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Neutrosophic DEMATEL to Prioritize Risk Factors in Teenage Pregnancy

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Abstract: Care during pregnancy is a task of high importance for the health system. In Ecuador, special importance has been given to pregnant teenagers. However, there are various factors that influence pregnancy and in many cases it is not possible to prioritize their care. This research aims to develop a model to prioritize the factors that influence teenage pregnancy. The model operates using the neutrosophic DEMATEL method for the study of cause and effect in complex situations. The method implements as a principle the modeling of neutrality using neutrosophic numbers and allows evaluation through the use of linguistic terms, which is a natural form of evaluation for humans.

Keywords: DEMATEL; Neutrosophic Numbers; teenage pregnancy; risk factors.

1. Introduction

Starting to have sexual activity at an early age often leads to early pregnancies. Teenage pregnancy has been increasing in recent years [1]. Studies have registered that the maternal mortality rate in Ecuador continues to be high, approximately between 500 and 700 women die each year due to complications related to pregnancy [2]. Avoiding perinatal complications associated with teenage pregnancy constitutes a challenge for the Public Health system [3, 4]. Recent research has identified aspects related to teenage pregnancy that range from the psychological to the social [5, 6].

For the gestation process in adolescents, the influence of a set of critical factors determine the success of pregnancy [7]. Quantifying compliance with these factors would allow continuous evaluation and recommendation to the pregnant woman. Processes of this nature have been covered by science using Artificial Intelligence techniques to model uncertainty[8]. A critical factor is represented by a degree of compliance, a degree of neutrality, and a degree of uncertainty. In this context, the representation of the fulfillment of critical factors can be modeled using neutrosophic numbers[9].

This research aims to develop a model for the prioritization of risk factors in adolescent pregnancy. The model operates using the DEMATEL method that includes the calculation with neutrosophic sets [10-12]. Indeterminacy is part of daily life, which is why the neutrosophic DEMATEL allows the study of complex cause-effect relationships, which includes indeterminacy and the use of linguistic terms, which is the natural form of communication for human beings.

This article is structured in several sections. In the Materials and Methods section, we describe the structure of the proposed model from the implementation of a neutrosophic DEMATEL. Next, the Results section is developed; in which the proposed method is implemented in a case study, thereby demonstrating the applicability of the method proposed in the previous section. Finally, the Conclusions and References are presented.

2. Preliminaries

This section describes the main definitions that make up the theoretical references on the object of study; such as the neutrosophic sets. We also make a description of the Neutrosophic Single Value Sets[13, 14] and the Neutrosophic Triangular Single Value Numbers[15, 16].

2.1 Definitions

Definition 1. Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x): X \rightarrow]^-0, 1^+[$, which satisfy the condition $-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denotes the membership functions to true, indeterminate and false of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$ (see [17],[18]).

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

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

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 $v_A(x)$ denotes the membership functions of true, indeterminate and false of x in A, respectively. For convenience, a *Single Value Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), where a, b, c ∈ [0,1] and satisfies $0 \leq a + b + c \leq 3$ (see [17],[19]).

Definition 3. A *Triangular Single Value Neutrosophic Number* (TSVNN), which is denoted by: $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a CN over $\mathbb{R}$, whose membership functions of truthfulness, indeterminacy, and falsehood are defined below (see [17],[20]):

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

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

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

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

Definition 4. Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two TSVNN and λ is any non-zero real number. Then the following operations are defined:

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
Inversion: $\tilde{a}^{-1} = \langle (a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, donde$a_1, a_2, a_3 \neq 0$.

Product by a scalar:

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

Division of two TSVNN:

