women without access to labor protection (WDNAL).	50	Women who do not have access to labor protection.
Women who have lost their pregnancies due to lack of job security (WPPJS)	50	Women who have lost their pregnancy due to lack of job security.
Total (sample number) 300 respondents		

The workflow followed in Orange version 3.36.2 for sentiment analysis from the 300 reviews using the Random Forest tool is presented below. This model is chosen for its ability to effectively capture the complex interaction of several factors influencing the health of pregnant women in work environments and highlights its potential utility in targeting specific interventions and preventative strategies to mitigate health risks and promote wellbeing among this vulnerable group. In this decision tree, respondents are classified based on the variables defined in Table 2. Each terminal node (leaf of the tree) where no further splits occur represents a homogeneous group with respect to some occupational wellbeing measure that has been assessed.

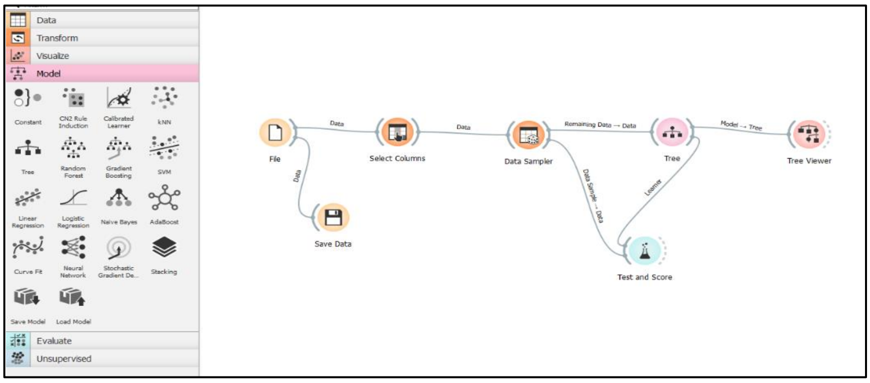

Figure 2. Workflow at Orange. Source: Own elaboration.

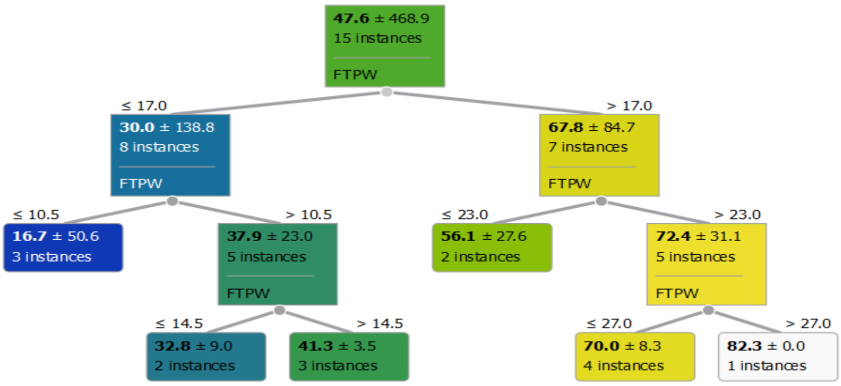

Figure 3. Random forest analysis model.
Source: Own elaboration.

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

As can be seen in Figure 3, the neutrosophic random forest model developed to analyze occupational health risks of pregnant women demonstrates a solid level of accuracy in its predictions, revealing a strong alignment between the model results and the actual health outcomes observed in this specific population. The interpretation of the results is presented below:

❖ The FTPW category is an important variable for classifying responses. Instances are divided according to the thresholds of other variables, indicating significant differences within this group. The sheet with the value of 47.6 ± 468.9 with 15 instances suggests high variability in perceived occupational well-being.

❖ Numerical thresholds (≤ 17.0, > 10.5) are associated with quantitative responses to survey questions. Each split attempts to maximize homogeneity within branches and heterogeneity between branches, while wide standard deviations on some sheets indicate considerable variability in occupational well-being experiences within those groups. This may be due to individual differences in perception or a wide range of working conditions among respondents. Some of the sheets in the model have very few instances, indicating a specific or uncommon situation. These instances represent extreme cases or very particular conditions within the study group.

❖ Nodes on the left indicate lower values for this variable, and those on the right have higher values. On the far left, there are three cases with an average value of 16.7 ± 50.6, while on the far right, there is one case with a value of 82.3 and no variation (± 0.0), suggesting a very specific measure or a unique case.

