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Research Article

Fuzzy Decision-Making Framework for Sensitively Prioritizing Autism Patients with Moderate Emergency Level

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that requires careful assessment and management. The prioritization of ASD patients involves navigating through complexities such as conflicts, trade-offs, and the importance of different criteria. Therefore, this study focuses on prioritizing patients with ASD in the healthcare setting through an evaluation and benchmarking framework. The aim of this study is to develop a framework that utilizes Multi-Criteria Decision Making (MCDM) methods to assist healthcare professionals in prioritizing ASD patients, particularly those with moderate injury levels. The methodology of the framework outlines several phases, including dataset identification, development of a decision matrix, weighting of 19 ASD criteria using the FWZIC method, ranking 432 patients using the VIKOR method, and evaluating the proposed framework using four sensitivity analysis scenarios. Among the 19 ASD criteria, the criterion 'verbal communication' obtained the highest weight. Additionally, criteria such as 'laughing for no reason', 'nodding', 'patient movement at home', and 'pointing with the index finger' obtained similar higher weights, indicating their potential impact on ASD patients. The experimental results highlight the significance of adjusting ASD weights in influencing the final rankings obtained through the VIKOR method. This emphasizes the need for careful consideration when assigning weights to the 19 ASD criteria to ensure accurate prioritization. Moreover, the framework provides valuable insights into improving the care and support provided to individuals with autism in Iraq. The findings contribute to the existing body of knowledge in the field of autism care prioritization and pave the way for future research and interventions aimed at enhancing the quality of care for individuals with autism in Iraq.

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neuropsychiatric disorder that is influenced by genetic factors. The World Health Organization (WHO) estimates that there are 67 million individuals worldwide affected by ASD [1][2]. Children with autism exhibit various symptoms, including repetitive behaviors, abnormalities in facial and vocal expressions, delayed speech learning, and difficulties in communication [3]. These symptoms typically emerge within the first two years of life and persist over time. The exact causes of ASD are still not fully understood, but they are believed to involve a combination of genetic mutations, such as "de novo or transmitted loss of function (LOF) mutations," as well as environmental factors that may contribute to genetic abnormalities [4][5]. In some cases, autism can be inherited from one or both parents, and it is more prevalent in males than females, with a fourfold higher occurrence [6]. Early diagnosis is crucial in managing and limiting the impact of autism [7]. However, traditional diagnostic methods, such as the Autism Diagnostic Observation Schedule (ADOS) and the Autism Diagnostic Interview-Revised (ADI-R), can be time-consuming. Many researchers have focused on the genetic aspects of ASD, attempting to identify specific gene sets and their priority

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in order to achieve accurate diagnoses. Given the complexities and various perspectives surrounding ASD, there is a need to explore different approaches, such as decision-making techniques, to develop effective prioritization methods for ASD patients.

Triage is a crucial process used in medical settings to assign degrees of urgency to wounds or illnesses and determine the order of treatment for a large number of patients [8]. It involves identifying the most urgent cases and deciding who should receive treatment and in what order [9][10]. Triage can be applied to ASD patients to determine their level of urgency and prioritize their needs [11]. This helps in reducing waiting times and effectively utilizing available resources. ASD patients can be categorized into different triage levels, such as severe, moderate, and mild cases [6]. Triage-based questionnaires can be used to identify patients who require priority diagnostic evaluation [9]. Certain autism centers have implemented criteria-based prioritization, considering factors like age, urgency of needs, and additional complexities that may impact treatment decisions [9]. Prioritization approaches in the context of genetic studies have also been utilized to identify genes that contribute to ASD. These methods prioritize genes based on their importance in specific cell types, which may have etiological relevance to ASD [12]. In summary, triage and prioritization tools are valuable in ASD diagnosis, supporting evidence-based decision-making in medical tests and treatment strategies. They contribute to improving the accuracy of autism medical contexts and interventions [10]. ASD triage involves assessing and prioritizing individuals with ASD based on the severity of their condition and healthcare needs. It facilitates resource allocation, patient flow management, and timely provision of interventions [13]. Healthcare professionals use triage systems to determine the appropriate level of care and intervention for each ASD patient, taking into account medical urgency, symptom severity, and available resources [14]. These systems often incorporate standardized assessment tools and protocols to guide clinicians in prioritizing patients effectively [15].

The prioritization of ASD patients is a complex decision-making process that involves various challenges and considerations. One of the key issues encountered is the presence of conflicts and trade-offs among different criteria used for prioritization. Healthcare professionals and decision-makers must navigate through conflicting factors and make difficult choices when determining the priority of ASD patients [13]. Additionally, the importance of different ASD criteria adds another layer of complexity to the prioritization process. Each criterion holds a certain level of significance and contributes to the overall assessment of a patient's condition. Balancing the importance of various criteria and weighting them appropriately is crucial to ensure fair and accurate prioritization [14]. Addressing these issues requires the application of robust decision-making methodologies, such as Multi-Criteria Decision-Making (MCDM) techniques. MCDM methods allow for the systematic evaluation of multiple criteria and facilitate the resolution of conflicts and trade-offs. By incorporating the perspectives and expertise of healthcare professionals, a comprehensive and well-informed prioritization approach can be developed [15]. These methods provide a structured framework for assessing and ranking ASD patients based on their individual needs, considering factors such as symptom severity, available resources, and urgency of care.

Because they can handle complicated decision issues with numerous objectives, MCDM approaches are operational research techniques that are extensively employed in many different domains [16–19]. MCDM is a decision theory extension that enables the assessment of options based on numerous criteria, sometimes with competing aims [20]. These methods require a number of processes, such as structure, planning, and resolving dilemmas utilizing various standards [21]. To evaluate how each alternative performs against each criterion and how important each criterion is in relation to the overall aim, decision-makers may use qualitative or quantitative methods [22–24]. There are several MCDM techniques available for evaluating and weighting criteria in different fields, including the Analytical Hierarchy Process (AHP) [25], Weighted Product Model (WPM) [26], Hierarchical Adaptive Weighting (HAW) [27], Best-Worst Method (BWM) [28], Multiplicative Exponential Weighting (MEW) [29], Weighted Sum Model (WSM) [30], Simple Additive Weighting (SAW) [31], and Analytical Network Process (ANP) [32]. However, when the number of criteria rises, several of these approaches, such as AHP, ANP, and BWM, may experience consistency problems. It gets more difficult to maintain consistency in the assessments as the number of pairwise comparisons increases. Complete consistency in the AHP technique has been argued to be almost unachievable when there are more than nine criteria By breaking down the criterion into sub-criteria, this problem may be solved, but it complicates the model even more. This inconsistency issue can be resolved using a relatively recent technique dubbed the Fuzzy-Weighted Zero-Inconsistency (FWZIC) approach [33]. Regardless of the quantity of criteria, the FWZIC technique consistently calculates the weight coefficients of the criterion. In order to determine each criterion's importance level throughout the decision-making process, it depends on variations in expert preferences. Different MCDM techniques have been created and used in many sectors to address the evaluation and benchmarking challenge [34][35]. The VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), which chooses the best choice from a group of options using quantitative or qualitative data, is one widely utilized technique. However, VIKOR relies on external weighing techniques since it lacks a means for allocating weights to the criterion. To solve this issue, the comprehensive FWZIC technique was developed [33]. It enables the consistent estimation of important weights for criterion. The primary objective of this study is to develop a framework for the evaluation and benchmarking of ASD patients with moderate injury levels. By integrating MCDM methods, such as FWZIC, with VIKOR, this framework aims to provide various solutions for prioritizing and managing ASD patients based on important criteria that can influence their condition. To this end, the study has the following objectives:

1. Develop a decision matrix for evaluation and benchmarking ASD patients.
2. Prioritize ASD patients using new fuzzy decision-making framework by integrated FWZIC-VIKOR methods.
3. Evaluate the developed framework results through sensitivity analysis.

By achieving these objectives, the study intends to provide healthcare professionals with a systematic and reliable approach to prioritize ASD patients. The framework incorporates decision-making techniques and addresses challenges such as conflicting criteria and the importance of different factors. The study contributes to improving the care and support provided to individuals with autism and paves the way for future research in autism care prioritization.

2. LITERATURE REVIEW

Patient prioritization involves determining the order in which patients receive healthcare interventions based on their individual needs and available resources. The goal is to attend to those with the most urgent or critical conditions first. In the context of ASD, prioritization focuses on determining the order in which individuals with ASD receive interventions based on the severity of their condition and the urgency of their healthcare needs. This ensures that those requiring immediate or specialized attention are given priority. Various factors are considered in the prioritization process, including symptom severity, functional impairments, safety concerns, medical emergencies, and resource availability. The aim is to allocate resources and interventions effectively and efficiently, especially when resources are limited or waiting lists are long. Standardized assessment tools, clinical judgment, and established criteria specific to ASD may be utilized in the prioritization process. Prioritizing ASD patients is crucial to ensure timely access to appropriate interventions, maximize outcomes, and address the specific needs and challenges faced by individuals with ASD and their families. In a study [13], a triage method was developed for early autism diagnosis and clinical treatment, utilizing fuzzy MCDM techniques and considering multidimensional criteria. The authors selected four medical criteria and gave significant attention to sociodemographic criteria, resulting in a total of 19 criteria for correlation analysis. Another study [36] aimed to develop a hybrid model for predicting and diagnosing autism by intersecting nine machine learning methods and eight feature selection techniques. The model focused on effective sociodemographic and medical factors and aimed for high accuracy by applying rigorous methodological standards. In another study [37], a model combining MCDM and machine learning was developed in three phases. The first phase involved handling imbalanced ASD datasets through preprocessing stages such as imputing missing values and feature selection of sociodemographic and family characteristics, resulting in a balanced dataset of 107,573 cases. The second phase applied the proposed complex T-spherical fuzzy-weighted zero-inconsistency (CT-SFWZIC) method for model development.
The mentioned studies provide valuable insights but also face some criticisms and limitations regarding the prioritization of autism patients. These limitations include the lack of transparency and reproducibility in describing the specific methodology used, limited validation and external application of the prioritization framework, insufficient consideration of a moderate emergency level which is the most frequent condition among autistic patients according to clinical expertise, and inadequate emphasis on sensitivity analysis. Addressing these limitations is crucial for improving the reliability, applicability, and ethical considerations of the fuzzy decision-making framework. Therefore, the development of a dynamic framework for prioritizing ASD patients provides a systematic and comprehensive approach to evaluate and benchmark individuals on the autism spectrum. By leveraging various methodologies and decision-making techniques, the framework aims to enhance the accuracy, reliability, and understanding of ASD patient evaluations.