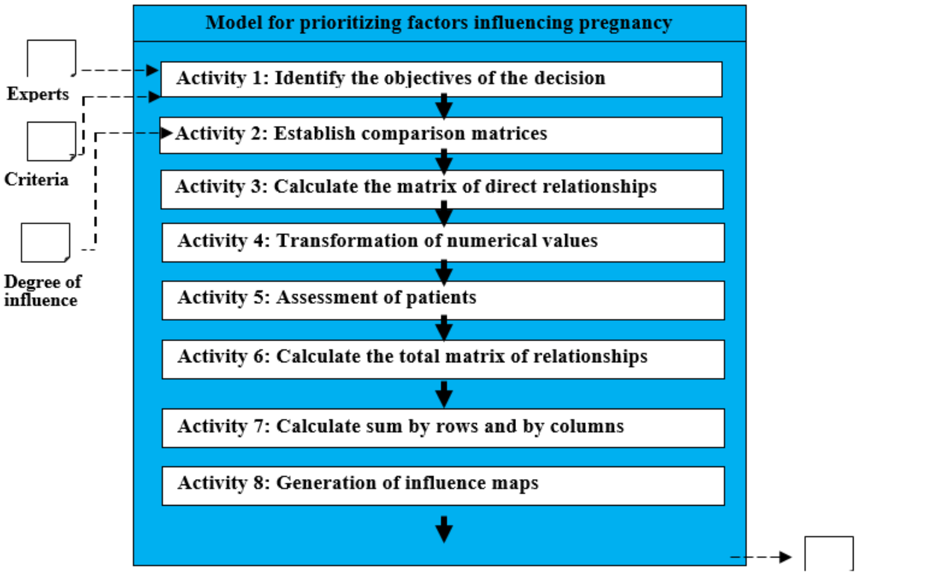

Figure 1: Structure of the model.

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

Multiplication of two TSVNN:

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

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

A t-norm is an operator T: $[0, 1]^2 \rightarrow [0, 1]$ such that it satisfies the following axioms for all a, b, c and d in [0, 1]:

1. T(0,0) = 0, T(a,1) = a, (Boundary conditions),
2. T(a,b) ≤ T(c,d) if a ≤ c and b ≤ d (Monotony)
3. T(a,b) = T(b,a) (Commutativity)
4. T(a,T(b,c)) = T(T(a,b),c) (Associativity)

A t-conorm is an operator S: $[0, 1]^2 \rightarrow [0, 1]$ such that it satisfies the following axioms for all a, b, c and d in [0, 1]:

1. S(1,1) = 1, S(a,0) = a, (Boundary conditions),
2. S(a,b) ≤ S(c,d) si a ≤ c y b ≤ d (Monotony)
3. S(a,b) = S(b,a) (Commutativity)
4. S(a,S(b,c)) = S(S(a,b),c) (Associativity)

To convert TSVNN into real numerical values, the following formulas are applied, known as Score Index and Precision Index, respectively:

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

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (6)$$

3. Materials and Methods

The proposed model is structured in a workflow to prioritize the factors that influence teenage pregnancy. It is based on the DEMATEL Neutrosophic method[21], which will adapt to triangular and non-trapezoidal neutrosophic numbers [17]. Figure 1 shows a general diagram of the operation of the proposed model.

Activity 1. Identify the objectives of the decision: compilation of the relevant information present in the problem. It consists of:

1. Selection of experts and decision-makers who have experience in the field under study. Let us denote the experts by $E = \{E_1, E_2,\dots, E_k\}$ ($k\geq 1$).
2. Identify the relevant criteria that characterize the problem. They will be denoted by $C = \{C_1, C_2,\dots,C_m\}$ ($m\geq 2$).

Activity 2. Establish comparison matrices: forming the comparison matrices by pairs of relevant criteria. The experts emit the k comparison matrices by pairs of criteria, with order m×m. For this, each expert must give a value to each criterion compared to another, in the form of TSVNN, evaluating according to the values shown in Table 1. The value of the element X_{ij} measures how much the factor F_i directly influences the factor F_j, where $X_{ij} = \tilde{0}$ if i = j. Table 1 shows the evaluation scales to measure the degree of influence between the factors.

Linguistic Term	Corresponding Unique Triangular Neutral-To-Value Number
No influence	$\tilde{0} = \langle(0,0,0); 0{,}50;\ 0{,}50;\ 0{,}50\rangle$
Low influence	$\tilde{1} = \langle(0,1,2); 0{,}30;\ 0{,}75;\ 0{,}70\rangle$
Medium influence	$\tilde{2} = \langle(1,2,3); 0{,}80;\ 0{,}15;\ 0{,}20\rangle$
High influence	$\tilde{3} = \langle(2,3,4); 0{,}90;\ 0{,}10;\ 0{,}10\rangle$
Very high influence	$\tilde{4} = \langle(4,4,4); 1{,}00;\ 0{,}00;\ 0{,}00\rangle$

Table 1. Linguistic terms that describe the relationship between two factors or criteria and their equivalent in TSVNN.