❖ The values reveal significant diversity in the sample, reflected in the wide standard deviations.

From this stage it can be concluded that several factors influence this phenomenon:

❖ The physical demands of the job,

❖ Exposure to harmful substances,

❖ Work stress,

❖ Lack of support from employers and

❖ Access to adaptations such as seating or rest areas.

These factors have a significant impact on the well-being of pregnant women and their babies, highlighting the importance of prioritising safety and support in the workplace.

The performance metrics of the applied Random Forest model and its validation are then executed. The metrics included, as illustrated in Table 3, are:

a) Root Mean Square Error (RMSE),
b) Mean absolute error (MAE), and
c) Coefficient of determination (R2).

Table 3: Statistics of the analysis of the Random Forest model. Source: Own elaboration.

Random forest model	RMSE	MAE	R2
Model obtained	4.699	3.714	0.953
Validated model	5,408	4.416	0.93 5

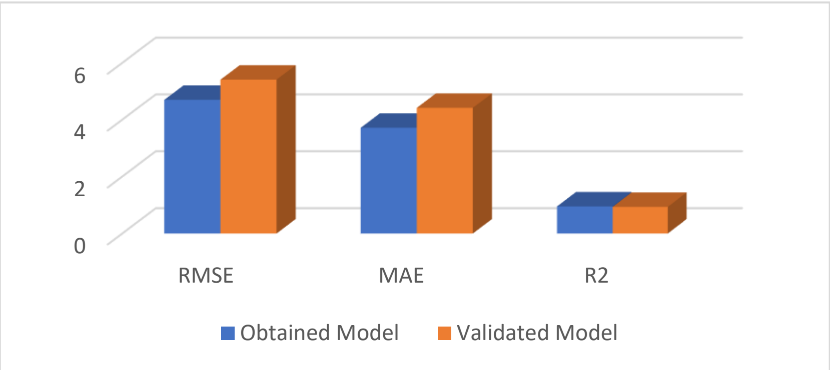

Figure 4. Statistics from the analysis of the Random Forest model.
Source: Own elaboration.

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

RMSE measures the deviation of the values predicted by the model from the actual values. The lower the RMSE value, the better, as it indicates that the model predictions are closer to the actual values. Therefore, the value of the obtained model and the validated model means that there is a slightly worse performance on data not seen during training, which is normal.

The MAE yields values of 3.714 for the obtained model and 4.416 for the validated model. Similar to the RMSE, it measures the average of the absolute differences between the predictions and the actual values. It is less sensitive to outliers than the RMSE. Again, a lower value is better and increasing the validation set indicates slightly worse performance with new data.

The determination (R^2) shows values of (0.953 for the obtained model, and 0.935 for the validated model. This coefficient varies between 0 and 1, where a higher value indicates a better fit of the model to the data. An R^2 of 0.953 suggests that the model explains 95.3% of the variability in the training data, while 93.5% in the validation set indicates a slightly lower but still excellent predictive capacity on unseen data.

From this part, it can be concluded that the model used has an excellent performance on the data set with which it was trained and maintains a reliable performance on the validation set. The metrics indicate that the model is accurate and has a high capacity to explain the variability of the target data.

Finally, it is decided to check the normal distribution of the data as shown in Figure 5, for the distribution of the survey scores for each group. It is worth noting that the histograms use kernel density estimates to smooth the distributions, and that the frequency is a function of the number of bins selected for the histogram (10 bins).