3. FUZZY DECISION-MAKING FRAMEWORK

This section provides a comprehensive overview of the dynamic framework for prioritizing ASD patients. The framework consists of four distinct phases that guide the entire process, starting from dataset identification and culminating in the ranking of patients. By integrating various methodologies and decision-making techniques, the framework enhances the accuracy and reliability of the evaluation process, ultimately contributing to a better understanding and support for individuals on the autism spectrum. Phase 1 focuses on the identification of an appropriate ASD dataset. This involves carefully selecting a dataset that contains relevant information and characteristics of ASD patients. The criteria for dataset selection are meticulously considered to ensure its suitability for the subsequent evaluation and benchmarking process. Phase 2 centres around the development of a decision matrix, which serves as a powerful tool for organizing and analysing the data collected from the ASD dataset. The decision matrix captures key parameters and encompasses 19 criteria related to ASD patients, facilitating a systematic evaluation and comparison of 432 moderate injury patients. Phase 3 introduces the FWZIC method, which plays a crucial role in assigning appropriate weights to the evaluation criteria. By incorporating fuzzy decision-making techniques, the FWZIC method ensures a fair and balanced assessment of the criteria's significance. This phase significantly contributes to the overall evaluation process. In the fourth phase, the VIKOR method is employed to rank ASD patients based on the weights obtained from the FWZIC method. VIKOR, as a multi-criteria decision-making approach, facilitates the identification of the most suitable patients according to predefined criteria. This phase enables the prioritization of ASD patients who require immediate attention or specific interventions. Lastly, the fifth phase involves conducting a sensitivity analysis to evaluate the robustness and reliability of the proposed framework. This analysis ensures that the framework's performance remains consistent and reliable under varying conditions and input parameters.

3.1 PHASE 1: ASD Dataset Identification

ASD raw data was obtained from two sources, namely [13] and [36]. To ensure the confidentiality and privacy of the patients, the data was anonymized. The dataset, consisting of 538 patients diagnosed with ASD, underwent pre-processing as described in the study conducted by [17]. This pre-processing step aimed to include 19 criteria related to the emergency triage level of the patients. For the triage process, the study utilized the Processes for Triaging Autism Patients (PTAP) method, which was developed by [17]. This method enabled the classification of patients into three severity levels: minor injury, moderate injury, and urgent injury. Figure 1 provides an overview of the distribution of patients across these severity levels. Notably, a significant proportion of patients, specifically 432 individuals, were assigned the moderate injury level. This level was specifically chosen to address the predefined problem and serve as a proof of concept.

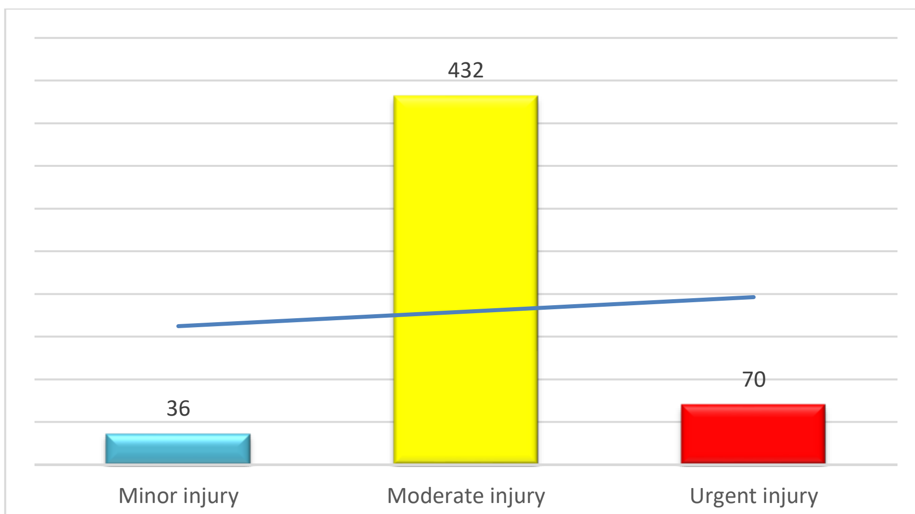

Fig. 1. The result of Triage ASD patients on the real dataset [36]

To further illustrate the dataset and its features, Table 1 presents a sample of the moderate injury patients along with their corresponding dataset features.

TABLE I. SAMPLE OF AUTISM PATIENTS TRIAGED WITH MODERATE INJURY LEVEL

C1= Verbal communication	C2= Laughing for no reason	C3= Nodding	C4= Patient movement at home	C5= Pointing with the index finger	C6= Complications of childbirth	C7= Spinning around things	C8= Bathroom skills	C9= Wave	C10= Unnecessary drug	C11= Maternal diseases during pregnancy	C12= Afraid of loud sounds	C13= Patient’ s Gender	C14= Notice the sound of the bell	C15= premature baby	C16= Crying for no reason	C17= Marital Relationship	C18= Taste the food	C19= Consanguinity	Triage level
no	yes	yes	yes	no	no	yes	no	yes	no	yes	yes	male	no	no	yes	good	yes	no	Moderate injury
yes	yes	yes	yes	no	yes	no	no	yes	no	no	yes	male	yes	yes	yes	good	yes	yes	Moderate injury
no	yes	no	yes	no	no	yes	no	yes	yes	yes	no	male	yes	no	yes	good	no	yes	Moderate injury
no	yes	yes	yes	no	no	yes	no	no	yes	yes	yes	male	yes	no	no	good	yes	no	Moderate injury
yes	yes	no	yes	no	yes	yes	no	yes	yes	yes	no	male	yes	no	yes	good	yes	yes	Moderate injury

3.2 PHASE 2: Development of Decision Matrix

This section presents the developed dynamic decision-making (DM) approach used for evaluating and benchmarking ASD patients. DM is a crucial component of the assessment and benchmarking technique, as indicated in previous studies [38–43]. The DM framework consists of two main elements: the evaluation criteria and the alternatives. The evaluation criteria represent the 19 ASD criteria utilized to benchmark the 432 patients, who serve as the alternatives. The construction of the DM involved a series of steps, which are outlined in detail in Table 2. These steps encompass the necessary procedures for creating a robust and comprehensive DM model for evaluating and benchmarking ASD patients.

TABLE II. DM

Alternatives/Criteria		ASD Criteria						
ASD Patients		**C1**	**C2**	**C3**	**C4**	**C5**	**…**	**C19**
A1	**Patient#1**	C1-A1	C2-A1	C3-A1	C4-A1	C5-A1	**…**	C19-A1
A2	**Patient#2**	C1-A2	C2-A2	C3-A2	C4-A2	C5-A2	**…**	C19-A2
A3	**Patient#3**	C1-A3	C2-A3	C3-A3	C4-A3	C5-A3	**…**	C19-A3

A4	**Patient#4**	C1-A4	C2-A4	C3-A4	C4-A4	C5-A4	…	C19-A4
. . .	. . .	. . .	. . .	. . .	. . .	. . .	…	. . .
A432	**Patient#432**	C1-A432	C2-A432	C3-A432	C4-A432	C5-A432	…	C19-A432
C= Criteria, A= Alternative, C= Criteria								

3.3 PHASE 3: FWZIC method for Weighting Criteria

The FWZIC method is employed as an MCDM technique for weighting the 432 ASD criteria. Figure 2 depicts the step-by-step process of FWZIC, highlighting the five essential processes that should be applied to the 19 ASD criteria. These five steps are outlined below:

Fig. 2. FWZIC methodology for weighting the 19 criteria [36]

Step 1: Establish the set of evaluation criteria: The planned set of assessment features for ASD is investigated and provided in the first phase of the evaluation and benchmarking procedure.

Step 2: Using structured expert judgment (SEJ), members of the expert team are found and chosen from appropriate medical specialties, mostly psychiatrists. The selection and nomination procedure then starts, leading to the creation of the SEJ panel. The language scale is converted to the matching numerical scale in order to speed up the panelists' judgment and ability to reach consensus. The process of this conversion is illustrated in Table 3. The SEJ team also creates an assessment form to record their collective agreement on each ASD criteria.

TABLE III. FIVE-POINT LIKERT SCALE AND EQUIVALENT NUMERICAL SCALE

Linguistic terms	**Numerical scoring scale**
Not important	1

Slight important	2
Moderately important	3
Important	4
Very important	5

Step 3: Creating the Expert Decision Matrix (EDM): In the step before, the list of chosen experts and their selections based on predetermined criteria were defined. Building the EDM is the main objective of this phase. The alternatives (ASD criteria) and decision criteria are the main elements of the EDM, as illustrated in Table 4. Each selective expert (Ei), who has assessed the level of significance for each criterion, interacts with each criterion (Cj) in the attribute (representing the ASD criteria).

