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ORIGINAL ARTICLE

# Developing Consensus-Based Criteria for Intensive Care Unit Admission Prioritization During Mass Casualty Incidents: A Delphi Study in Iran

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**Abstract:** **Introduction:** Mass casualty incidents create sudden surges in critical care demand that can overwhelm hospital capacity. This study aimed to develop consensus-based ICU admission criteria for mass casualty incidents. **Methods:** This methodological study employed a two-stage sequential design to identify, refine, and prioritize ICU admission criteria for mass casualty incidents (MCIs). First, an expert panel of 15 specialists in critical care, emergency medicine, and disaster management refined a preliminary checklist derived from a scoping review. Then, a two-round Delphi survey was conducted with 20 experts to assess consensus, and the study was reported in accordance with the CREDES recommendations. Consensus was predefined as a mean score of at least 4.0 on a five-point Likert scale. The response rate was 100%. **Results:** The initial checklist, which consisted of 46 criteria, was expanded to 51 items after the expert panel review. Following a two-round Delphi survey, consensus was reached on 18 criteria across six components: respiratory, cardiovascular, neurological, trauma and bleeding, multisystem, and special clinical considerations. The mean scores for these criteria ranged from 4.00 to 4.55, with the highest score being for respiratory rate at 4.55. Additionally, all retained items had an interquartile range of 1.00 to 1.25, indicating strong agreement among the experts. **Conclusions:** The proposed framework may serve as a preliminary decision-support tool for ICU triage in mass casualty incidents, based on expert consensus rather than clinical outcome validation. It may support equitable resource allocation and disaster preparedness, but external validation in other healthcare settings is required before broader application.

**Keywords:** Mass Casualty Incidents; Intensive Care Unit; ICU Admission; Patient Prioritization; Triage; Delphi Study

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## 1. Introduction

Mass casualty incidents (MCIs) represent critical challenges for healthcare systems globally. An MCI occurs when the number of casualties within a short timeframe exceeds available healthcare capacity and disrupts routine response capabilities (1, 2). The World Health Organization (WHO) defines these catastrophic events as incidents whose severity, magnitude, and diversity of casualties necessitate extraordinary mobilization of healthcare resources (3). Despite differing etiologies, all such surge events share a defining characteristic: a sudden, overwhelming increase in healthcare demand that strains system capacity(4).

Disaster management phases, mitigation, preparedness, response, and recovery, are essential for handling these events (5). The response phase is particularly critical, as hospitals serve as the cornerstone of the healthcare system (6, 7) Effective hospital performance during this phase can substantially reduce mortality and morbidity (8).

During surge events, hospitals must balance routine services with rapid patient influx; inadequate preparedness can lead to severe, potentially irreversible consequences (6, 9). Successful management relies on effective triage, resource allocation, and timely medical care (10-12) .

Recent decades have seen millions affected by such events, imposing considerable pressure on healthcare infrastructure. The demand for ICU services increases exponentially during these surge events, creating acute supply-demand imbalances (1, 13).

During these critical moments, ICU admission decisions must be made rapidly. However, standard severity scores such as SOFA, APACHE II, and NEWS are often unsuitable for this purpose. These tools are resource-intensive, time-consuming, and were not designed for the rapid, mass-casualty decision-making required during disaster contexts (14-16). In addition, they depend on information that may not be immediately available during surge conditions, which limits their practical utility for frontline ICU prioritization.

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The limited availability of context-specific prioritization frameworks tailored to these unique settings may contribute to inefficient resource utilization and delayed care. Although various tools have been proposed for critically ill patients, existing approaches for ICU prioritization during surge events remain heterogeneous, and many lack practical applicability under disaster conditions (15-19). A substantial body of literature has highlighted limitations in current ICU admission processes, particularly under resource scarcity (20-23).