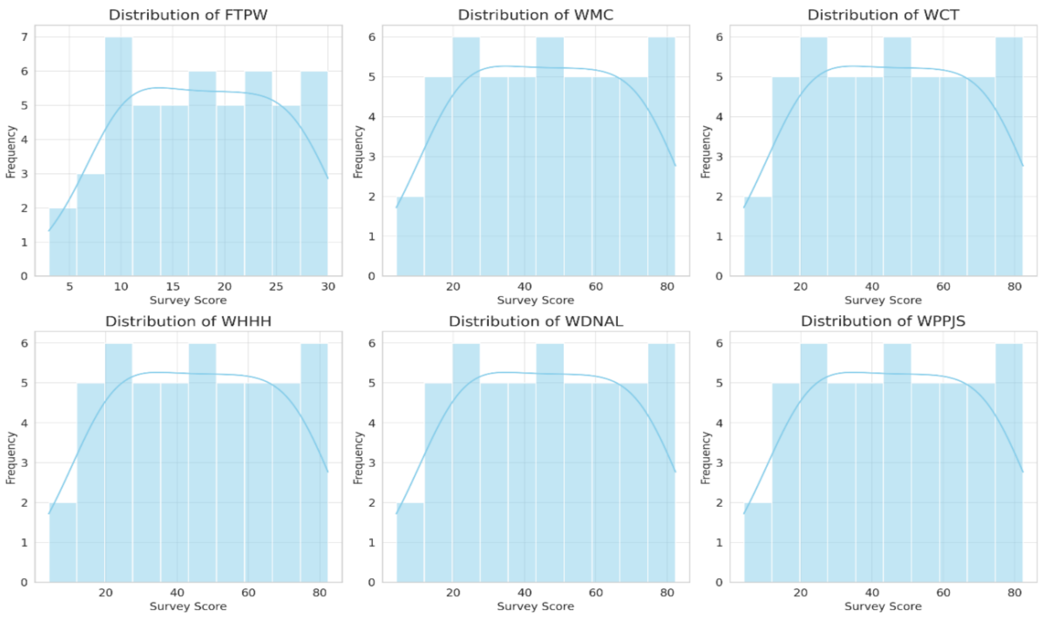

Figure 5. Distribution of survey scores for each group. Source: Own elaboration.

Where the FTPW category is distributed more evenly across the range, with a slight concentration around the mean. This indicates variability in perceptions of job well-being among first-time pregnant women. On the other hand, the rest of the categories show identical distributions, which is indicative that the data does not vary between these groups. The distribution is normal and centered around the mean, with scores ranging from low to high values. It can be observed that there is an overlap of the distributions.

For this reason, it is concluded that the impacts that pregnant women receive from the work environment do not express a distinction based on belonging to one group or another. According to the data analyzed, there are no significant differences in the scores of job well-being between women who are pregnant for the second time, those who have more than two children, those who have had health problems during pregnancy, those who do not have access to labor protection, and those who have lost pregnancies due to lack of job security. Therefore, all have suffered in some way the consequences of job insecurity regardless of their condition.

3. Results and discussion

The use of a scale with ratings ranging from “Extremely good” to “Extremely bad” was particularly useful in this sentiment analysis study of pregnant women’s occupational well-being, for several reasons:

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

Gradation of responses: Allows participants to express their perceptions in a more nuanced way, capturing the complexity and degrees of satisfaction or dissatisfaction they may experience.

Quantitative analysis of qualitative data: transforms qualitative responses into statistically analysable quantitative data. This allowed the use of advanced data analysis tools, such as Random Forest, to identify patterns and trends.

Comparability: Facilitates comparison between different groups or categories within the study, since all participants evaluate their experiences on the same scale.

Sensitivity: The variety in the scale helps to identify minor changes in perception that might not be captured with less graduated scales.

Balance: Provides a balanced range of positive and negative responses, which is important to avoid response bias.

Identification of Extremes: Allows you to identify extreme cases of satisfaction or dissatisfaction that may require special attention.

Ease of interpretation: For participants, these labels tend to be easy to understand and apply to their own experiences.

Improving interventions: Detailed data informs organizations about specific areas that require improvement to support pregnant women in the workplace.

Personalization of actions: Allows decision-makers to design more personalized and effective interventions, as they better understand the spectrum of occupational well-being experiences.

The data analyzed reveal that occupational health of pregnant women is a crucial aspect to ensure the well-being of both the pregnant mother and the developing fetus, as exposure to certain hazardous substances or stressful working conditions has detrimental effects on their health. Therefore, employers should provide a safe and conducive work environment, implement appropriate workplace accommodations, and offer regular health assessments to pregnant employees to minimize potential risks and promote a healthy pregnancy [15,21].

It is imperative to consider pregnant women from a unique perspective to support their professional development without any negative impact on their career growth and well-being. It is necessary to recognize the specific needs and challenges they may face in the workplace and implement the necessary measures and accommodations to ensure their continued success [16]. By taking a more inclusive and supportive approach towards employees in these conditions, organizations can foster a more positive and inclusive work environment and ultimately benefit overall productivity and workforce morale [17].