Activity 3. Calculate the matrix of direct relationships as the sum of the k comparison matrices and then divide by k, that is, the arithmetic mean of the previous matrices, where the operations between TSVNN of sum and product by the scalar 1/k. This matrix is called $A = (A_{ij})_{mxm}$.

Activity 4. Transformation of numerical values using the formula of Equations 5 or 6.

Activity 5. A is normalized by dividing it by $s = \max\left(\max_{1\leq i\leq m}\sum_{j=1}^{m} a_{ij}, \max_{1\leq j\leq m}\sum_{i=1}^{m} a_{ij}\right)$, it will be called A_N.

Activity 6. Calculate the total matrix of relationships using the following formula:

$$T = A_N(I - A_N)^{-1} \quad (7)$$

Where I is the identity matrix of order m, the superscript -1 means inverse.

Activity 7. Calculate sum by rows and by columns of $T = (T_{ij})_{mxm}$. The sum by rows is denoted by D and the sum by columns is denoted by R. That is, $D = \left[\sum_{i=1}^{m} T_{ij}\right]_{1xm}$ y $R = \left[\sum_{j=1}^{m} T_{ij}\right]'_{mx1}$. Where the apostrophe indicates the matrix transposition.

Activity 8. Generation of relationship influence maps. For this, we calculate (R+D) called "Prominence" that measures the degree of central role that the factor or criterion plays within the system. While (R-D) is called "Ratio" and represents the effect that the factor or criterion produces in the system.

1. If rj-cj>0 the factor or criterion Cj is located in the group of causes,
2. If r_j-c_j<0 the factor or criterion C_j is located in the group of effects.

The pairs (R+D, R-D) can be represented graphically to give decision-makers a graphic idea about the system.

4. Results

This section presents the results of this research. It was carried out using data obtained from pregnant teenagers admitted at the Gynecology and Obstetrics service of Alfredo Noboa Montenegro Hospital in Guaranda, Ecuador. The study followed the sequence described in the model.

Three independent subject experts are selected, who issue their evaluations on the risk factors influencing adolescent pregnancy. The factors determined were those referred in [22] and that we reproduce below:

F_1: Individual factors.
F_2: Psychological factors.
F_3: Family factors.
F_4: Social factors.
F_5: Cultural factors.

Tables 2, 3, 4 show the comparison matrices by pairs of criteria according to the evaluations issued by Experts 1, 2, 3 respectively. Table 5 contains the results of the aggregation using the arithmetic mean of the TSVNN shown in Tables 2, 3, 4. *Min* was used as t-norm and *max* as t-conorm.

All the calculations carried out in this article were made with Octave 4.2.1, which is a free software that uses the MATLAB language, and facilitates the calculation with matrices, see [17].

Factor	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**
F_1	$\tilde{0}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$
F_2	$\tilde{4}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$
F_3	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$
F_4	$\tilde{2}$	$\tilde{3}$	$\tilde{2}$	$\tilde{0}$	$\tilde{4}$
F_5	$\tilde{3}$	$\tilde{1}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$

Table 2. Evaluation carried out by Expert 1 by pairs of factors on the degree of direct influence of the row factor on the column factor.

Factor	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**
F_1	$\tilde{0}$	$\tilde{1}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$
F_2	$\tilde{2}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$
F_3	$\tilde{2}$	$\tilde{3}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$
F_4	$\tilde{\tilde{2}}$	$\tilde{3}$	$\tilde{2}$	$\tilde{0}$	$\tilde{3}$
F_5	$\tilde{3}$	$\tilde{1}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$

Table 3. Evaluation carried out by Expert 2 by pairs of factors on the degree of direct influence of the row factor on the column factor.

Factor	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**
F_1	$\tilde{0}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$
F_2	$\tilde{3}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$
F_3	$\tilde{4}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$
F_4	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$	$\tilde{0}$	$\tilde{4}$
F_5	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	$\tilde{4}$	$\tilde{0}$

Table 4. Evaluation carried out by Expert 3 by pairs of factors on the degree of direct influence of the row factor on the column factor.