To our knowledge, this study extends prior disaster triage and critical care consensus work by adapting a consensus-based ICU prioritization framework to the specific operational constraints of mass casualty incidents, with an emphasis on criteria that can be assessed rapidly at the bedside. Given the limited empirical evidence and the complexity of the issue, the Delphi method was considered an appropriate approach to achieve expert consensus. Therefore, this study aimed to identify, refine, and prioritize a set of consensus-based criteria for ICU admission during mass casualty incidents, using a two-stage expert panel and Delphi process.

## 2. Methods

### *2.1. Study Design and setting*

This methodological study employed a two-stage sequential design to identify, refine, and prioritize ICU admission criteria for mass casualty incidents (MCIs). The study consisted of two consecutive stages: (1) expert panel validation of a preliminary checklist and (2) a classical Delphi consensus process.

Initially, key variables, models, and instruments influencing ICU admissions during mass casualty incidents (MCIs) were identified, extracted, and synthesized through a scoping review. This process resulted in the development of a preliminary checklist of ICU admission criteria specific to MCI conditions. The checklist was created based on a review of 18 studies that identified and synthesized criteria across seven domains, as published by the authors of this article(24).

Figure 1 illustrates the study design and methodological process. It outlines the sequential stages of the study, which begin with a scoping review and the development of a preliminary checklist. This is followed by expert panel validation and refinement, the administration of a two-round Delphi questionnaire, and the provision of aggregated feedback between rounds. The process also includes the assessment of predefined consensus and the development of the final ICU admission framework.

### *2.2. Expert Panel Validation*

Expert panels are established methodological tools for evaluating and refining clinical criteria when no universally accepted gold standard is available (25). In the first stage, a 15-member expert panel was convened to review, validate, and refine the preliminary checklist. The panel comprised anesthesiologists and critical care specialists (n=6, 40%), emergency medicine specialists (n=5, 33.3%), PhD-prepared nurses (n=2, 13.3%), and hospital triage supervisors (n=2, 13.3%). The panel size was selected based on methodological considerations and the need to include diverse perspectives from relevant clinical and disaster-management disciplines. A panel of 15 experts was considered adequate to support content review while maintaining feasibility and allowing detailed evaluation of each criterion. Characteristics of Expert Panel and Delphi Panel participants are summarized in table 1.

### *2.3. Expert Selection Criteria*

Panelists were selected using purposive sampling and predefined inclusion criteria:

- a minimum of 10 years of clinical or managerial experience in critical care, emergency medicine, or MCI response;
- an advanced academic qualification, defined as at least a master's degree;
- institutional affiliation with a relevant healthcare or emergency-management organization; documented involvement in disaster or emergency response;
- geographic diversity across country.

These criteria were established to ensure that participants had sufficient professional experience, academic expertise, and practical familiarity with critical care and emergency response. The combination of clinical, managerial, and disaster-response experience was intended to strengthen the content validity and applicability of the refined checklist.

### *2.4. Delphi Study Participants*

In the second stage, a classical Delphi technique was employed to achieve expert consensus on ICU admission prioritization criteria. The process adhered to four core Delphi principles:

- participant anonymity,
- iterative rounds of structured input,
- the opportunity for participants to reconsider their ratings based on aggregated group feedback,
- provision of structured summaries between rounds (26).

A panel of 20 experts was recruited using purposive sampling. The Delphi panel included anesthesiologists and critical care specialists (n=10, 50%), emergency medicine specialists (n=5, 25%), PhD-prepared nurses (n=2, 10%), and hospital triage supervisors (n=3, 15%) (Table 1). All participants had at least 10 years of professional experience in critical care, emergency medicine, disaster management, or hospital emergency response.

The Delphi panel size was selected in accordance with established methodological considerations for Delphi studies. A panel of approximately 15–30 experts is generally considered sufficient to provide diversity of professional perspectives and reliable consensus while maintaining the feasibility of repeated data collection (27, 28). Accordingly, 20 experts were included to ensure adequate representation of the relevant professional groups without compromising the feasibility of the two-round process.

An equal-weight approach was applied to all responses to minimize hierarchical bias and ensure that the consensus reflected collective expert judgment rather than the influence of any particular professional group (29-32).

