Neutrosophic Sets and Systems {Special Issue: Neutrosophic Advancements And Their Impact on Research in Latin America}, Vol. 62, 2023

University of New Mexico

Neutrosophic Evaluation of Healthcare System Resilience

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Abstract. Currently, the resilience of the healthcare system in Ecuador is at the forefront of attention due to the need to address crises such as pandemics, natural disasters, and economic crises. Therefore, this study has focused on evaluating six proposed programs aimed at enhancing the resilience of the Ecuadorian healthcare system and selecting the best proposal to protect the health and well-being of communities in Ecuador. The evaluated programs aim to enhance the system's capacity for adaptation, preparedness, and response to crises and disruptions. Due to existing indeterminacies in assessing the resilience of the healthcare system for each program, the application of the neutrosophic VIKOR method is necessary. The results emphasize the need to diversify approaches to strengthen resilience, including the formation of multidisciplinary teams and the enhancement of Ecuador's public health response capacity. In conclusion, the modeling of the neutrosophic method has been essential for assigning weights and evaluating the proposed programs. Furthermore, strengthening the resilience of the healthcare system in Ecuador is crucial to ensure effective and equitable medical care during times of crises and future challenges.

Keywords: Resilience, neutrosophy, health crises, healthcare system.

1 Introduction

The resilience of the health system has become a topic of increasing relevance today, especially in the Ecuadorian context. In recent years, Ecuador has faced significant challenges, such as pandemics, natural disasters, and economic crises [1]. The ability of a health system to adapt, prepare, and respond effectively to crises and disruptions has become a critical indicator of its quality and efficiency [2].

After Covid 19, evaluating the resilience of the health system has become a fundamental objective to understand its capabilities and weaknesses, as well as to identify areas for improvement in the public health and well-being of Ecuadorian communities. Therefore, this process should not be understood as a static characteristic, but as a dynamic process of rapid response to unforeseen events. To understand this concept in depth, it is necessary to analyze the following key components:

- Adaptive capacity: Health system resilience implies the ability to adapt to changes and disruptions efficiently and effectively. This may include flexibility to adjust resources, policies, and procedures based on changing population needs and circumstances [3].
- Preparation and planning: Preparation is essential for resilience. This involves creating contingency plans, identifying potential risks, and investing in emergency infrastructure and resources. Health systems must be prepared to face a variety of scenarios, from pandemics to natural disasters.
- Coordination and collaboration: Collaboration between various stakeholders, such as hospitals, clinics, government agencies, aid organizations, and the community in general, is essential for resilience. The ability to coordinate efforts and resources in times of crisis can make a significant difference in the system's capacity to withstand adverse situations.
- Evaluation and continuous learning: Health system resilience implies the ability to learn from past experiences and critical evaluations. This allows for constant improvement and adaptation to new threats. Self-assessment and feedback are essential in this process.
- Equity and access: A truly resilient healthcare system must be equitable in the delivery of services and access to healthcare. Equity ensures that all populations, regardless of their ethnic background, socioeconomic status, or geographical location, have access to quality services and care in times of crisis.

- Effective communication: Transparent and effective communication with the public is essential to maintain trust in the health system. Lack of accurate and timely information can undermine crisis response and jeopardize system resilience.

Among the events that occurred with the emergence of the COVID-19 pandemic, it has been highlighted that Ecuadorian health systems faced unprecedented challenges and difficulties [4] [5-15]. Therefore, it is necessary to work through preparedness programs to promote and enhance the resilience of the healthcare system in Ecuador [6]. These programs should prepare the Ecuadorian healthcare system to quickly adapt to new circumstances and reallocate resources. This will enable them to develop effective treatment protocols and maintain open communication with the public. Thus, the main objective of this study is to focus on this matter:

- Evaluate six program proposals focused on enhancing the resilience of the Ecuadorian health system and select the best proposal in order to protect the health and well-being of communities in Ecuador.