Factor	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**
F_1	$\tilde{0}$	$\tilde{1}$	$\tilde{3}$	0	$\tilde{2}$
F_2	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$
F_3	$\tilde{2}$	$\tilde{3}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$
F_4	$\tilde{2}$	$\tilde{3}$	$\tilde{2}$	$\tilde{0}$	$\tilde{3}$
F_5	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$

Table 5. Arithmetic mean of factor pairwise expert evaluations of the degree of direct influence of the row factor on the column factor.

Table 6. contains the total matrix of relations T, calculated after successively finding the elements of the matrix in Table 5, the precision index of the elements with Equation 6. It is then normalized as indicated in activity 5 of the model, and finally Equation 7 is applied.

Factor	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**
F_1	0	0,15625	0,34375	0	0,21875
F_2	0,28125	0	0,3125	0	0
F_3	0,25	0,34375	0	0,15625	0,125
F_4	0,21875	0,28125	0,21875	0	0,34375

F5	0,25	0,15625	0,21875	0,375	0

Table 6. Matrix of total relations.

From the matrix of total relations we have that D = [1,0000; 0,9375;1,09375;0,53125;0,6875; 4,2500] and R = [0,71875; 0,59375; 0,8750; 1,0625; 1], see activity 7 of the model.

The vector R+D = [1,718751,53125 1,96875 1,59375 1,6875] , while R-D = [-0,28125 -0,34375 -0,21875 0,53125 0,3125]. See also Figure 2, where the pairs (R+D, R-D) are plotted.

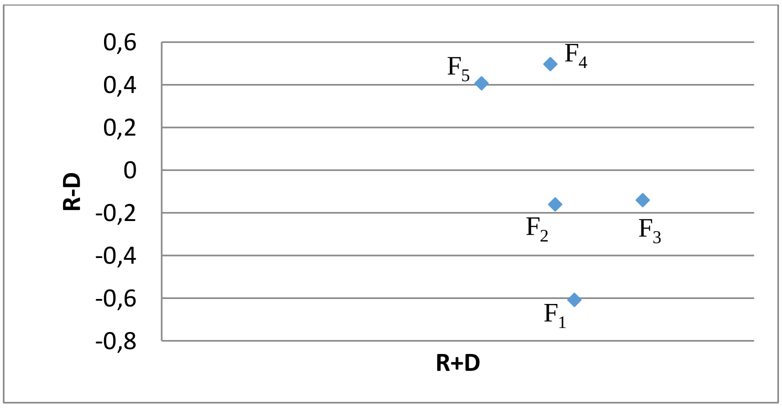

Figure 2. Graphical representation of the pairs (R + D, R-D). Each pair has a legend associated with the factor it represents.

From Figure 2 we can notice that factors 4 and 5 are the main cause of the other factors.

Conclusions

This investigation implemented a model to prioritize the factors that influence teenage pregnancy. The model based its inference process on the method known as DEMATEL neutrosophic for the study of cause and effect. The use of neutrosophic sets allowed the inclusion of uncertainty, indeterminacy and the use of linguistic terms. The evaluation of three experts was reviewed and the most important factors for the case under study were identified. As a result of the research, a case study was implemented based on data obtained from pregnant adolescents admitted at the Gynecology and Obstetrics service of Alfredo Noboa Montenegro Hospital in Guaranda, Ecuador, from which it was possible to demonstrate the applicability of the presented proposal.