### *2.5. Data Collection Procedures*

A structured questionnaire was developed based on the criteria identified through the scoping review and was subsequently reviewed and refined by the expert panel. Participants rated the importance of each criterion for ICU admission during MCIs using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The Delphi process was conducted over two rounds. In Round 1, experts evaluated all criteria. Based on the analysis of the Round 1 responses, criteria with a mean score below 4.0 were excluded according to the predefined study decision rule (33), while the remaining criteria were retained for further evaluation in Round 2.

In Round 2, the revised questionnaire was redistributed to the same panel. Participants received a summary of the Round 1 finding before re-evaluating the criteria. This aggregated feedback included the mean score, standard deviation, and distribution of ratings for each criterion, together with anonymized qualitative comments provided by the other panelists where applicable. Participants were therefore able to reconsider their ratings in light of the group-level results while maintaining individual anonymity.

Each Delphi round remained open for three weeks to allow adequate time for participation. All 20 experts completed both Delphi rounds, and no attrition occurred between the rounds.

### 2.6. Consensus Definition

Consensus was defined a priori as a mean score of at least 4.0 on the five-point Likert scale. This threshold corresponded to ratings of "Agree" or "Strongly agree" and represented meaningful agreement regarding the clinical relevance of the criterion (33-36). The stability of responses across the two rounds was assessed to determine whether additional iterations were necessary. The Delphi process was concluded after Round 2 because the responses demonstrated stability, inter-round variation was minimal, and the predefined consensus threshold was achieved for all retained criteria. This decision was consistent with established principles of consensus achievement in Delphi studies(34, 37, 38).

### 2.7. Statistical Analysis

Descriptive statistics were used to analyze the ratings provided by the Delphi panel. For each criterion, the mean score, standard deviation, and interquartile range were calculated. Criteria with a mean score of at least 4.0 were retained in the final framework, whereas criteria with a mean score below this threshold were excluded.

The distribution of ratings and changes in scores between the two Delphi rounds were also examined to assess response stability and the degree of agreement among participants. The final criteria were organized into thematic domains based on their clinical relevance and the consensus achieved during the Delphi process.

## 3. Results

The scoping review identified 46 initial criteria organized into seven domains. Following expert panel review, the checklist was expanded to 51 criteria and reorganized into seven major components (Supplementary table 1). These components included respiratory system disorders, cardiovascular system disorders, neurological system disorders, trauma and bleeding, multisystem disorders, special clinical considerations, and diagnostic and paraclinical assessments.

### 3.1. Stage 1 (Expert Panel Findings)

During the expert panel review, several modifications were made to improve the clinical applicability of the preliminary checklist. Respiratory rate was retained as a distinct respiratory indicator, and blood pressure and heart rate were considered as separate cardiovascular criteria. In the trauma domain, head trauma, abdominal trauma, and chest trauma were treated as independent indicators. In addition, severe temperature disturbances were retained within the multisystem disorder's component. The original survival-related items were also reorganized under the broader component of special clinical considerations, which included pregnancy, age, post-CPR likelihood of survival, and requirement for a high level of nursing care.

As a result of these revisions, the checklist increased from 46 to 51 criteria across seven components (Supplementary table 1).

### 3.2. Stage 2: Delphi Study Findings and Final Consensus

In Round 1 of the Delphi process, 18 of the 51 criteria (35.3%) achieved the predefined consensus threshold of a mean score of at least 4.0 and were retained for the second round. The remaining 33 criteria were excluded because they did not meet the predefined threshold (Supplementary table 2). The mean scores of the excluded criteria ranged from 1.70 to 2.55. Among these, age received a mean score of 2.00, with an SD of 0.86 and an IQR of 1.25, and was therefore excluded from the final framework. No new criterion was added based on the qualitative comments provided by panelists in Round 1. Following the completion of the first Delphi round, the seventh component, Diagnostic and Paraclinical Assessments, was excluded, together with all criteria assigned to this component.