Due to the variety of criteria and indetermination provided in the evaluations, it is necessary to proceed through an analysis using the neutrosophic VIKOR method. Through this methodology, the key uncertainties in the selection of the best alternative are analyzed. It is essential in the neutrosophic evaluation that the selected proposal includes indeterminacy as part of the multiple elements that can impact the resilience of the Ecuadorian health system. Therefore, the following specific objectives are determined:

- Analyze the six proposals for programs focused on enhancing the resilience of Ecuadorian health systems.
- Select the most important proposal to enhance the resilience of the Ecuadorian health system, through the analysis of the VIKOR neutrosophic method.

2 Materials and methods

2.1 Neutrosophic VIKOR

The Neutrosophic VIKOR method provides one or several compromise solutions for a set of alternatives. The compromise solution obtained includes indeterminacy as part of the result of the analyzed problem. The Neutrosophic VIKOR method is suitable for solving decision problems with conflicting and non-commensurable criteria by using single-valued neutrosophic units. The compromise solution is determined as the one closest to the ideal solution. To implement the method, it is proposed to define the neutrosophic decision matrix (see Figure 1).[7-16]

Figure 1. Neutrosophic decision matrix. Source: own elaboration based on [7-10].

$$
\begin{array}{cc|cccccc|}
 & & k_{Q1} & k_{Q2} & \cdots & k_{Qj} & \cdots & k_{Qn} \\
 & & w_1 & w_2 & \cdots & w_j & \cdots & w_n \\
 & \boldsymbol{F_j} & Min & Max & \cdots & \cdots & \cdots & \cdots \\
 & T_1 & m_{11} & m_{12} & \cdots & m_{1j} & \cdots & m_{1n} \\
\boldsymbol{Max\,V_i} & T_2 & m_{21} & m_{22} & \cdots & m_{2j} & \cdots & m_{2n} \\
 & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\
 & T_i & m_{i1} & m_{i2} & \cdots & m_{ij} & \cdots & m_{in} \\
\boldsymbol{Min\,V_i} & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\
 & T_m & m_{m1} & m_{m2} & \cdots & m_{mj} & \cdots & m_{mn} \\
 & \boldsymbol{f^*_{Qi}} & m_{i1} & m_{22} & \cdots & \cdots & \cdots & \cdots \\
 & \boldsymbol{f^-_{Qi}} & m_{11} & m_{i2} & \cdots & \cdots & \cdots & \cdots
\end{array}
$$

Before analyzing the neutrosophic decision matrix of the method, the neutrosophic set must be defined. The neutrosophic set is defined by the following elements: true ϑ, indeterminate η, and false δ of x in Q, respectively and their images constitute standard or non-standard subsets within the range $\{0,1\}$. For X of the universe of discourse, it is defined from the single-valued neutrosophic set Q over X as an object in the representation $Q = \{\langle x, \vartheta_A(x), \eta_A(x), \delta_A(x)\rangle : x \in X\}$.

Where $\vartheta_A(x), \eta_A(x), \delta_A(x)$ satisfy the following condition $0 \leq \vartheta_A(x), \eta_A(x), \delta_A(x) \leq 3$ for all $x \in X$. So, to define each neutrosophic number, it is expressed in the following way h, i, j for modeling the Neutrosophic VIKOR method. Therefore, the following functions are defined:

$h = \vartheta_A(x)$ for true membership functions, where $\in \{0,1\}$.
$i = \eta_A(x)$ for indeterminacy membership functions, where $\in \{0,1\}$.
$j = \delta_A(x)$ for false membership functions, where $\in \{0,1\}$.

Therefore, the neutrosophic number defined for the study is determined as $Q = (h, i, j)$, where h, i, j $\in$ {0,1} and satisfy the following condition $0 \leq h + i + j \leq 3$. In this way, the scoring function B for a neutrosophic number is defined as the following equation:

$$B(Q) = \frac{1 + h - 2i - j}{2} \tag{1}$$

Analysis of the elements of the neutrosophic decision matrix:

Decision criteria $K_Q = K_{Q1}, K_{Q2}, K_{Qj}, \ldots, K_{Qn}$ can be defined as the conditions or parameters that allow discriminating alternatives and establishing important preferences of the decision-maker. The decision-making criteria for each alternative are evaluated based on the linguistic terms in single-valued neutrosophic numbers (SVNN) according to the scales shown in Table 1.