References

1. Mendoza Tascón, L.A., D.I. Claros Benítez, and C.B. Peñaranda Ospina, Actividad sexual temprana y embarazo en la adolescencia: estado del arte. Revista chilena de obstetricia y ginecología, 2016. 81(3): p. 243-253.
2. Chiriboga Dorado, A., Causas y factores de riesgo que conllevan a presentar hemorragias postparto en pacientes atendidas en el Hospital Enrique C. Sotomayor de septiembre 2012 a febrero 2013. 2013, Universidad de Guayaquil. Facultad de Ciencias Médicas. Escuela de Obstetricia.
3. Velasteguí Egüez, J.E., M.I. Hernández Navarro, J.J. Real Cotto, A.J. Roby Arias, H.J. Alvarado Franco, and A.J. Haro Velastegui, Complicaciones perinatales asociadas al embarazo en adolescentes de Atacames. Revista Cubana de Medicina General Integral, 2018. 34(1): p. 37-44.
4. Espinosa, C.S., T.M. Plancarte, E.O. Mendoza, and A.S. Campos, El embarazo en adolescentes, un verdadero problema de salud pública en México. Journal of Negative and No Positive Results, 2019. 4(3): p. 304-314.
5. Muñiz, G.R.Á.A., M.L.O. Alcívar, J.A.Q. Soledispa, and Y.J.G. Tomalá, Aspectos psicosociales en adolescentes embarazadas. RECIAMUC, 2019. 3(3): p. 1467-1485.
6. Mariscal, E.M.A., A.V.G. Puente, L.L.O. Tobar, and J.A.M. Calderón, Causas relacionadas con el embarazo precoz en adolescentes del canton Babahoyo provincia de Los Rios, Ecuador. Ciencia y Educación (ISSN: 2707-3378), 2020. 1(3): p. 62-72.
7. Carvajal Barona, R., H.L. Valencia Oliveros, and R.M. Rodríguez Amaya, Factores asociados al embarazo en adolescentes de 13 a 19 años en el municipio de Buenaventura, Colombia. Revista de la Universidad Industrial de Santander. Salud, 2017. 49(2): p. 290-300.
8. Guaman Chacha, K.A., E.H. Ramos, C.O. Dias, and T.S. Coba Toledo, Neutrosophic model for the analysis of administrative offences on sexual abuse in the ecuadorian educational system. Neutrosophic Sets and Systems, 2019. 26(1): p. 21.
9. Saleh Al-Subhi, S.H., I.P. Pupo, R.G. Vacacela, and P.Y. Pinero Perez, A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections: Application in Project Management. Neutrosophic Sets and Systems, 2018. 22(1): p. 6.
10. Si, S.-L., X.-Y. You, H.-C. Liu, and P. Zhang, DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications Mathematical Problems in Engineering. 2018, Volume.

11. Smarandache, F., About Nonstandard Neutrosophic Logic (Answers to Imamura's "Note on the Definition of Neutrosophic Logic"). 2019: Infinite Study.
12. Kandasamy, I., W. Vasantha, J.M. Obbineni, and F. Smarandache, Sentiment analysis of tweets using refined neutrosophic sets. Computers in Industry, 2020. 115: p. 103180.
13. Elhassouny, A., S. Idbrahim, and F. Smarandache, Machine learning in Neutrosophic Environment: A Survey. Neutrosophic Sets and Systems, 2019. 28(1): p. 7.
14. Pramanik, S., R. Mallick, and A. Dasgupta, Contributions of Selected Indian Researchers to Multi Attribute Decision Making in Neutrosophic Environment: An Overview. Neutrosophic Sets and Systems. 2018: p. 109.
15. Alava, M.V., S.P. Delgado Figueroa, H.M. Blum Alcivar, and M.Y. Leyva Vazquez, Single valued neutrosophic numbers and analytic hierarchy process for project selection. Neutrosophic Sets and Systems, 2018. 21(1): p. 13.
16. Smarandache, F., M.A. Quiroz-Martínez, J.E. Ricardo, and N. Batista, APPLICATION OF NEUTROSOPHIC OFFSETS FOR DIGITAL IMAGE PROCESSING. Investigación Operacional, 2020. 41: p. 603-610.
17. Vázquez, M.L. and F. Smarandache, Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre. 2018: Infinite Study.
18. Smarandache, F., J.E. Ricardo, E.G. Caballero, M.Y.L. Vasquez, and N.B. Hernández, Delphi method for evaluating scientific research proposals in a neutrosophic environment. Neutrosophic Sets and Systems, 2020: p. 204.
19. Ricardo, J.E., M.L. Poma, A.A. Pazmiño, A.A. Navarro, L.M. Estévez, and N.B. Hernandez, Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. Neutrosophic Sets & Systems, 2019. 26.
20. Batista Hernández, N. and J. Estupiñán Ricardo, Gestion empresarial y posmodernidad: Infinite Study. 2018.
21. Nagarajan, D., M. Lathamaheswari, S. Broumi, and J. Kavikumar, Blockchain Single and Interval Valued Neutrosophic Graphs. Neutrosophic Sets and Systems, 2019: p. 23.
22. Arguello Caiza, K.J., incidencia y factores de riesgo del embarazo adolescente en el servicio de ginecología y obstetricia del hospital Alfredo Noboa Montenegro, Enero-Diciembre 2018. 2019.

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