In Round 2, the 18 retained criteria were re-evaluated by the same panel of experts. All 18 criteria again achieved the consensus threshold of a mean score of at least 4.0, indicating stable agreement across rounds. Final mean scores ranged from 4.00 to 4.55. The highest mean score was observed for respiratory rate (mean 4.55, SD 0.51, IQR 1.00), whereas the lowest mean scores were observed for post-CPR likelihood of survival and requirement for a high level of nursing care (both mean 4.00, SD 1.03, IQR 1.25). Table 2 presents the mean, SD, and IQR values for the retained criteria across both Delphi rounds.

All invited experts completed both Delphi rounds, resulting in a 100% response rate and no attrition between rounds. Overall, the final consensus-based framework consisted of 18 criteria classified into six major components: respiratory system disorders, cardiovascular system disorders, neurological system disorders, trauma and bleeding, multisystem disorders, and special clinical considerations. Criteria were prioritized based on the scores obtained at the end of the second Delphi round.

### 3.3. Component - Level Consensus Pattern

At the component level, the strongest consensus was observed in the respiratory and cardiovascular components, which contained several of the highest-rated criteria in the final framework. Respiratory rate showed the highest overall agreement, while abnormal heart rate, abnormal blood pressure, and need for ventilatory support also received consistently high ratings. Neurological criteria, including decreased level of consciousness and persistent seizures, similarly demonstrated strong consensus.

In contrast, slightly greater variability was observed in the special clinical consideration's component. In particular, post-CPR likelihood of survival and requirement for a high level of nursing care had the widest dispersion among the final criteria, as reflected by IQR values of 1.25. Nevertheless, both criteria remained above the predefined consensus threshold and were retained in the final framework.

### 3.4. Final Consensus - Based ICU Admission Framework

Figure 2 illustrates the final ICU admission prioritization framework for MCIs. The figure organizes the 18 retained criteria into six component-based clusters and visually demonstrates the progression from the broader 51-item expert-reviewed checklist to the final consensus set. This structure clarifies the hierarchical relationship among components and highlights the criteria that achieved stable expert agreement across the two Delphi rounds.

## 4. Discussion

The allocation of critical care resources during mass casualty incidents (MCIs), particularly decisions regarding ICU admission, represents one of the most challenging aspects of hospital disaster management. MCIs often result in a sudden influx of critically ill patients that overwhelms healthcare resources and may render routine standards of care unattainable, potentially leading to avoidable mortality (14). Consequently, hospitals require evidence-based and operational frameworks that facilitate appropriate ICU prioritization and optimize the utilization of available resources. Although several tools and criteria have been proposed for hospital and ICU admission prioritization, previous studies have demonstrated that many of these instruments are insufficient and do not perform optimally across different clinical contexts and disaster situations(15, 17, 19, 21). In some cases, these limitations have resulted in inappropriate ICU admissions, whereby patients with genuine critical care needs were denied access, while others with less urgent conditions were admitted (39, 40). For example, during the COVID-19 pandemic, age was occasionally used as a criterion for ICU admission based on assumptions regarding recovery potential among older adults, raising important ethical concerns regarding equity and resource allocation(41).

Traditionally, ICU admission decisions have relied on the assessment of acute physiological derangements and pre-existing chronic conditions. However, final decisions frequently remain dependent on clinicians' subjective judgment (42). Scoring systems such as the Sequential Organ Failure Assessment (SOFA), Simple Triage Scoring System (STSS), and National Early Warning Score (NEWS) have been developed primarily for continuous patient assessment and mortality prediction rather than for guiding ICU admission decisions during disasters (43). Similarly, the Acute Physiology and Chronic Health Evaluation II (APACHE II) score was designed for severity assessment and mortality prediction under routine critical care conditions and was not specifically developed for ICU prioritization during mass casualty events (44, 45). The Society of Critical Care Medicine has emphasized the importance of equitable access to critical care resources while simultaneously acknowledging the limitations of existing ICU prioritization protocols (46). Therefore, developing evidence-based prioritization frameworks tailored to disaster conditions may improve resource allocation, facilitate more effective decision-making, and reduce unnecessary healthcare expenditures (47).