TABLE IV. EDM

Criteria / Experts	***C1***	***C2***	**…**	***Cn***
E1	*Imp (E1/C1)*	*Imp (E1/C2)*	…	*Imp (E1/Cn)*
E2	*Imp (E2/C1*	*Imp (E2/C2)*	…	*Imp (E2/Cn)*
E3	*Imp (E3/C1)*	*Imp (E3/C2)*	…	*Imp (E3/Cn)*
…	…	…	…	…
Em	*Imp (En/C1)*	*Imp (En/C2)*	…	*Imp (Em/Cn)*

Imp represents the importance level.

Step 4: Application of a fuzzy membership function: A fuzzy membership function and defuzzification technique are used to improve the precision and usability of the data in the EDM for further analysis. It is hard to give accurate preference ratings to each criterion in the context of Multiple Criteria Decision Making (MCDM) since the situation is frequently unclear and imprecise. The fuzzy approach allows for the management of ambiguous and imprecise circumstances by using fuzzy numbers rather than exact numbers to compute the relative value of each characteristic (criteria) [44]–[46]. Triangular fuzzy numbers (TFNs), one of several forms of fuzzy numbers, are frequently employed in fuzzy MCDM. A = (a, b, c) is used to express them, with a, b, and c denoting the lower, middle, and upper values, respectively. TFNs are appropriate for use in practical applications due to their conceptual and computational simplicity [47]. The triangle membership function used to describe TFNs in this work is shown in Figure 3.

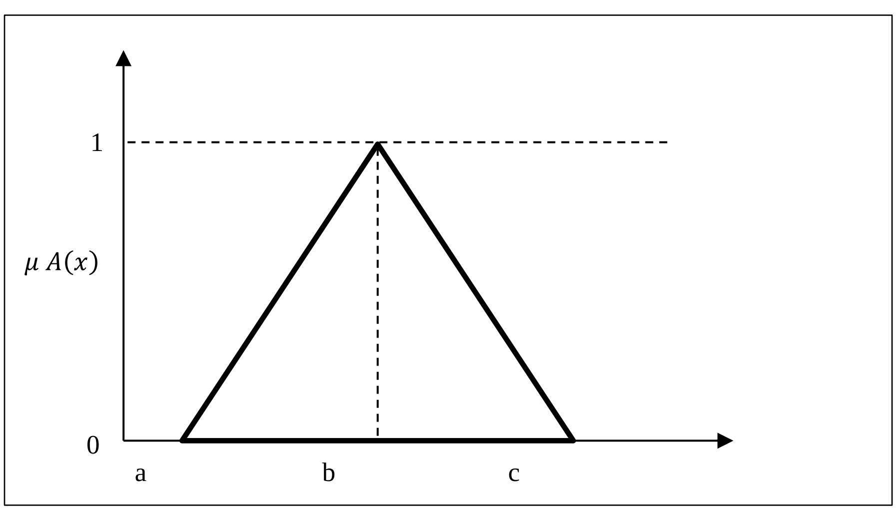

Fig. 3. Membership of TFNs

The membership function (x) of TFN A is given by Equation 1

$$\mu A(x) = \begin{cases} 0 \ if \ x < a \\ \frac{x-a}{b-a} \quad if \ a \le x \le b \\ \frac{c-x}{c-b} \quad if \ b \le x \le c \\ 0 \ if \ x > c \end{cases}, \ where \ a \le b \le c. ... \tag{1}$$

Remark: Let x̃ = (a1, b1, c1) and ỹ = (a2, b2, c2) be two non-negative TFNs and α ∈ $\mathbb{R}_+$. Following the extension principle, the arithmetic operations are defined as follows:

1. x̃ + ỹ = (a1 + a2, b1 + b2, c1 + c2), (2)
2. x̃ − ỹ = (a1 − c2, b1 − b2, c1 − a2), (3)
3. αx̃ = (αa1, αb1, αc1), (4)
4. x̃−1 ≅ (1/c1, 1/b1, 1/a1), (5)
5. x̃ ×ỹ ≅ (a1a2, b1b2, c1c2), (6)
6. x̃/ỹ ≅ (a1/c2, b1/b2, c1/a2). (7)

The value of each Numerical term with TFN is shown in Table 5.

TABLE V. NUMERICAL TERMS AND THEIR EQUIVALENT TFNS

Numerical scoring scale	TFNs
1	(0.00,0.10,0.30)
2	(0.10,0.30,0.50)
3	(0.30,0.50,0.75)
4	(0.50,0.75,0.90)
5	(0.75,0.90,1.00)

For each expert and set of criteria, the conversion of linguistic variables into TFNs is shown in Table 5. Using language factors, psychiatric expert N evaluates the relative weight of each evaluation criterion. Given the fuzziness and ambiguity of the situation, the linguistic variables are transformed into TFNs to express the judgments. The assessments may now be represented in a more precise and quantitative manner, allowing for more in-depth analysis and decision-making during the evaluation and benchmarking process.

Step 5: Computation of the final values of the weight coefficients of the evaluation criteria: In this stage, the final values of the weight coefficients for the evaluation criteria $(w1, w2, ..., w19)^T$ are determined using the fuzzy data for the criterion from the previous step.

1) By using Equation 8, the ratio of fuzzification data is determined. As demonstrated in Table 6, the preceding equations are employed with TFNs [47].

$$\frac{Imp(\widetilde{E1}/C1)}{\sum_{j=1}^{n} Imp(\widetilde{E1}/C_{1j})} \tag{8}$$

where $Imp(\widetilde{E1}/C1)$ represent the fuzzy number of Imp (E1/C1).

TABLE VI. FUZZY EDM ($\widetilde{EDM}$) [47]

Criteria\Experts	$\widetilde{C1}$	$\widetilde{C2}$	…	$\widetilde{Cn}$
E1	$\frac{Imp(\widetilde{E1}/C1)}{\sum_{j=1}^{n} Imp(\widetilde{E1}/C_{1j})}$	$\frac{Imp(\widetilde{E1}/C2)}{\sum_{j=1}^{n} Imp(\widetilde{E1}/C_{1j})}$	…	$\frac{Imp(\widetilde{E1}/Cn)}{\sum_{j=1}^{n} Imp(\widetilde{E1}/C_{1j})}$
E2	$\frac{Imp(\widetilde{E2}/C1)}{\sum_{j=1}^{n} Imp(\widetilde{E2}/C_{2j})}$	$\frac{Imp(\widetilde{E2}/C2)}{\sum_{j=1}^{n} Imp(E2/C_{2j})}$	…	$\frac{Imp(\widetilde{E2}/Cn)}{\sum_{j=1}^{n} Imp(E2/C_{2j})}$

E3	$\frac{Imp(\widetilde{E3}/C1)}{\sum_{j=1}^{n} Imp(\widetilde{E3}/C_{3j})}$	$\frac{Imp(\widetilde{E3}/C2)}{\sum_{j=1}^{n} Imp(\widetilde{E3}/C_{3j})}$	…	$\frac{Imp(\widetilde{E3}/Cn)}{\sum_{j=1}^{n} Imp(\widetilde{E3}/C_{3j})}$
E4	$\frac{Imp(\widetilde{E4}/C1)}{\sum_{j=1}^{n} Imp(\widetilde{E4}/C4_{j})}$	$\frac{Imp(\widetilde{Em}/C2)}{\sum_{j=1}^{n} Imp(\widetilde{Em}/C_{4j})}$	…	$\frac{Imp(\widetilde{E4}/Cn)}{\sum_{j=1}^{n} Imp(\widetilde{E4}/C_{nj})}$

2) To determine the final fuzzy values of the weight coefficients of the evaluation criteria $(\widetilde{w1}, \widetilde{w2}, \ldots, \widetilde{wn})^T$, The mean values are determined. The Fuzzy EDM ($\widetilde{EDM}$) is utilized to calculate the final weight value of each criterion using Equation 9.

$$\widetilde{w_j} = \left(\sum_{i=1}^{m} \frac{Imp(\widetilde{E_{ij}}/C_{ij})}{\sum_{j=1}^{n} Imp(\widetilde{E_{ij}}/C_{ij})}\right)/m\ ), \text{for } i = 1,2,3,..m \text{ and } j = 1,2,3,..n \quad (9)$$

3) The most common defuzzification method is the centroid approach, which is used to determine the final weight. The mathematical formula for this process using TFNs is $((a + b + c))/3$. Prior to determining the final values of the weight coefficients, each criterion should be given a weight of importance based on the sum of all weights for the rescaling purpose employed in this phase.

At this point and after calculating the weights for 19 criteria.

3.4 PHASE 4: VIKOR for Ranking Patients

We employ the VIKOR method to evaluate and benchmark the 432 alternatives for the ASD patients as follows:

STEP 1: Mark the worst f^-i and best f^*i values for the overall ASD criteria, as i=1; 2; ...; n. If the ith criteria function act as a benefit, then

$$\int_i^* = max_j \int ij, \quad \int_i^- = min_j \int ij, \quad (10)$$

STEP 2: The weights for each criterion (FWIZC weights) are introduced to VIKOR throughout this phase. The decision-makers set of weights, $\mathrm{w} = \mathrm{w}_1, \mathrm{w}_2, \mathrm{w}_3, \cdots, \mathrm{w}_j, \cdots, \mathrm{w}_n$, is accommodated in the DM and is equal to 1. Calculating the resultant matrix is also possible, as shown in Equation 11 below:

$$WM = wi * (f^*i - fij\ )/(f^*i - f^-i\ ) \quad (11)$$

Upon applying the above process, it will produce a new weighted matrix as follows:

$$\begin{bmatrix} w_1(f^*1 - f11\ )/(f^*1 - f^-1\ ) & w_2(f^*2 - f12\ )/(f^*2 - f^-2\ ) & \ldots & w_i(f^*i - fij\ )/(f^*i - f^-i\ ) \\ w_1(f^*1 - f21\ )/(f^*1 - f^-1\ ) & w_2(f^*2 - f22\ )/(f^*2 - f^-2\ ) & \ldots & w_i(f^*i - fij\ )/(f^*i - f^-i\ ) \\ \vdots & \vdots & \vdots & \vdots \\ w_1(f^*1 - f31\ )/(f^*1 - f^-1\ ) & w_2(f^*2 - f32\ )/(f^*2 - f^-2) & \ldots & w_i(f^*i - fij\ )/(f^*i - f^-i\ ) \end{bmatrix} \quad (12)$$

STEP 3: Compute the values Sj and Rj , $j = 1,2,3, \ldots., J, i = 1,2,3, \ldots, n$ by using the following equations:

$$Sj = \sum_{i=1}^{n} wi * (f^*i - fij\ )/(f^*i - f^-i\ ) \quad (13)$$

$$Rj = \max_i wi\ * (f^*i - fij\ )/(f^*i - f^-i\ ) \quad (14)$$

Where wi are the weights of criteria expressing their relative importance.