Table 1: Linguistic terms that represent the weight of the importance of alternatives. Source: own elaboration based on [7-10].

Linguistic scale	**SVNN**(h, i, j)
Very high (VH)	(0.95,0.05,0.05)
High (H)	(0.8,0.15,0.1)
Medium (M)	(0.5,0.4,0.5)
Low (L)	(0.45,0.6,0.85)
Very low (VL)	(0.25,0.75,0.95)

The weights or weightings constitute measures of the neutrosophic importance that the criteria have for the decision maker. Associated with the criteria, a vector of weights $(w_Q) = (w_{Q1}, w_{Q2} \ldots w_{Qj} \ldots w_{Qn})$ is assigned, where $w \in$ with n as the number of criteria of the linguistic terms used (SVNN). The weight reflects the importance of the criterion in each decision of the neutrosophic set and is assumed positive. To assign weights by criterion, the direct assignment method or the eigenvector method can be applied (see Table 2).

Table 2: Linguistic terms that represent the weight of importance for(w_Q). Source: own elaboration based on [7-10].

Linguistic scale	**SVNN**(h, i, j)
Very Important (VI)	(0.9;0.1;0.1)
Important (I)	(0.75;0.25;0.20)
Medium (M)	(0.50;0.5;0.50)
Not Important (NI)	(0.35;0.75;0.80)
Very Not Important (VNI)	(0.10;0.90;0.90)

Each set of alternatives T are different, exclusive, and exhaustive alternatives that are represented as $T = \{t_1, t_2, \ldots, t_n\}$, where $T \epsilon m$ $(i = 1, 2, \ldots, m)$ as the number of each of the possible alternatives.

The assessment or decision matrix is defined once the criteria and their weights associated with the linguistic term used (SVNN) have been established. The decision-maker can give, for each of the criteria considered and for each alternative of the neutrosophic set of choice, an SVNN or symbolic Q_{ij} value that expresses an evaluation or judgment of the alternative T_i with respect to the criterion k_j. This neutrosophic evaluation can be represented in the form of a matrix, evaluation, or decision matrix. Each row of the matrix expresses qualities of the alternative T_i with respect to the n criteria considered. Each column of the matrix collects the evaluations or judgments issued by the decision maker of all the alternatives with respect to the criterion k_j. Therefore, to obtain the compromise solution (or solutions), one must:

I. Calculate the f_{Qi}^*, and the worst f_{Qi}^-, values of each criterion.

$f_{Qi}^* = max_i f_{Qij}$	$f_{Qi}^- = min_i f_{Qij}$	If function i represents a benefit
$f_{Qi}^* = min_i f_{Qij}$	$f_{Qi}^- = max_i f_{Qij}$	If function i represents a cost

II. Calculate the values S_{Qj}, R_{Qj} and P_{Qj} for each alternative:

$$S_{Qj} = \sum_{i=1}^{n} w_{Qj} \frac{f_{Qi}^{*} - f_{Qij}}{f_{Qi}^{*} - f_{Qi}^{-}} \quad (2)$$

$$R_{Qj} = max_i \left\{ w_{Qj} \frac{f_{Qi}^{*} - f_{Qij}}{f_{Qi}^{*} - f_{Qi}^{-}} \right\} \quad (3)$$

$$P_{Qj} = v \frac{S_{Qj} - S_Q^{*}}{S_Q^{-} - S_Q^{*}} + (1 - v) \frac{R_{Qj} - R_Q^{*}}{R_Q^{-} - R_Q^{*}} \quad (4)$$

Where:

$$S_Q^{*} = min_j S_{Qj};\ S_Q^{-} = max_j S_{Qj}$$
$$R_Q^{*} = min_j R_{Qj};\ R_Q^{-} = max_j R_{Qj} \quad (5)$$

And v is introduced as a weight of the group's maximum utility strategy, while $(1 - v)$, is the weight of the individual opposition.