Historically, ICU admission criteria under routine conditions have primarily focused on the severity of organ dysfunction and physiological derangement (47). Earlier allocation models frequently relied on utilitarian principles such as maximizing the benefits of medical interventions or adopting a "first-come, first-served" approach (48, 49). However, these traditional approaches have increasingly been challenged because they may not adequately address the ethical and operational complexities associated with disasters and resource scarcity. More recent studies have therefore advocated for prioritization strategies that emphasize objective clinical indicators, fairness, and resource stewardship (14, 20, 47, 50).

### 4.1. Comparison with Existing Triage Systems

The findings of the present study suggest that ICU admission criteria during MCIs differ in several important respects from those applied under routine circumstances. During disasters, clinicians often face overwhelming patient volumes, severe resource constraints, and insufficient time for comprehensive clinical assessments or extensive diagnostic investigations. Consequently, decision-making must rely on parameters that can be assessed rapidly and objectively at the bedside. The significant overlap found between the criteria identified in this study and those typically used in routine ICU settings indicates that disaster triage should not replace established principles of critical care. Instead, it should adapt these principles to situations where time is limited and resources are scarce (16, 18, 51) .

The scoping review showed that respiratory and circulatory domains were the most important determinants of intensive care unit admission during MCIs. Respiratory and circulatory parameters were consistently emphasized in the literature because they can be evaluated rapidly and directly reflect acute physiological deterioration. Similar observations have been reported in studies of emergency triage and early warning systems, where disturbances in airway, breathing, and circulation constitute the earliest indicators of clinical deterioration and frequently trigger escalation of care (52, 53). In contrast, diagnostic investigations and estimates of survival probability were less frequently emphasized because they often require additional time, resources, or subjective clinical judgments.

The expert panel further refined the preliminary criteria and introduced several modifications that increased the clinical applicability of the proposed framework. One important revision involved redefining the cardiovascular domain as the circulatory system and explicitly incorporating blood pressure and heart rate as independent indicators. This modification is consistent with contemporary disaster medicine recommendations that emphasize the early recognition of shock and hemodynamic instability through simple bedside observations rather than advanced investigations (54). Another notable finding was the introduction of the "special conditions" domain, including pregnancy, survival probability, age, and high nursing care requirements. Previous disaster studies have similarly suggested that patient characteristics and resource-related considerations may influence triage decisions beyond the severity of acute physiological derangement (51). The inclusion of these variables therefore reflects the complex and multifactorial nature of ICU prioritization during MCIs (18) .

The Delphi process achieved consensus by eliminating criteria that were either time-consuming, difficult to operationalize, or lacking sufficient specificity for mass casualty situations. This finding is particularly important because several previously proposed ICU triage systems, including SOFA, APACHE II, and other prognostic models, require laboratory investigations, repeated assessments, or complex calculations that may be impractical during disasters (16, 18, 55). By contrast, experts in the present study consistently favored criteria that facilitate the rapid and accurate identification of patients requiring intensive care while minimizing delays in decision-making. The study culminated in the development of a final checklist consisting of six domains and eighteen criteria specifically tailored to the operational realities of MCIs. Importantly, experts consistently prioritized rapidly measurable physiological indicators over anatomical injuries and prognostic estimations, aligning with contemporary concepts in disaster medicine that increasingly advocate physiology-based triage strategies (56, 57).

More importantly, the present study contributes a novel synthesis rather than a simple confirmation of previously known indicators. Its added value lies in converting a broad and heterogeneous set of candidate ICU admission criteria into a focused, consensus-based, disaster-specific framework that is operationally feasible under surge conditions. In this sense, the study does not merely reaffirm the importance of respiratory, circulatory, and neurological instability; it clarifies which of these indicators remain most useful when time, staffing, diagnostic capacity, and ICU beds are all constrained. This practical narrowing of criteria addresses an important gap between theoretical triage principles and bedside decision-making during MCIs.