STEP 4: Calculate the values $\mathrm{Qj,j} = (1,2, \cdots, \mathrm{J})$ using Equation 15:

$$Q_j = \frac{v(S_j - S^*)}{S^- - S^*} + \frac{(1-v)(R_j - R^*)}{R^- - R^*} \quad (15)$$

Where:

$\mathrm{S}^* = \min_j \mathrm{S}_j$, $\mathrm{S}^- = \max_j \mathrm{S}_j$

$\mathrm{R}^* = \min_j \mathrm{R}_j$, $\mathrm{R}^- = \max_j \mathrm{R}_j$

v is presented as the weight of the strategy of 'the majority of criteria' or 'the maximum group utility'; in this research, v = 0.5.

STEP 5: The alternative set, which consists of ASD patients, is sorted in ascending order based on the value Q. The lowest value obtained from each detection model indicates a higher emergency level for the patient. After individual rankings are completed, variations may be observed among different decision makers involved in the research. To combine the individual decisions and obtain an aggregated ranking, the scores of each alternative in Group Decision Making (GDM) are calculated using an arithmetic mean. The alternative with the highest mean value is considered the best alternative and represents the most critical emergency situation.

3.5 PHASE 5: Evaluation Framework

In this phase, a sensitivity analysis was performed to investigate the effect of different weight allocations on the prioritization outcomes. The purpose of the sensitivity analysis was to assess the robustness of the decision framework and understand how changes in criteria weights could impact the final rankings of autism patients' emergency levels. The 19 criteria were divided into two groups: the first group included 10 criteria, and the second group included 9 criteria, as described in Equation 16. The objective was to examine how variations in weight allocations within these groups would influence the prioritization results.

$$wf = (wo * ws) \tag{16}$$

Furthermore, to determine the weight of each criterion, the original weight assigned to the criterion (*wo*) was adjusted through the sensitivity analysis. The adjusted weight (*ws*) was calculated using Equation 17.

$$ws = (m/n) * 100 \qquad \dots (17)$$

where *m* represents the chosen percentage for the weight allocation scenario, and *n* represents the total number of criteria in the group. The sensitivity analysis was conducted using four weight allocation scenarios: 60%:40%, 40%:60%, 70%:30%, and 30%:70%. By implementing these different weight allocations, we examined how the changes affected the final rankings of autism patients' emergency levels. The new scores for each alternative were calculated using the VIKOR method, and the results were compared across the scenarios.

4. Results and Discussion

This section provides a comprehensive overview of the results achieved through the proposed framework for prioritizing ASD patients with moderate injury levels. The section presents the results of the decision matrix, highlighting the priority weights assigned to the evaluation criteria using the FWZIC method. It also showcases the prioritization results obtained through the VIKOR method. Additionally, this chapter discusses the evaluation framework for the proposed methodology, including a sensitivity analysis using four different weight allocation scenarios. These findings contribute to a better understanding of the patients' status and help identify cases that require immediate attention and intervention.

4.1 Decision Matrix Results

The decision matrix, which represents the ASD dataset for the 432 patients, is presented in Table 7.

TABLE VII. SAMPLES OF FOUR PATIENTS WITHIN THE DEVELOPED DECISION MATRIX

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19
1st patient	1	2	1	2	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1

2nd patient	1	2	2	2	1	1	2	1	2	1	1	1	1	1	1	2	1	1	1
3rd patient	1	2	2	2	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1
4th patient	1	2	2	2	1	1	1	1	2	1	1	1	1	2	1	2	1	1	1

In this step, the evaluation of the decision matrix is carried out using the ASD data of the 19 criteria. The weights for each criterion are required, as discussed in the next section.

4.2 Weights Result

The FWZIC method, as described in a previous study [13], was used to determine the priority weights for each criterion in the decision matrix. In [13], four experts with expertise in ASD were selected to provide their subjective judgments and weight the 19 criteria based on their experience. The experts used the Five-point Likert scale and the corresponding numerical scale presented in Table 3 in Section 3 to provide their judgments for the criteria. These judgments are reflected in the EDM presented in Table 8. It is important to note that the presentation of these weights, which were already constructed in [13], is done to establish a connection between the results of different phases and to provide clarity for the readers.

TABLE VIII. EDM RESULTS OF [13]

Criteria \ Experts	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**
1st Expert	4	4	4	4	3	2	3	4	5	4	1	5	1	4	4	5	2	4	2
2nd Expert	2	3	2	3	2	1	3	4	5	5	4	5	2	5	4	5	4	4	4
3rd Expert	4	4	3	4	3	3	4	3	3	3	3	5	3	2	2	2	3	4	3

4^{th} Expert	3	2	3	4	2	1	3	5	4	3	4	4	2	4	4	5	4	5	3

Depending on the EDM Table, the weights result of the 19 criteria based on the FWZIC method for the four experts are presented in Table 9.

TABLE IX. RESULT OF WEIGHTING 19 CRITERIA OF ASD PATIENTS [13]

ASD Criteria	FWZIC Weights
C1=Verbal communication	0.07298
C2=Laughing for no reason	0.06666
C3=Nodding	0.06528
C4=Patient movement at home	0.06330
C5=Pointing with the index finger	0.06232
C6=Complications of childbirth	0.05976
C7=Spinning round things	0.05822
C8=Bathroom skills	0.05711
C9=Wave	0.05412
C10=Unnecessary drug	0.05185
C11=Maternal diseases during pregnancy	0.05117
C12=Afraid of loud sounds	0.05073
C13=Patient's Gender	0.04969
C14=Notice the sound of the bell	0.04713
C15=Premature baby	0.04707
C16=Crying for no reason	0.04675
C17=Marital Relationship	0.03853
C18=Taste the food	0.03037
C19=Consanguinity	0.02687

As shown in Table 9, the criterion 'verbal communication' obtained the highest weight of 0.07298183, indicating its significant impact on ASD patients. Several other criteria, including 'laughing for no reason', 'nodding', 'patient movement at home', and 'pointing with the index finger', also obtained relatively high weights, suggesting their importance in assessing ASD. On the other hand, the criterion 'consanguinity' received the lowest weight of 0.026873862, indicating that it may have lower priority in relation to ASD patients. The results of the criteria weighting were discussed with the four experts, who provided their analysis and positive opinions on using these weights in their diagnosis through a questionnaire. The ranking results of the VIKOR method for ASD patients will be presented in the following section, considering the weightings obtained through the FWZIC method.

4.3 VIKOR Prioritization Result

In this stage, the VIKOR method is applied to benchmark the 432 patients and identify high emergency cases based on the weights assigned to the evaluation criteria. The overall weights obtained from Table 9 are incorporated into the VIKOR method, utilizing the configurations derived from the FWZIC method. The patients are ranked according to their value Q, with the ranking presented in ascending order in Table 10. Additionally, a visualization of the first 100 ranks is shown in Figure 4. These rankings provide valuable insights into the priority levels of the ASD patients, helping to identify those requiring immediate attention and intervention.