- $v > 0.5$ *Majority vote*
- $v \sim 0.5$ *Consensus vote*
- $v < 0.5$ *Veto vote*

III. The alternatives are ordered, according to the values of S_Q, R_Q and P_Q (see Figure 2)

Figure 2. Matrix according to the values of S_Q, R_Q and P_Q. Source: own elaboration based on [7-10].

$$\begin{bmatrix} S_{Q1} \\ S_{Q2} \\ \vdots \\ S_{Qj} \\ \vdots \\ S_{Qm} \end{bmatrix} \begin{bmatrix} R_{Q1} \\ R_{Q2} \\ \vdots \\ R_{Qj} \\ \vdots \\ R_{Qm} \end{bmatrix} \begin{bmatrix} P_{Q1} \\ P_{Q2} \\ \vdots \\ P_{Qj} \\ \vdots \\ P_{Qm} \end{bmatrix}$$

IV. Determine as a compromise solution the alternative $T_b^{(1)}$ that is the best classified according to the value of P_b (according to equation 1), that is, with the value of $P_{b\,min}$, if the following two conditions are satisfied:

a. Condition 1: Acceptable advantage.
$P_b(T_b^{(2)}) - P_b(T_b^{(1)}) \geq DP_b$,
Where $T_b^{(2)}$ is the second alternative according to the classification of the values of P_b, and $DP_b = \frac{1}{N-1}$, with N as the number of alternatives.

b. Condition 2: Acceptable stability in the decision process.
The alternative $T_b^{(1)}$ must be the best classified according to the list of values of S_b and/or R_b, this is the stable compromise solution within a decision process.
If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of:

- Alternatives $T_b^{(1)}$ and $T_b^{(2)}$ if condition 2 is not satisfied.
- Alternatives $T_b^{(1)}, T_b^{(2)}, \ldots, T_b^{(m)}$ and if condition 1 is not satisfied; $T_b^{(m)}$ is determined by taking into account the relationship $T_b^{(m)}$. These alternatives are considered to be close to the ideal solution.

3 Results

Below are six programs designed to enhance the resilience of the healthcare system in Ecuador. These programs address various dimensions of resilience, including adaptability, preparedness, coordination, and equity in healthcare service delivery (See Tables 3 to 8). Each program is described in terms of its impact (C1), benefits (C2), recovery time (C3), regional scope (C4), and preparation and training (C5). The criteria or elements classified from C1 to C5 define the conditions or parameters that help define the alternatives and establish the decision maker's importance preferences.

Table 3: Formation of multidisciplinary disaster response teams. Source: own elaboration.

Program 1	**Formation of multidisciplinary disaster response teams**
Aspect	**Detail**
Impact	This program has a high impact on improving the resilience of the health system in Ecuador. By forming multidisciplinary teams trained to respond to disasters, the capacity to respond to catastrophic events is strengthened, reducing human and material losses.
Benefits	• Improvement of the healthcare system's preparedness and response to natural disasters and catastrophic events. • Reduction of human and material losses. • Enhanced coordination among various institutions and stakeholders. • Strengthening public trust in the healthcare system.
Recovery time	The benefits of this program become evident in the medium term, approximately within 2-3 years.
Regional scope	The program has a national scope, with an emphasis on disaster-prone areas in Ecuador.
Preparation and Training	• To successfully implement this program, a significant investment in training and resource development is required. Training centers must be established and resources and equipment necessary for the formation of multidisciplinary teams should be provided. In addition, collaboration between different institutions and disaster response organizations must be promoted. • Training is a crucial component of this program. Health professionals and other members of multidisciplinary teams should receive specialized training in disaster management, response protocols [11-17], coordination, and communication in emergencies. Ongoing training and simulation exercises are essential to maintain team readiness.

Table 4: Strengthening public health response capacity. Source: own elaboration.

Program 2	**Strengthening of public health response capacity**
Aspect	**Detail**
Impact	This program has a significant impact on improving the resilience of the health system in Ecuador. By strengthening public health response capacity, the spread of diseases can be more efficiently controlled and critical resources managed.
Benefits	• Enhanced control of disease outbreaks. • Reduction in the spread of infectious diseases [12-18]. • Improved management of health resources.
Recovery time	The results of this program would be visible in the short term, with effective implementation in one year.
Regional scope	The scope of this program would be the entire country.
Preparation and training	• To implement this program, an initial investment in infrastructure would be required, as well as the training of health personnel in the management of public health emergencies. • Training would be essential to train health personnel in epidemiology and the management of outbreaks and health emergencies [13-19].