### *4.2. Clinical Implications*

Respiratory rate received the highest score among all identified criteria (mean score = 4.55). This finding is consistent with previous studies demonstrating that respiratory abnormalities represent some of the earliest manifestations of physiological deterioration and are strongly associated with respiratory failure, hypoxemia, and early mortality (52, 54). Respiratory rate is also a core component of several established triage and early warning systems, including NEWS and other emergency severity assessment tools. Unlike many laboratory-based parameters, respiratory rate can be assessed immediately without specialized equipment and generally requires less than one minute to measure. Consequently, in disaster settings characterized by uncertainty and resource scarcity, respiratory rate may serve as a highly feasible and clinically informative indicator for prioritizing ICU admission.

Circulatory indicators were ranked as the second most important criteria, with heart rate and blood pressure receiving mean scores of 4.35 and 4.25, respectively. These findings suggest that experts placed considerable emphasis on the early identification of shock and hemodynamic instability. During MCIs, extensive laboratory investigations and advanced diagnostic procedures are often impractical; therefore, heart rate and blood pressure are particularly valuable, as they represent the earliest manifestations of circulatory compromise and can be assessed rapidly, noninvasively, and at minimal cost (58, 59).

Neurological criteria also achieved high consensus scores, with decreased level of consciousness assessed by GCS/AVPU and persistent seizures receiving mean scores of 4.30 and 4.20, respectively. Previous investigations have consistently demonstrated that altered mental status and persistent seizures are associated with increased mortality and frequently indicate severe underlying conditions such as central nervous system injury, hypoxia, shock, or multiple organ dysfunction (59-61). Neurological assessment has therefore been incorporated into numerous triage systems and critical care scoring models. The high prioritization of GCS/AVPU in the present study likely reflects both its prognostic significance and its practicality as a rapid bedside assessment tool during disasters.

Anatomical injuries, including abdominal trauma and chest trauma, received comparatively lower scores (mean score = 4.05). This finding suggests that experts considered the location of injury alone to be insufficient for determining ICU admission priority. Instead, physiological derangement was perceived as a more reliable indicator of critical illness(58, 62) . This preference reflects a key principle in disaster triage: that the physiological consequences of injury, rather than anatomical descriptions, should guide resource allocation decisions.

Special clinical considerations, particularly survival probability and high nursing care requirements, achieved the lowest consensus scores among all retained criteria. Although survival probability has frequently been emphasized in disaster triage protocols (18), experts in the present study assigned it a relatively lower priority. Estimating survival probability during MCIs is inherently challenging and may involve considerable uncertainty and subjective judgment (18, 63). Reliance on subjective prognostic assessments may therefore introduce ethical concerns and inconsistencies in decision-making. Consequently, experts appeared to favor objective and rapidly measurable physiological indicators that can be applied more consistently and equitably under resource-constrained conditions.

The exclusion of diagnostic investigations from the final checklist suggests that, in the context of mass casualty incidents, experts favored immediately measurable physiological indicators over laboratory and imaging assessments. This preference reflects the need for rapid, simple, and operationally feasible criteria to support timely ICU admission decisions when resources are limited and patient volumes exceed available capacity (12, 64, 65). During MCIs, delays associated with obtaining laboratory results or imaging studies may result in inappropriate allocation of resources and increased mortality among patients who could benefit from early intervention.

From an operational perspective, the framework may be most useful if incorporated into existing disaster triage workflows rather than implemented as a stand-alone instrument. In practice, it could be administered by an emergency physician, intensivist, trauma team leader, or another designated senior clinician responsible for surge triage, depending on institutional structure. Because the final checklist relies predominantly on bedside physiological indicators, its completion is likely to be rapid and feasible even in high-pressure settings. Its clinical utility therefore lies not only in identifying critically ill patients, but also in standardizing decision-making, reducing avoidable variability, and supporting transparent ICU prioritization when demand exceeds available capacity. These findings are broadly aligned with prior disaster and critical care triage literature, including earlier consensus-based efforts that emphasized resource stewardship, fairness, and the prioritization of patients most likely to benefit from intensive care (18). However, the present study places greater emphasis on rapidly assessable bedside clinical criteria intended for use under the operational constraints of mass casualty incidents.