TABLE X. VIKOR RESULTS OF THE BENCHMARKING OF MODERATE EMERGENCY LEVEL FOR ASD PATIENTS

Patients	Q Value	Ranking Order	Patients	Q Value	Ranking Order	Patients	Q Value	Ranking Order	Patients	Q Value	Ranking Order
P1	0.6189	230	**P109**	0.6268	224	**P217**	0.6743	183	**P325**	0.9147	27
P2	0.4705	311	**P110**	0.5594	267	**P218**	0.6534	200	**P326**	0.6843	173
P3	0.4662	312	**P111**	0.7251	152	**P219**	0.1196	429	**P327**	0.6541	197
P4	0.4804	308	**P112**	0.6056	237	**P220**	0.9350	17	**P328**	0.8918	39
P5	0.5016	296	**P113**	0.9345	18	**P221**	0.2742	403	**P329**	0.7548	138
P6	0.4260	332	**P114**	0.7662	125	**P222**	0.4276	328	**P330**	0.4103	347
P7	0.4026	352	**P115**	0.8345	74	**P223**	0.6329	219	**P331**	0.6609	190
P8	0.3017	389	**P116**	0.3419	376	**P224**	0.8713	51	**P332**	0.5106	292
P9	0.4142	343	**P117**	0.5439	274	**P225**	0.5023	295	**P333**	0.2993	394
P10	0.0523	431	**P118**	0.2566	411	**P226**	0.1849	421	**P334**	0.5700	253
P11	0.4068	349	**P119**	0.4003	355	**P227**	0.4937	302	**P335**	0.7763	113
P12	0.3554	373	**P120**	0.8623	61	**P228**	0.7739	115	**P336**	0.4087	348
P13	0.5298	281	**P121**	0.5051	294	**P229**	0.2131	418	**P337**	0.6887	169
P14	0.7837	110	**P122**	0.7491	141	**P230**	0.4943	301	**P338**	1.0000	1
P15	0.7231	153	**P123**	0.8066	86	**P231**	0.5990	241	**P339**	0.6655	188
P16	0.6881	170	**P124**	0.7512	139	**P232**	0.9067	31	**P340**	0.3266	382
P17	0.4170	341	**P125**	0.4436	320	**P233**	0.9119	28	**P341**	0.8219	81
P18	0.4544	316	**P126**	0.5147	288	**P234**	0.8658	59	**P342**	0.7886	98
P19	0.4147	342	**P127**	0.8711	54	**P235**	0.1848	422	**P343**	0.7347	151
P20	0.9296	22	**P128**	0.8050	87	**P236**	0.6360	215	**P344**	0.8867	41
P21	0.7670	123	**P129**	0.4718	310	**P237**	0.7844	107	**P345**	0.2455	412
P22	0.6235	227	**P130**	0.7004	166	**P238**	0.8976	36	**P346**	0.8668	58
P23	0.7740	114	**P131**	0.2428	414	**P239**	0.7572	128	**P347**	0.6155	232
P24	0.9039	33	**P132**	0.7550	137	**P240**	0.9387	15	**P348**	0.9678	10
P25	0.6445	206	**P133**	0.4841	307	**P241**	0.6328	220	**P349**	0.5125	290
P26	0.4270	331	**P134**	0.3633	368	**P242**	0.2911	399	**P350**	0.3621	370
P27	0.9271	23	**P135**	0.5393	276	**P243**	0.7498	140	**P351**	0.6221	228
P28	0.4854	306	**P136**	0.7552	136	**P244**	0.8851	43	**P352**	0.9029	34
P29	0.6387	214	**P137**	0.6570	193	**P245**	0.7982	91	**P353**	0.1811	424
P30	0.3700	366	**P138**	0.8520	71	**P246**	0.5894	245	**P354**	0.6113	235
P31	0.8074	85	**P139**	0.7035	165	**P247**	0.8183	83	**P355**	0.3305	380
P32	0.5473	273	**P140**	0.7723	117	**P248**	0.8828	45	**P356**	0.9221	26
P33	0.6319	221	**P141**	0.6451	205	**P249**	0.7854	105	**P357**	0.8267	78
P34	0.3992	356	**P142**	0.7678	121	**P250**	0.7733	116	**P358**	0.6506	203
P35	0.5491	271	**P143**	0.7075	163	**P251**	0.8521	70	**P359**	0.6600	191
P36	0.4219	336	**P144**	0.7382	150	**P252**	0.5163	286	**P360**	0.7859	104
P37	0.7173	154	**P145**	0.6871	171	**P253**	0.7912	96	**P361**	0.1968	420
P38	0.8694	56	**P146**	0.3880	359	**P254**	0.6855	172	**P362**	0.4895	303
P39	0.4105	346	**P147**	0.6748	182	**P255**	0.8945	38	**P363**	0.7714	118
P40	0.7673	122	**P148**	0.7850	106	**P256**	0.8577	65	**P364**	0.6520	201
P41	0.6197	229	**P149**	0.6588	192	**P257**	0.6285	223	**P365**	0.5493	270

P42	0.2010	419	**P150**	0.4644	313	**P258**	0.6676	185	**P366**	0.6643	189
P43	0.3217	383	**P151**	0.6422	209	**P259**	0.2862	400	**P367**	0.4981	297
P44	0.6347	218	**P152**	0.2697	404	**P260**	0.5611	265	**P368**	0.3812	361
P45	0.4129	344	**P153**	0.5286	282	**P261**	0.7663	124	**P369**	0.6749	181
P46	0.8888	40	**P154**	0.4042	350	**P262**	0.7767	112	**P370**	0.3783	362
P47	0.8729	46	**P155**	0.6809	178	**P263**	0.5399	275	**P371**	0.8700	55
P48	0.7865	102	**P156**	0.5637	261	**P264**	0.8537	66	**P372**	0.8621	62
P49	0.5662	259	**P157**	0.7458	145	**P265**	0.2298	416	**P373**	0.2317	415
P50	0.6685	184	**P158**	0.5263	283	**P266**	0.4979	298	**P374**	0.7108	158
P51	0.1705	425	**P159**	0.3938	358	**P267**	0.5872	246	**P375**	0.2433	413
P52	0.4196	338	**P160**	0.4226	334	**P268**	0.7430	146	**P376**	0.1672	426
P53	0.4459	319	**P161**	0.7944	95	**P269**	0.4433	321	**P377**	0.9565	11
P54	0.7396	147	**P162**	0.9787	8	**P270**	0.9894	4	**P378**	0.6670	186
P55	0.5649	260	**P163**	0.9796	6	**P271**	0.5685	258	**P379**	0.1644	427
P56	0.2635	407	**P164**	0.4304	327	**P272**	0.7382	149	**P380**	0.3311	379
P57	0.8728	47	**P165**	0.8712	53	**P273**	0.6548	196	**P381**	0.1847	423
P58	0.5689	255	**P166**	0.7712	120	**P274**	0.6511	202	**P382**	0.5215	284
P59	0.7885	99	**P167**	0.5686	257	**P275**	0.8672	57	**P383**	0.2156	417
P60	0.6567	194	**P168**	0.6761	180	**P276**	0.8721	50	**P384**	0.6119	234
P61	0.8089	84	**P169**	0.6537	199	**P277**	0.5145	289	**P385**	0.7958	93
P62	0.6470	204	**P170**	0.8725	49	**P278**	0.9338	19	**P386**	0.2989	396
P63	0.4887	304	**P171**	0.3159	385	**P279**	0.5167	285	**P387**	0.3005	392
P64	0.3323	378	**P172**	0.8521	70	**P280**	0.6812	177	**P388**	0.6388	213
P65	0.8342	75	**P173**	0.4019	354	**P281**	0.3872	360	**P389**	0.3560	372
P66	0.9024	35	**P174**	0.3759	364	**P282**	0.0499	432	**P390**	0.7562	132
P67	0.4397	323	**P175**	0.7568	130	**P283**	0.3016	390	**P391**	0.7077	162
P68	0.5694	254	**P176**	0.5969	243	**P284**	0.1079	430	**P392**	0.2599	410
P69	0.8531	67	**P177**	0.7092	160	**P285**	0.6093	236	**P393**	0.2639	406
P70	0.6291	222	**P178**	0.4968	300	**P286**	0.1570	428	**P394**	0.7839	109
P71	0.8191	82	**P179**	0.9236	25	**P287**	0.5484	272	**P395**	0.7144	156
P72	0.7460	144	**P180**	0.6051	239	**P288**	0.4206	337	**P396**	0.9311	21
P73	0.3667	367	**P181**	0.4534	318	**P289**	0.8005	90	**P397**	0.5616	264
P74	0.6661	187	**P182**	0.6824	176	**P290**	0.4397	322	**P398**	0.6347	217
P75	0.2965	397	**P183**	0.9081	30	**P291**	0.4173	340	**P399**	0.5734	251
P76	0.4035	351	**P184**	0.7462	143	**P292**	0.4380	324	**P400**	0.3938	358
P77	0.4361	325	**P185**	0.6267	226	**P293**	0.4189	339	**P401**	0.4226	334
P78	0.5149	287	**P186**	0.5834	248	**P294**	0.3119	386	**P402**	0.7944	95
P79	0.7062	164	**P187**	0.4271	330	**P295**	0.7560	133	**P403**	0.9787	8
P80	0.5377	277	**P188**	0.6425	208	**P296**	0.5328	280	**P404**	0.9796	6
P81	0.5931	244	**P189**	0.7556	135	**P297**	0.2963	398	**P405**	0.4304	327
P82	0.9368	16	**P190**	0.6889	168	**P298**	0.6119	234	**P406**	0.8712	53
P83	0.7383	148	**P191**	0.9900	3	**P299**	0.7958	93	**P407**	0.7712	120
P84	0.4730	309	**P192**	0.6565	195	**P300**	0.2989	396	**P408**	0.5686	257
P85	0.7136	157	**P193**	0.7615	127	**P301**	0.3005	392	**P409**	0.6761	180
P86	0.3621	370	**P194**	0.5726	252	**P302**	0.6388	213	**P410**	0.6537	199

P87	0.5350	278	**P195**	0.8295	76	**P303**	0.3560	372	**P411**	0.8725	49
P88	0.9457	13	**P196**	0.5091	293	**P304**	0.7562	132	**P412**	0.3159	385
P89	0.3543	374	**P197**	0.3003	393	**P305**	0.7077	162	**P413**	0.8521	70
P90	0.6392	211	**P198**	0.5575	268	**P306**	0.2599	410	**P414**	0.4019	354
P91	0.8459	73	**P199**	0.4225	335	**P307**	0.2639	406	**P415**	0.3759	364
P92	0.2793	401	**P200**	0.7889	97	**P308**	0.7839	109	**P416**	0.7568	130
P93	0.8947	37	**P201**	0.5608	266	**P309**	0.7144	156	**P417**	0.5969	243
P94	0.4574	315	**P202**	0.6830	174	**P310**	0.9311	21	**P418**	0.7092	160
P95	0.8025	88	**P203**	0.9456	14	**P311**	0.5616	264	**P419**	0.4968	300
P96	0.5106	292	**P204**	0.4122	345	**P312**	0.6347	217	**P420**	0.9236	25
P97	0.8834	44	**P205**	0.3437	375	**P313**	0.5734	251	**P421**	0.6051	239
P98	0.8275	77	**P206**	0.4606	314	**P314**	0.7881	100	**P422**	0.4534	318
P99	0.4855	305	**P207**	0.9040	32	**P315**	0.5334	279	**P423**	0.6824	176
P100	0.8243	79	**P208**	0.3048	387	**P316**	0.3299	381	**P424**	0.9081	30
P101	0.5633	262	**P209**	0.3392	377	**P317**	0.8856	42	**P425**	0.7462	143
P102	0.8627	60	**P210**	0.6041	240	**P318**	0.9708	9	**P426**	0.6267	226
P103	0.2601	408	**P211**	0.7864	103	**P319**	0.6399	210	**P427**	0.5834	248
P104	0.5742	249	**P212**	0.8620	63	**P320**	0.8468	72	**P428**	0.4271	330
P105	0.3748	365	**P213**	0.9538	12	**P321**	0.8599	64	**P429**	0.6425	208
P106	0.3017	388	**P214**	0.5534	269	**P322**	0.2749	402	**P430**	0.7556	135
P107	0.8008	89	**P215**	0.8237	80	**P323**	0.7648	126	**P431**	0.6889	168
P108	0.7880	101	**P216**	0.6184	231	**P324**	0.7832	111	**P432**	0.9900	3