The impact of having more than two children on occupational health is a complex and multifaceted issue that deserves thorough examination from several perspectives, such as the physical, mental and emotional well-being of parents, potential pressure on work-life balance, the financial implications of maintaining a larger family, and the availability of social support systems to help mitigate the challenges associated with balancing work and family responsibilities [18, 19, 20].

4. Conclusions

The neutrosophic model examines occupational health outcomes of pregnant women, developed through a random forest algorithm, which provides insights into the interactions between work environments and maternal well-being during pregnancy. The model findings reveal a strong determination of the data variation explained by values close to 1 or 100%, and its validation exhibits the same behavior. When analyzing the error that occurs when determining the possible risk factors and protective factors that influence the health and safety of pregnant women in the workplace, it is observed that the values are within the ranges in which the variables were measured. The FTPW category is more evenly distributed, indicating variability in perceptions of occupational well-being among first-time pregnant women. Thus, the neutrosophic model obtained highlights the importance of specific interventions and policies to support the well-being of pregnant women and can be used in research under the same conditions. However, little variation is perceived between the experiences of the impacts suffered by all groups surveyed. They all report having had unpleasant experiences in workplaces that did not take their status into account, violating the provisions of labor legislation and constitutional rights.

Funding: “This research did not receive external funding”

Conflicts of interest: “The authors declare that they have no conflict of interest.”

DOI: https://doi.org/10.54216/FPA.160214
Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

References

[1] C. Cai, B. Vandermeer, R. Khurana, K. Nerenberg, R. Featherstone, R., Sebastianski, M., and M. Davenport, "The impact of occupational activities during pregnancy on pregnancy outcomes : a systematic review and meta-analysis," American Journal of Obstetrics and Gynecology , 222 (3), 224-238, 2020.

[2] P. Cheng, M. Pantel, J. Smith, G. Dumas, A. Leger, A. Plamondon, J. Tranmer, J. E, "Back pain in working pregnant women: identification of associated occupational factors", Applied Ergonomics , 40 (3), 419-423, 2009 .

[3] W. Pick, M. Ross and Y. Dada, "The reproductive and occupational health of female street vendors in Johannesburg, South Africa" Social science & medicine, 54 (2), 193-204.

[4] H. Skröder, H. Pettersson, F. Norlén, P. Gustavsson, L. Rylander, M. Albin, and J. Selander, "Occupational exposure to whole-body vibration and birth outcomes: a nationwide cohort study of Swedish women," Science of the Total Environment, 751, 141476, 2020.

[5] S. Vigoureux, E. Lorthe, B. Blondel, V. Ringa and M. Saurel-Cubizolles, "Occupational status of women during pregnancy and preventive behavior and health outcomes between 1998 and 2016 in France", Journal of Gynecology Obstetrics and Human Reproduction , 52 (3), 102545, 2023.

[6] J. Selander, L. Rylander, M. Albin, U. Rosenhall, M. Lewné and P. Gustavsson "Continuous exposure to occupational noise during pregnancy was associated with reduced birth weight in a nationwide cohort study of Swedish women", Science of the total environment , 651 , 1137–1143, 2019.

[7] A. Handal, L. Hund, M. Páez, S. Bear, C. Greenberg, R. Fenske and D. Barr, "Characterization of pesticide exposure in a sample of pregnant women in Ecuador. Archives of Environmental Contamination and Toxicology, 70, 627-639, 2016.

[8] M. Sebastián, B. Armstrong and C. Stephens, C, "Pregnancy outcomes among women living in proximity to oil fields in the Amazon basin of Ecuador", International Journal of Occupational and Environmental Health , 8 (4), 312-319, 2002.

[9] I. González, M. Barragán, D. Domínguez and A. Falcón, "Neutrosophic sentiment analysis in in-depth interview transcripts for action research", Neutrosophic Sets and Systems, 44, 82-89, 2021.

[10] Q. Li, Y. Ma, F. Smarandache, and S. Zhu, "Single-valued neutrosophic clustering algorithm based on Tsallis entropy maximization," Axioms, 7 (3), 57, 2018.