### 4.3. Ethical Considerations

The failure of age to achieve consensus in the Delphi process may reflect the experts' recognition that chronological age, despite its inclusion in some prognostic models and its association with adverse outcomes, is an indirect and non-specific predictor of critical illness outcomes. Established severity scoring systems, such as APACHE and SOFA, place greater emphasis on acute physiological derangements and organ dysfunction rather than age alone when estimating prognosis (1, 51, 65, 66). Moreover, the use of age as a criterion for ICU admission during disasters has raised substantial ethical concerns regarding fairness and equity, particularly during the COVID-19 pandemic (41). Consequently, in mass casualty incidents where rapid and ethically defensible triage decisions are required, experts appeared to prioritize immediately assessable indicators of physiological compromise and potential benefit from intensive care over chronological age as an isolated admission criterion. This finding supports the ethical preference for using directly observable physiological indicators and likely benefit from intensive care, rather than chronological age alone, when making time-sensitive triage decisions under crisis conditions.

While age was excluded, this decision may be controversial; however, experts may have prioritized physiological indicators as more equitable and objective in disaster contexts. This interpretation is ethically important because it suggests a shift away from demographic characteristics toward measurable clinical need. At the same time, the exclusion of age should not be interpreted as implying that all ethical tensions have been resolved. Rather, it underscores the difficulty of balancing fairness, efficiency, and expected benefit during crisis triage and highlights the need for transparent and accountable implementation of any prioritization framework.

### 4.4. Implementation Considerations and Barriers

Although the proposed consensus-based framework provides a structured set of physiological criteria, its translation into clinical practice would depend on several contextual and operational factors. First, clinicians and disaster response teams require prior orientation to ensure a shared understanding and consistent interpretation of the identified criteria during surge conditions. Second, inter-rater reliability remains a critical operational consideration, particularly in high-stress disaster environments where rapid prioritization decisions must be made by healthcare providers with varying levels of critical care experience. Third, resistance to adopting structured criteria may arise during mass casualty incidents (MCIs), as clinicians operating in dynamic and chaotic settings may perceive predefined frameworks as overly rigid. These barriers should be viewed not as arguments against the utility of standardized criteria, but as challenges to be addressed through scenario-based simulation exercises, disaster preparedness training, and local protocol adaptations.

In this context, the proposed framework should be regarded as a conceptual decision-support aid and a foundation for consensus-driven prioritization rather than a definitive decision-making tool or a substitute for expert clinical judgment. Because the framework reflects expert consensus derived from a two-round Delphi process rather than prospectively validated clinical outcome data, it must be applied in conjunction with real-time bedside assessment, institutional policies, and available critical care surge capacity. Integrating these consensus-based criteria into disaster response plans may help improve decision transparency, reduce cognitive burden, and promote equitable resource allocation during critical care resource scarcity.

### 4.5. Future Research Directions

The proposed consensus-based framework differs from established critical care scoring systems in several important aspects. First, unlike conventional systems such as SOFA and APACHE II, which rely on repeated physiological measurements and laboratory investigations (16, 18, 55), the present framework prioritizes clinical parameters that can be evaluated rapidly at the bedside without relying on ancillary diagnostic testing. Second, whereas routine scoring models are designed for baseline critical care management, this framework was developed specifically to address the operational constraints, high patient volumes, and severe resource limitations characteristic of MCIs. Third, by focusing on acute physiological deterioration and applying a rigorous threshold—wherein criteria with mean scores below 4.0 were excluded during the Delphi consensus process—the framework highlights core parameters essential for initial critical care prioritization.