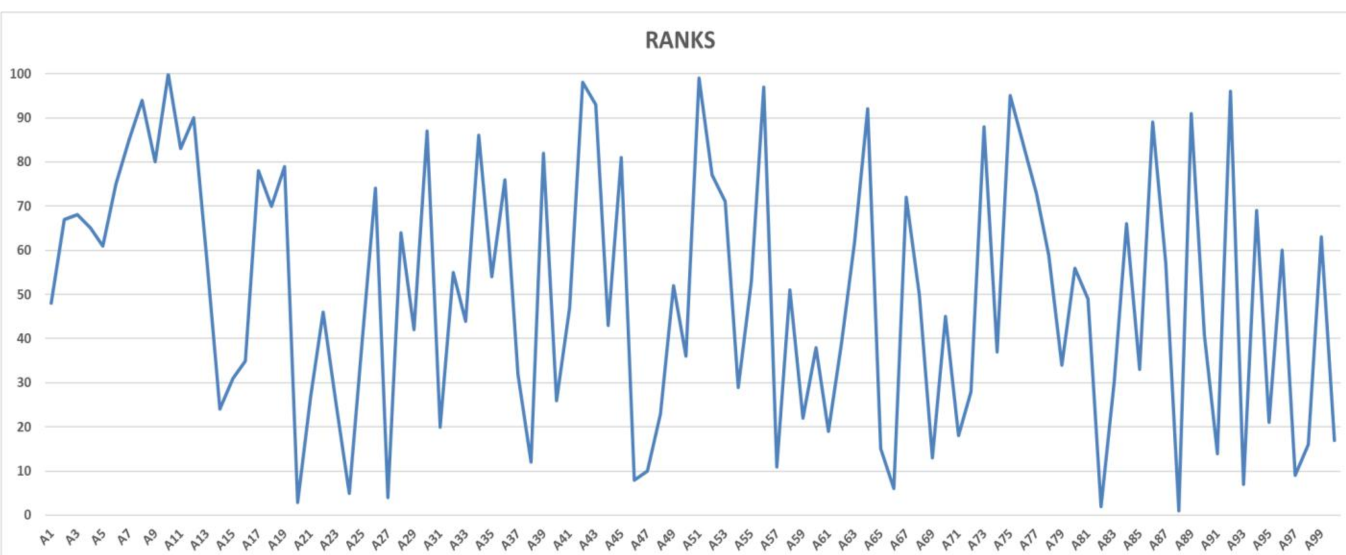

Fig. 4. Ranking samples of the first 100 ASD patients of moderate emergency level

In Table 11, the rankings of the first three emergency cases among the ASD patients are presented. These patients have been identified as requiring immediate attention based on their evaluation scores and prioritization using the VIKOR method. Table 12, on the other hand, displays the rankings of the last three patients, indicating those with the lowest priority levels among the evaluated cases. These tables provide a snapshot of the extreme cases in terms of emergency levels, aiding in the identification of patients who may need urgent interventions or can be managed with lower priority.

TABLE XI. FIRST THREE RANKS OF ASD PATIENTS OF MODERATE EMERGENCY LEVEL ACCORDING TO VIKOR METHOD

Patients / Criteria	Patient Gander	Marital Relationship	Consanguinity	Unnecessary drugs	Maternal diseases during pregnancy	Complications of childbirth	premature baby	Taste the food	Wave	Patient movement at home	Frightened by loud noises	Laughing for no reason	Crying for no reason	No verbal communication	Pointing with the index finger	Notice the sound of the bell	Bathroom skills	Nodding	Spinning round things
1st	no	yes	yes	no	yes	yes	no	no	yes	yes	no	yes	yes	yes	yes	yes	no	yes	no
2nd	yes	no	yes	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
3rd	yes	no	yes	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	yes

TABLE XII. LAST THREE RANKS OF ASD PATIENTS OF MODERATE EMERGENCY LEVEL ACCORDING TO VIKOR METHOD

Patients / Criteria	Patient Gander	Marital Relationship	Consanguinity	Unnecessary drugs	Maternal diseases during pregnancy	Complications of childbirth	premature baby	Taste the food	Wave	Patient movement at home	Frightened by loud noises	Laughing for no reason	Crying for no reason	No verbal communication	Pointing with the index finger	Notice the sound of the bell	Bathroom skills	Nodding	Spinning round things
100th	yes	no	no	no	no	yes	yes	no	yes	no	yes	no	no	no	yes	yes	no	no	no
99th	yes	yes	yes	no	no	no	no	yes	yes	yes	no	yes	no	no	no	yes	no	no	no
98th	yes	no	no	no	yes	no	no	no	no	yes	yes	no	no	no	yes	yes	yes	no	no

In Table 11, it can be observed that the top three ranked patients share common high-weighted criteria such as 'no verbal communication', 'laughing for no reason', 'nodding', and 'patient movement at home'. However, there may be slight differences in some criteria with lower weights, such as 'frightened by loud noises', 'taste the food', and 'notice the sound of the bell'. On t-he other hand, Table 12 represents the last three ranked patients, and when compared to the top three ranks, there are differences in the criteria with high weights. The top three ranks have a value of 'yes' for criteria like 'no verbal communication', 'laughing for no reason', and 'nodding', while the last three ranks have a value of 'no'. This highlights the importance of weight allocation and how it influences the ranking of patients. The benchmarking results obtained from the VIKOR method demonstrate the effectiveness of the prioritization approach in ranking and evaluating the 432 ASD patients based on the evaluation criteria and their assigned weights. The application of VIKOR allows for the identification of high emergency cases among the patients, enabling timely intervention and care.

4.4 Evaluation Framework

This section provides the results of the sensitivity analysis conducted in Phase 5. Four different weight allocation scenarios were implemented based on Equation 16 and 17, and the outcomes are presented in Table 12.

TABLE XII. SENSITIVELY WEIGHTS RESULT FOR THE FOUR SCENARIOS

Weights/Scenario	**Patient' s Gander**	**Marital Relationship**	**Consanguinity**	**Unnecessary drugs**	**Maternal diseases during pregnancy**	**Complications of childbirth**	**premature baby**	**Taste the food**	**Wave**	**Patient movement at home**	**Frightened by loud noises**	**Laughing for no reason**	**Crying for no reason**	**No verbal communication**	**Pointing with the index finger**	**Notice the sound of the bell**	**Bathroom skills**	**Nodding**	**Spinning round things**
Scenario 1	0.0576	0.0446	0.0311	0.0601	0.0593	0.0692	0.0545	0.0352	0.0627	0.0733	0.0435	0.0572	0.0401	0.0626	0.0535	0.0404	0.0490	0.0560	0.0500
Scenario 2	0.0368	0.0285	0.0199	0.0384	0.0379	0.0442	0.0348	0.0225	0.0401	0.0468	0.0626	0.0822	0.0577	0.0900	0.0769	0.0581	0.0704	0.0805	0.0718
Scenario 3	0.0686	0.0532	0.0371	0.0716	0.0707	0.0826	0.0650	0.0420	0.0748	0.0875	0.0334	0.0439	0.0308	0.0480	0.0410	0.0310	0.0376	0.0429	0.0383
Scenario 4	0.0270	0.0209	0.0146	0.0282	0.0278	0.0325	0.0256	0.0165	0.0294	0.0344	0.0715	0.0939	0.0659	0.1029	0.0878	0.0664	0.0805	0.0920	0.0821

The first scenario involved assigning weights of 60% to the first group and 40% to the second group. This allocation aimed to emphasize the importance of the criteria in the first group while considering the relevance of the criteria in the second group. In the second scenario, weights of 40% were assigned to the first group and 60% to the second group. This weight allocation aimed to give greater weightage to the criteria in the second group, acknowledging their potential impact on the prioritization outcomes. The third scenario allocated weights of 70% to the first group and 30% to the second group. This adjustment sought to increase the significance of the criteria in the first group in the prioritization process while downplaying the influence of the criteria in the second group. Lastly, the fourth scenario involved assigning weights of

30% to the first group and 70% to the second group. This distribution placed more emphasis on the criteria in the second group, recognizing their critical role in the decision-making process.

By examining the results of the sensitivity analysis presented in Table 12, we can observe the variations in the rankings of the ASD patients across the different weight allocation scenarios. This analysis provides valuable insights into how changes in weight allocations can impact the prioritization outcomes. It helps us understand the robustness and stability of the decision-making process and identify the criteria that have the most significant influence on the final rankings. The sensitivity analysis enhances our understanding of the decision model and its reliance on the assigned weights. It provides valuable information for decision-makers to consider when using the prioritization framework in practice.

Table 13 and Table 14 present the results of the sensitivity analysis, showcasing the changes in rankings and their implications for selecting the most emergency patients across the four weight allocation scenarios using the VIKOR method.