[11] Jain, Amita, Basanti Pal Nandi, Charu Gupta, and Devendra KumarTayal. "A hybrid framework based on PSO and neutrosophic set for document level sentiment analysis." In Recent Advances in Intelligent Information Systems and Applied Mathematics, pp. 372-379. Springer International Publishing, 2020

[12] Kandasamy, Ilanthenral, W. B. Vasantha, Niharika Mathur, Mayank Bisht, and Florentin Smarandache. "Sentiment analysis of the# MeToo movement using neutrosophy: Application of single-valued neutrosophic sets." In Optimization Theory Based on Neutrosophic and Plithogenic Sets, pp. 117-135. Academic Press, 2020

[13] R. Şahin and M. Yiğider, "A TOPSIS-based multi-criteria neutrosophic group decision making method for supplier selection," arXiv preprint arXiv: 1412.5077. , 2014.

[14] H. Valecha, A. Varma, I. Khare, A. Sachdeva, and M. Goyal, "Consumer behavior prediction using random forest algorithm." In 2018 IEEE Uttar Pradesh Section 5th International Conference on Electrical, Electronics and Computer Engineering (UPCON) (pp. 1–6). IEEE, 2018.

[15] A. Kulkarni and B. Lowe, "Random forest algorithm for land cover classification", 2016.

[16] L. Robson, J. Clarke, K. Cullen, A. Bielecky, C. Severin, P. Bigelow, Q. Mahood, "The effectiveness of occupational health and safety management system interventions: a systematic review", Safety science , 45 (3), 329-353, 2007.

[17] F. Samarandache, "Introduction to Neutrosophic Statistics", Sitech & Education Publishing 2014.

[18] I. Mohammadfam, M. Kamalinia, M. Momeni, R. Golmohammadi, Y. Hamidi and A. Soltanian, "Quality assessment of occupational health and safety management systems based on key performance indicators in certified organizations," Occupational Safety and Health , 8 (2), 156-161, 2017.

[19] S. Yoon, H. Lin, G. Chen, S. Yi, J. Choi, and Z. Rui, "Effect of occupational health and safety management system on occupational accident rate and differences in knowledge of occupational health and safety management system among managers in the construction industry of South Korea," Occupational Safety and Health , 4 (4), 201-209, 2013.

[20] Kandasamy, Ilanthenral, W. B. Vasantha, Jagan M. Obbineni, and Florentin Smarandache. "Sentiment analysis of tweets using refined neutrosophic sets." Computers in Industry 115 (2020): 103180

[21] Shayaa, Shahid, Noor Ismawati Jaafar, Shamshul Bahri, Ainin Sulaiman, Phoong Seuk Wai, Yeong Wai Chung, Arsalan Zahid Piprani, and Mohammed Ali Al-Garadi. "Sentiment analysis of big data: methods, applications, and open challenges." Ieee Access 6 (2018): 37807-37827.

DOI: https://doi.org/10.54216/FPA.160214

Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024

[22] Abirami, A. M., and V. Gayathri. "A survey on sentiment analysis methods and approach." In 2016 Eighth International Conference on Advanced Computing (ICoAC), pp. 72-76. IEEE, 2017.

[23] Mohamed, Lamia. , Soliman, Gawaher. , Nasser, Abdel. A Survey on Sentiment Analysis Algorithms and Techniques for Arabic Textual Data. Fusion: Practice and Applications, vol. , no. , 2020, pp. 74-87. DOI: https://doi.org/10.54216/FPA.020205

[24] I., Mohammed. Single Valued Neutrosophic Sets with Optimal Support Vector Machine for Sentiment Analysis. International Journal of Neutrosophic Science, vol. , no. , 2022, pp. 227-237. DOI: https://doi.org/10.54216/IJNS.1803020

[25] Smarandache, F., Quiroz-Martínez, M.A., Ricardo, J.E., Hernández, N.B., & Vázquez, M.Y.L. ¨Application of neutrosophic compensations for digital image processing¨. Infinite Studio, 2020.

[26] Ricardo, JE, Fernández, AJ, & Vázquez, MY ¨Compensatory fuzzy logic with single-valued neutrosophic numbers in the analysis of university strategic management¨. International Journal of Neutrosophic Sciences (IJNS), vol 18 num 4, 2022.

DOI: https://doi.org/10.54216/FPA.160214

Received: December 30, 2023 Revised: March 15, 2024 Accepted: June 29, 2024