Table 5: Development of telemedicine and telehealth strategies. Source: own elaboration.

Program 3	**Development of telemedicine and telehealth strategies**
Aspect	**Detail**
Impact	This program has a significant impact on improving the resilience of the health system in Ecuador, as it facilitates access to health care, especially in rural and remote areas.
Benefits	• Expansion of health care coverage. • Better control of chronic diseases. • Reduction of geographical barriers
Recovery time	The results of this program would be visible in the medium term, with effective implementation in 2-3 years.
Regional scope	The scope of this program would be national, with a special focus on rural and remote areas.
Preparation and training	It requires investment in information technology infrastructure and staff training in telemedicine. Health professionals would need training in the use of telemedicine technologies.

Table 6: Implementation of advanced public health surveillance systems. Source: own elaboration.

Program 4	Implementation of advanced public health surveillance systems
Aspect	**Detail**
Impact	This program has a significant impact on improving the resilience of the health system in Ecuador. By implementing advanced public health surveillance systems, early detection of disease outbreaks and public health threats is improved.
Benefits	• Faster response to disease outbreaks. • Reduction in the spread of diseases. • Better health resource planning
Recovery time	The benefits of this program would be visible in the short and medium term, with effective implementation in 2-3 years.
Regional scope	The program has a national scope, with an emphasis on areas with high population density.
Preparation and Training	To implement this program, investment in technology and training in epidemiology is required. Health Professionals would need training in advanced epidemiological surveillance.

Table 7: Promotion of inclusive public health policies. Source: own elaboration.

Program 5	Promotion of inclusive public health policies
Aspect	**Detail**
Impact	This program has a significant impact on improving the resilience of the healthcare system in Ecuador by promoting equity in healthcare.
Benefits	• Reduction of disparities in healthcare. • Improved health of disadvantaged populations. • Strengthening social cohesion.
Recovery time	The benefits of this program become evident in the long term, with effective implementation in 3-5 years.
Regional scope	The program has a national scope, with special emphasis on areas with health inequalities.
Preparation and training	• It requires the development of inclusive policies and awareness programs. • Training of health professionals in culturally sensitive care is needed.

Table 8: Establishment of research centers in health resilience. Source: own elaboration.

Program 6	Establishment of research centers in health resilience
Aspect	**Detail**
Impact	This program has a high impact by facilitating research and development of best practices in health resilience.
Benefits	• Data-driven evidence generation. • Healthcare innovation. • Knowledge dissemination
Recovery time	The benefits of this program become evident in the long term, with effective implementation in 3-5 years.
Regional scope	The program has a national scope, with the potential for international collaboration.
Preparation and training	• Requires investment in research and development infrastructure. • Training of researchers and professionals in health research methods is needed.

Each program has its own set of impact, benefits, recovery time, regional scope, preparation, and training. The choice of the most relevant program depends on the specific priorities and needs of the healthcare system in Ecuador, as well as the available resources. The programs contribute to improving the resilience of the healthcare system from different perspectives. Once the programs are defined, the next step is to select the best proposal through the analysis of the Neutrosophic VIKOR method.

Development of the Neutrosophic VIKOR method

The first step in the development of the method is to define the weights of each criterion according to the scale in Table 2. Then, the assessment of each alternative for each criterion is carried out according to Table 1. This results in a ranking of alternatives, and thus, the determination of the compromise solution or solutions (see Tables 9 to 12). These solutions constitute the most suitable programs to enhance the resilience of the Ecuadorian healthcare system.

Table 9: Neutrosophic normalization of the decision matrix. Source: own elaboration.