TABLE XIII. RANKS BY FOUR SENSITIVITY ANALYSIS USING PHASE 5 WEIGHTS WITH THE VIKOR METHOD (PATIENT 1 TO 216)

Patients	Original Rank	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Patients	Original Rank	Scenario 1	Scenario 2	Scenario 3	Scenario 4
P1	230	140	169	151	146	**P109**	224	318	227	339	88
P2	311	234	104	273	48	**P110**	267	219	109	217	188
P3	312	340	97	353	89	**P111**	152	213	293	170	349
P4	308	225	142	228	96	**P112**	237	288	238	277	306
P5	296	323	116	337	91	**P113**	18	419	400	417	399
P6	332	286	94	322	51	**P114**	125	236	321	219	375
P7	352	148	102	135	99	**P115**	74	133	364	18	315
P8	389	229	45	247	47	**P116**	376	14	89	16	132
P9	343	232	139	222	43	**P117**	274	375	182	375	50
P10	431	4	5	26	14	**P118**	411	141	21	181	19
P11	349	3	133	12	85	**P119**	355	28	99	46	276
P12	373	124	57	138	53	**P120**	61	120	414	83	361
P13	281	291	144	326	149	**P121**	294	12	137	6	243
P14	110	97	313	80	308	**P122**	141	334	288	305	354
P15	153	220	265	218	352	**P123**	86	275	351	252	402
P16	170	387	289	392	136	**P124**	139	64	349	51	381
P17	341	305	61	333	24	**P125**	320	154	180	100	137
P18	316	235	77	299	69	**P126**	288	15	152	7	332
P19	342	17	135	24	267	**P127**	54	314	398	278	411
P20	22	377	401	381	366	**P128**	87	282	344	260	295
P21	123	261	280	268	216	**P129**	310	386	100	396	80
P22	227	144	174	153	187	**P130**	166	208	258	180	178
P23	114	376	263	384	325	**P131**	414	109	27	127	44
P24	33	365	385	369	248	**P132**	137	246	275	251	271
P25	206	204	148	236	113	**P133**	307	228	141	237	74
P26	331	210	86	223	160	**P134**	368	128	66	136	18
P27	23	382	393	391	326	**P135**	276	90	93	111	247
P28	306	202	140	184	103	**P136**	136	62	363	57	374
P29	214	51	187	55	161	**P137**	193	47	260	20	342
P30	366	82	82	77	162	**P138**	71	396	361	390	338
P31	85	289	335	276	321	**P139**	165	61	264	9	302
P32	273	378	184	376	142	**P140**	117	260	294	258	277

P33	221	121	226	90	215	**P141**	205	143	222	126	303
P34	356	108	90	95	122	**P142**	121	238	326	220	350
P35	271	250	173	264	115	**P143**	163	196	281	146	390
P36	336	346	72	363	57	**P144**	150	418	336	416	272
P37	154	319	259	301	336	**P145**	171	57	256	54	227
P38	56	335	373	334	305	**P146**	359	25	87	45	100
P39	346	114	98	99	118	**P147**	182	183	231	165	317
P40	122	374	262	379	185	**P148**	106	245	348	221	278
P41	229	48	171	60	78	**P149**	192	193	194	205	173
P42	419	96	12	129	6	**P150**	313	379	95	395	40
P43	383	218	32	263	25	**P151**	209	168	189	175	83
P44	218	132	214	112	138	**P152**	404	76	19	98	35
P45	344	163	58	201	131	**P153**	282	11	196	2	189
P46	40	356	375	359	403	**P154**	350	182	75	200	86
P47	46	336	378	332	391	**P155**	178	54	250	53	281
P48	102	89	337	72	398	**P156**	261	136	200	186	125
P49	259	34	257	11	194	**P157**	145	364	232	377	231
P50	184	184	215	176	68	**P158**	283	268	170	281	119
P51	425	86	4	133	8	**P159**	358	26	91	47	104
P52	338	173	106	169	111	**P160**	334	265	112	282	107
P53	319	351	111	352	64	**P161**	95	293	299	306	384
P54	147	254	241	292	184	**P162**	8	428	415	425	427
P55	260	24	164	23	109	**P163**	6	420	425	421	368
P56	407	145	22	193	46	**P164**	327	130	114	119	167
P57	47	350	357	368	228	**P165**	53	406	345	414	343
P58	255	98	134	103	197	**P166**	120	84	322	92	312
P59	99	287	301	296	268	**P167**	257	269	190	284	127
P60	194	166	218	145	285	**P168**	180	206	212	208	206
P61	84	381	327	366	291	**P169**	199	49	219	49	319
P62	204	142	225	124	242	**P170**	49	337	376	335	282
P63	304	205	143	187	95	**P171**	385	185	47	202	81
P64	378	209	53	224	135	**P172**	70	401	339	404	237
P65	75	117	384	107	413	**P173**	354	179	73	194	37
P66	35	410	383	412	293	**P174**	364	102	63	108	120
P67	323	304	96	311	28	**P175**	130	239	296	229	213
P68	254	115	110	144	219	**P176**	243	126	145	140	220
P69	67	322	367	321	307	**P177**	160	199	283	147	299
P70	222	129	208	113	265	**P178**	300	391	127	397	251
P71	82	309	312	331	405	**P179**	25	197	423	122	378
P72	144	430	360	423	199	**P180**	239	105	201	86	208
P73	367	137	62	149	150	**P181**	318	164	120	154	133
P74	187	397	287	383	182	**P182**	176	55	252	61	345
P75	397	226	35	215	42	**P183**	30	366	387	370	396
P76	351	244	103	257	102	**P184**	143	69	324	68	330
P77	325	170	147	134	63	**P185**	226	38	239	29	235
P78	287	21	105	41	153	**P186**	248	31	178	32	210
P79	164	217	251	213	193	**P187**	330	174	118	160	180

P80	277	20	151	15	141	**P188**	208	36	278	3	323
P81	244	42	163	44	362	**P189**	135	248	273	254	266
P82	16	352	428	314	421	**P190**	168	298	242	261	392
P83	148	216	310	172	304	**P191**	3	422	430	419	356
P84	309	221	136	226	98	**P192**	195	187	198	196	261
P85	157	332	221	344	124	**P193**	127	233	315	216	234
P86	370	150	40	190	21	**P194**	252	35	138	42	289
P87	278	23	122	22	322	**P195**	76	110	380	110	355
P88	13	413	422	403	353	**P196**	293	252	157	267	76
P89	374	107	76	94	106	**P197**	393	171	38	192	41
P90	211	46	236	36	335	**P198**	268	19	205	8	203
P91	73	147	365	128	269	**P199**	335	347	34	364	54
P92	401	66	44	59	129	**P200**	97	357	338	318	241
P93	37	370	368	385	309	**P201**	266	33	124	40	174
P94	315	214	131	204	151	**P202**	174	189	246	166	382
P95	88	300	305	308	157	**P203**	14	416	419	407	324
P96	292	73	83	81	250	**P204**	345	243	79	233	79
P97	44	327	397	310	389	**P205**	375	201	81	185	65
P98	77	320	317	341	294	**P206**	314	215	129	211	284
P99	305	383	125	387	155	**P207**	32	399	420	354	341
P100	79	301	352	286	260	**P208**	387	176	42	197	29
P101	262	29	149	5	275	**P209**	377	8	78	21	75
P102	60	324	371	325	240	**P210**	240	41	188	39	246
P103	408	65	29	63	101	**P211**	103	283	295	294	380
P104	249	58	230	70	116	**P212**	63	306	394	274	425
P105	365	169	46	207	20	**P213**	12	380	421	367	404
P106	388	78	39	79	87	**P214**	269	292	199	303	218
P107	89	385	304	380	328	**P215**	80	302	350	295	290
P108	101	363	331	330	339	**P216**	231	122	203	104	232

TABLE XIV. RANKS BY FOUR SENSITIVITY ANALYSIS USING PHASE 5 WEIGHTS WITH THE VIKOR METHOD (PATIENT 217 TO 432)

Patients	**Original Rank**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Patients**	**Original Rank**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
P217	183	271	254	225	340	**P325**	27	203	411	143	371
P218	200	361	271	360	58	**P326**	173	60	237	71	158
P219	429	113	2	183	3	**P327**	197	211	158	242	298
P220	17	369	417	351	279	**P328**	39	330	404	302	383
P221	403	231	20	246	13	**P329**	138	345	272	342	245
P222	328	355	80	374	30	**P330**	347	167	101	156	177
P223	219	159	176	171	249	**P331**	190	325	270	329	110
P224	51	349	355	372	217	**P332**	292	73	83	81	49
P225	295	16	108	14	66	**P333**	394	195	30	231	55
P226	421	6	15	35	45	**P334**	253	295	223	287	165