	C1	C2	C3	C4	C5
Weight	**(0.75;0.25;0.20)**	**(0.35;0.75;0.80)**	**(0.10;0.90;0.90)**	**(0.9;0.1;0.1)**	**(0.75;0.25;0.20)**
fj	**Max**	**Max**	**Min**	**Max**	**Max**
P1	(0.95,0.05,0.05)	(0.8,0.15,0.1)	(0.25,0.75,0.95)	(0.95,0.05,0.05)	(0.95,0.05,0.05)
P2	(0.95,0.05,0.05)	(0.95,0.05,0.05)	(0.45,0.6,0.85)	(0.8,0.15,0.1)	(0.8,0.15,0.1)
P3	(0.8,0.15,0.1)	(0.45,0.6,0.85)	(0.95,0.05,0.05)	(0.5,0.4,0.5)	(0.5,0.4,0.5)
P4	(0.5,0.4,0.5)	(0.25,0.75,0.95)	(0.8,0.15,0.1)	(0.45,0.6,0.85)	(0.45,0.6,0.85)
P5	(0.45,0.6,0.85)	(0.95,0.05,0.05)	(0.5,0.4,0.5)	(0.95,0.05,0.05)	(0.25,0.75,0.95)
P6	(0.45,0.6,0.85)	(0.95,0.05,0.05)	(0.45,0.6,0.85)	(0.8,0.15,0.1)	(0.5,0.4,0.5)
Better f_{Qi}^{*}	(0.95,0.15,0.1)	(0.95,0.15,0.1)	(0.25,0.9,0.95)	(0.95,0.15,0.1)	(0.95,0.3,0.25)
Worse f_{Qi}^{-}	(0.45,0.9,0.95)	(0.25,0.4,0.5)	(0.95,0.15,0.1)	(0.45,0.85,0.75)	(0.25,0.9,0.95)

Table 10: Measurement of utility S_{Qj} and regret R_{Qj} for each program. Source: own elaboration.

Program	C1	C2	C3	C4	C5	S_j	R_j
P1	(0,0,0)	(0.04,0.03,0.01)	(0,0,0)	(0,0,0)	(0,0,0)	(0.04,0.03,0.01)	(0.04,0.03,0.01)
P2	(0,0,0)	(0,0,0)	(0.04,0.03,0.02)	(0.09,0.05,0.02)	(0.02,0.01,0.01)	(0.15,0.09,0.05)	(0.09,0.05,0.02)
P3	(0.08,0.05,0.02)	(0.14,0.16,0.18)	(0.15,0.15,0.15)	(0.27,0.19,0.17)	(0.06,0.05,0.05)	(0.7,0.6,0.57)	(0.27,0.19,0.18)
P4	(0.23,0.16,0.14)	(0.2,0.2,0.2)	(0.12,0.13,0.14)	(0.3,0.3,0.3)	(0.07,0.08,0.09)	(0.92,0.87,0.87)	(0.3,0.3,0.3)
P5	(0.25,0.25,0.25)	(0,0,0)	(0.05,0.08,0.08)	(0,0,0)	(0.1,0.1,0.1)	(0.4,0.43,0.43)	(0.25,0.25,0.25)
P6	(0.25,0.25,0.25)	(0,0,0)	(0.04,0.03,0.02)	(0.09,0.05,0.02)	(0.06,0.05,0.05)	(0.44,0.38,0.34)	(0.25,0.25,0.25)

Table 11: Index P_{Qj} of each program. Source: own elaboration.

Program	S_{Qj}	R_{Qj}	v	P_{Qj}	Hierarchy
P1	(0.04,0.03,0.01)	(0.04,0.03,0.01)	0.5	(0.71,0.64,0.62)	4
P2	(0.15,0.09,0.05)	(0.09,0.05,0.02)		(0.38,0,0)	1
P3	(0.7,0.6,0.57)	(0.27,0.19,0.18)		(0.71,0.64,0.62)	4
P4	(0.92,0.87,0.87)	(0.3,0.3,0.3)		(1,1,1)	6
P5	(0.4,0.43,0.43)	(0.25,0.25,0.25)		(0.02,0.53,0.59)	3
P6	(0.44,0.38,0.34)	(0.25,0.25,0.25)		(0.41,0.62,0.59)	2