P227	302	311	183	319	156	**P335**	113	296	261	328	222
P228	115	264	298	259	152	**P336**	348	158	107	142	239
P229	418	104	14	139	34	**P337**	169	373	330	358	395
P230	301	155	172	210	90	**P338**	1	400	429	400	372
P231	241	40	181	52	329	**P339**	188	53	216	56	176
P232	31	348	403	338	419	**P340**	382	1	67	13	175
P233	28	409	395	410	416	**P341**	81	290	362	265	376
P234	59	316	392	291	273	**P342**	98	263	334	244	418
P235	422	5	18	25	15	**P343**	151	358	374	320	386
P236	215	160	185	167	263	**P344**	41	405	381	401	225
P237	107	256	332	240	412	**P345**	412	135	17	177	62
P238	36	341	407	312	387	**P346**	58	398	379	386	287
P239	128	247	277	253	388	**P347**	232	138	165	150	367
P240	15	414	413	409	360	**P348**	10	223	432	214	393
P241	220	134	210	121	123	**P349**	290	278	123	317	39
P242	399	87	23	105	59	**P350**	370	150	40	190	130
P243	140	328	303	300	400	**P351**	228	276	282	234	297
P244	43	329	399	309	357	**P352**	34	417	359	424	166
P245	91	308	268	349	301	**P353**	424	77	8	96	7
P246	245	412	209	418	270	**P354**	235	161	126	198	92
P247	83	91	391	78	422	**P355**	380	99	50	102	154
P248	45	339	390	324	401	**P356**	26	415	396	413	406
P249	105	95	333	106	363	**P357**	78	125	358	97	394
P250	116	81	329	66	351	**P358**	203	360	269	361	314
P251	70	401	339	404	296	**P359**	191	353	302	348	259
P252	286	262	161	279	192	**P360**	104	285	290	298	145
P253	96	259	342	239	316	**P361**	420	88	13	116	27
P254	172	191	247	173	373	**P362**	303	284	168	235	226
P255	38	333	406	304	417	**P363**	118	83	318	67	370
P256	65	162	372	130	288	**P364**	201	408	267	411	258
P257	223	146	177	157	311	**P365**	270	224	217	199	286
P258	185	317	311	289	179	**P366**	189	326	276	327	253
P259	400	71	33	76	67	**P367**	297	331	160	357	56
P260	265	354	195	345	223	**P368**	361	149	71	164	60
P261	124	79	316	65	358	**P369**	181	59	224	73	212
P262	112	344	328	315	327	**P370**	362	227	85	245	147
P263	275	279	186	290	233	**P371**	55	172	382	189	377
P264	66	321	370	313	224	**P372**	62	343	347	362	198
P265	416	116	16	152	26	**P373**	415	212	3	250	2
P266	298	237	159	243	117	**P374**	158	63	266	58	254
P267	246	30	193	28	200	**P375**	413	13	56	17	11
P268	146	257	244	297	229	**P376**	426	75	7	91	61
P269	321	192	132	174	257	**P377**	11	393	408	399	420
P270	4	431	418	427	310	**P378**	186	315	309	288	126
P271	258	92	150	88	159	**P379**	427	72	6	89	4
P272	149	253	235	293	183	**P380**	379	297	26	323	5
P273	196	181	204	178	163	**P381**	423	80	9	101	22

P274	202	177	197	182	264	**P382**	284	267	166	275	52
P275	57	404	356	408	410	**P383**	417	190	11	232	12
P276	50	310	402	270	409	**P384**	234	312	206	346	204
P277	289	194	211	137	337	**P385**	93	280	319	271	255
P278	19	411	412	402	359	**P386**	396	152	51	158	32
P279	285	10	167	1	230	**P387**	392	156	54	162	93
P280	177	188	245	168	186	**P388**	213	394	248	393	139
P281	360	258	60	316	23	**P389**	372	118	69	117	190
P282	432	7	10	19	16	**P390**	132	389	353	388	347
P283	390	222	43	227	31	**P391**	162	424	285	428	143
P284	430	18	28	31	17	**P392**	410	111	36	114	9
P285	236	123	175	125	70	**P393**	406	67	24	74	72
P286	428	139	1	206	1	**P394**	109	100	307	131	364
P287	272	241	192	241	172	**P395**	156	426	291	430	333
P288	337	255	117	269	148	**P396**	21	371	409	355	414
P289	90	368	343	340	292	**P397**	264	273	233	248	201
P290	322	362	88	365	36	**P398**	217	44	228	37	195
P291	340	359	59	382	77	**P399**	251	93	155	84	164
P292	324	251	162	238	170	**P400**	358	26	91	47	104
P293	339	52	153	64	84	**P401**	334	265	112	282	107
P294	386	178	49	188	169	**P402**	95	293	299	306	384
P295	133	384	369	373	262	**P403**	8	428	415	425	427
P296	280	303	130	350	71	**P404**	6	420	425	421	368
P297	398	2	68	10	112	**P405**	327	130	114	119	167
P298	234	312	206	346	204	**P406**	53	406	345	414	343
P299	93	280	319	271	255	**P407**	120	84	322	92	312
P300	396	152	51	158	32	**P408**	257	269	190	284	127
P301	392	156	54	162	93	**P409**	180	206	212	208	206
P302	213	394	248	393	139	**P410**	199	49	219	49	319
P303	372	118	69	117	190	**P411**	49	337	376	335	282
P304	132	389	353	388	347	**P412**	385	185	47	202	81
P305	162	424	285	428	143	**P413**	70	401	339	404	237
P306	410	111	36	114	9	**P414**	354	179	73	194	37
P307	406	67	24	74	72	**P415**	364	102	63	108	120
P308	109	100	307	131	364	**P416**	130	239	296	229	213
P309	156	426	291	430	333	**P417**	243	126	145	140	220
P310	21	371	409	355	414	**P418**	160	199	283	147	299
P311	264	273	233	248	201	**P419**	300	391	127	397	251
P312	217	44	228	37	195	**P420**	25	197	423	122	378
P313	251	93	155	84	244	**P421**	239	105	201	86	208
P314	100	272	314	266	280	**P422**	318	164	120	154	133
P315	279	242	154	256	97	**P423**	176	55	252	61	345
P316	381	9	65	27	171	**P424**	30	366	387	370	396
P317	42	342	386	343	424	**P425**	143	69	324	68	330
P318	9	388	427	378	408	**P426**	226	38	239	29	235
P319	210	43	255	34	407	**P427**	248	31	178	32	210
P320	72	277	405	212	426	**P428**	330	174	118	160	180

P321	64	307	389	280	274	**P429**	208	36	278	3	323
P322	402	22	31	43	114	**P430**	135	248	273	254	266
P323	126	432	306	432	318	**P431**	168	298	242	261	392
P324	111	230	366	179	423	**P432**	3	422	430	419	75

Upon examining the rankings in Table 13 and Table 14, several observations can be made:

- **Scenario 1**: In this scenario, the first group of criteria is assigned a higher weight (60%) compared to the second group (40%). As a result, the rankings of some patients have changed compared to the original ranking. For example, patient A1 is ranked higher in Scenario 1 compared to the original ranking. This indicates that the criteria in the first group have a more significant impact on the prioritization outcomes in this scenario.
- **Scenario 2**: In this scenario, the weight allocation is reversed, with the second group of criteria receiving a higher weight (60%) and the first group a lower weight (40%). This adjustment leads to further changes in the rankings of the patients. For instance, patient A2 is ranked higher in Scenario 2 compared to the original ranking. This suggests that the criteria in the second group play a more prominent role in determining the emergency levels of the patients in this scenario.
- **Scenario 3**: Here, the weight allocation is skewed towards the first group of criteria, with a weight of 70%, while the second group receives a weight of 30%. This adjustment emphasizes the importance of the first group in the prioritization process. As a result, some patients experience significant changes in their rankings. For example, patient A3 is ranked considerably higher in Scenario 3 compared to the original ranking, indicating the increased significance of the criteria in the first group.
- **Scenario 4**: In this scenario, the weight allocation is reversed compared to Scenario 3. The second group of criteria is assigned a higher weight (70%), while the first group receives a lower weight (30%). The rankings of the patients are again affected by this adjustment. Patient A10, for instance, is ranked higher in Scenario 4 compared to the original ranking. This suggests that the criteria in the second group have a greater influence on the prioritization outcomes in this scenario.

By comparing the rankings across the four scenarios, it becomes apparent that different weight allocations result in varying rankings for the ASD patients. This demonstrates the sensitivity of the prioritization process to changes in criteria weights. It also highlights the importance of carefully considering the weight allocation and its implications for identifying high emergency cases. In conclusion, the results in Table 13 and Table 14 provide insights into the impact of different weight allocation scenarios on the rankings of ASD patients. This information can assist in understanding the robustness and stability of the decision-making process and aid in the selection of the most critical cases for immediate attention and intervention.

5. CONCLUSION

The integration of the FWZIC and VIKOR methods in this study has proven to be effective in prioritizing the emergency levels of autism patients with a moderate injury level. The developed framework provides a systematic and reliable approach for assessing and ranking patients based on their emergency needs. The experimental results and performance evaluation demonstrate the accuracy and effectiveness of the integrated methods in accurately prioritizing autism patients. The sensitivity analysis conducted in this study has highlighted the significance of weight configurations in the prioritization process. It emphasizes the need for careful consideration and selection of appropriate weights to ensure accurate and reliable rankings. This insight is crucial for healthcare professionals and decision-makers involved in prioritizing autism patients and allocating resources accordingly. The findings of this study contribute valuable insights to the field of autism patient prioritization, specifically for patients with a moderate injury level. By enabling early identification and intervention for these patients, healthcare professionals can take proactive measures to prevent their conditions from worsening. This framework addresses the needs of healthcare professionals and supports ongoing efforts to optimize patient care and resource allocation in the field of ASD medicine. However, it is important to acknowledge the limitations of this research. The study focused solely on autism patients with a moderate injury level and did not include patients with other levels of severity. Therefore, the proposed framework and results may not be applicable to patients in different severity categories. Additionally, the framework was developed and tested using a specific dataset, and its effectiveness may vary when applied to different datasets or populations. Further research and validation on diverse datasets are necessary to assess the generalizability of the framework.

In terms of future development, there is potential to create a real-time web-based application based on the proposed framework. Such an application would provide a user-friendly interface for healthcare professionals to input patient data and generate prioritization results efficiently. This would enhance the accessibility and usability of the framework.

Furthermore, extending the framework to include other severity levels of injury, such as urgent injury and minor injury autistic patients, would be beneficial. Adapting and expanding the framework to cater to a broader range of cases would enhance its applicability and relevance in the field of ASD patient care. Overall, this study has contributed to the understanding of prioritizing emergency levels in autism patients and has provided a foundation for further research and development in this area.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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