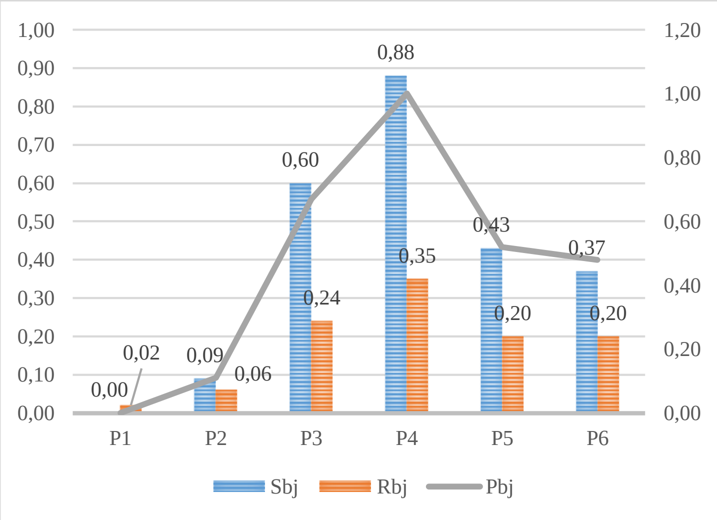
For the classification of the alternatives, evaluation is made for a v ~ 0.5 (Vote by consensus)

Table 12: Acceptable advantage condition. Source: own elaboration.

Program	$P_b\,(a")$	Hierarchy	$P_b\,(a')$	N	$P_b\,(a") - P_b\,(a')$	DP_b	$Q_b\,(a") - P_b\,(a') \geq DP_b$
P1	0.00	1	0	6	0.00	0.2	DOES NOT COMPLY
P2	0.11	2			0.11		DOES NOT COMPLY
P3	0.67	5			0.67		COMPLIES
P4	1.00	6			1.00		COMPLIES
P5	0.52	4			0.52		COMPLIES
P6	0.48	3			0.48		COMPLIES

The acceptable advantage condition is met in Program 3. Therefore, Programs 1 and 2 are defined as part of the compromise solution group. Meanwhile, Program 2 is the highest ranked on the index P_{b_j}. It should be determined if it is the highest ranked based on the list of values of S_b and/or R_b. To do this, a representation of S_{bj}, R_{bj} and P_{bj} is shown in Figure 3.

Figure 3: Analysis of S_{bj}, R_{bj} and P_{bj}. Source: own elaboration.



The graph shows that for program 1 it is at the minimum of the values S_{bj}, R_{bj} and P_{bj}. Therefore, it meets the second condition of being best classified in and is also the best classified by with a value of (0;0.02).

Therefore, the training of multidisciplinary disaster response teams is defined as the best program to enhance the resilience of the health system in Ecuador. Although the P2 program is present as a compromise condition.

In summary, the study has defined Ecuador as a country with a diverse geography and population, facing unique challenges in healthcare management. Therefore, neutrosophic evaluation of healthcare system resilience has provided a deeper understanding of the complexity of this environment and a solid basis for selecting the best alternative.

In general, the diversification of the proposed Programs P1 and P2 allows for a comprehensive approach to strengthen the resilience of the healthcare system in Ecuador [14]. The choice of programs depends on the needs and available resources. The combination of these programs could substantially improve the healthcare system's responsiveness to future crises and ensure more effective healthcare for the population.

Conclusion

The study has emphasized the importance of considering a variety of programs to strengthen the resilience of the healthcare system in Ecuador. Each proposed program addresses key aspects such as disaster response, telemedicine, epidemiological surveillance, inclusive health policies, and resilience research. The combination of these programs would enable the healthcare system to address a wide range of challenges and threats, which is essential for ensuring effective and equitable healthcare.

The analysis using the neutrosophic Vikor method has identified two programs to enhance the resilience of the Ecuadorian healthcare system. These include the formation of multidisciplinary disaster response teams and the strengthening of public health response capacity. The integration of these two programs is essential for assessing the effective implementation of healthcare system resilience in Ecuador.

Assessing resilience requires the formation of teams capable of effectively coordinating in emergencies to reduce human and material losses. Investing in the training and necessary resources for these teams is essential to strengthen the healthcare system's response capacity. Addressing healthcare system resilience in Ecuador is a multidimensional challenge that requires the implementation of several complementary programs.

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Received: October 28, 2023. **Accepted:** December 17, 2023