Future research should focus on several priority areas:

1. Prospective Clinical Validation: Prospective observational and registry-based studies are needed to evaluate whether prioritizing patients based on these consensus criteria correlates with clinical outcomes, critical care utilization, and overall survival during surge events.
2. Comparative Utility: Comparative studies should evaluate the operational feasibility and decision-making accuracy of this consensus framework relative to existing disaster triage models.
3. Simulation and Inter-Rater Reliability: High-fidelity simulation exercises should be conducted to assess inter-rater agreement across clinicians with diverse training backgrounds and under varying levels of simulated resource scarcity.
4. Digital and Protocol Integration: Future investigations should explore the integration of these consensus-based criteria into digital disaster management platforms and electronic triage dashboards for real-time decision support.
5. Qualitative and Ethical Assessments: Qualitative studies examining clinician acceptability, ethical feasibility, and perceived fairness during crisis standards of care will be essential to guide formal implementation.

### 4.6. Strengths and Limitations

This study has several notable strengths. First, it utilized a rigorous two-stage sequential design that combined a structured scoping review with expert panel validation and a classical Delphi consensus process. Second, the panel comprised experts with extensive operational and clinical experience in disaster medicine, emergency care, and intensive care medicine, ensuring that the identified criteria reflect real-world clinical priorities. Third, the Delphi methodology ensured participant anonymity and iterative feedback, thereby minimizing groupthink and authority bias. Fourth, applying a strict consensus threshold (mean score ≥4.0) which led to the exclusion of 33 candidate criteria in Round 1, ensured that only criteria meeting the predefined consensus threshold were retained in the final framework.

Nevertheless, several limitations must be acknowledged:

National Context and Generalizability: The consensus process was conducted predominantly within the Iranian healthcare

system. Differences in disaster epidemiology, emergency medical infrastructure, and resource availability may limit direct generalizability to other health systems without contextual adaptation.
Consensus vs. Clinical Validation: The Delphi method establishes expert consensus rather than direct clinical validation. The framework has not been prospectively tested in active disaster scenarios, and its direct impact on patient morbidity and mortality remains to be established.
Language Scope in Evidence Synthesis: The preliminary scoping review was restricted to literature published in English and Persian, which may have omitted relevant consensus documents or disaster protocols published in other languages.
Lack of Inter-Rater Reliability Testing: The study design did not evaluate inter-rater variability or the degree of concordance among healthcare providers applying these criteria in acute clinical or simulated settings.

## 5. Conclusions

This study established a consensus-based framework comprising core, rapidly assessable physiological criteria to assist in ICU admission prioritization during mass casualty incidents. Under conditions of severe critical care resource scarcity, prioritization decisions must rely on objective, bedside-accessible parameters rather than time-consuming laboratory or diagnostic workups.
The consensus findings demonstrate that acute respiratory, cardiovascular, and neurological indicators, specifically respiratory rate, heart rate, blood pressure, oxygen saturation, and level of consciousness, represent the fundamental clinical criteria for identifying patients in urgent need of intensive care interventions. Criteria requiring complex prognostic scoring or extensive diagnostic investigations were deemed impractical for initial disaster triage. While this consensus framework offers an evidence-informed basis for emergency preparedness and disaster protocol development, prospective validation and simulation-based evaluation are essential before its formal incorporation into clinical guidelines and disaster triage policies.

## 6. Declarations

### 6.1. Acknowledgments

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### 6.2. Conflict of interests

The authors declare no conflict of interest.

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### 6.4. Authors' contributions

K.J. and B.E.B. conceived and designed the study. B.E.B. collected the data. K.J., B.E.B., M.M., A.E., and H.J. contributed to data analysis and interpretation. All authors contributed to drafting, critically revising, and approving the final version of the manuscript.

### 6.5. Ethical statement

This study was conducted in accordance with ethical guidelines and received approval from the Ethics Committee of the School of Public Health and Neuroscience Research Center, Shahid Beheshti University of Medical Sciences. Ethical approval was granted under code [IR]. [SBMU.PHNS.REC.1403.007].

### 6.6. Informed consent

Written informed consent was obtained from all participants before their participation in the study.

### 6.7. Availability of supporting data

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

### 6.8. Using artificial intelligence chatbots statement

AI-assisted technologies were utilized solely during the writing process to enhance the manuscript's readability and language. Additionally, we employed AI to create figures.

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**Table 1:** Characteristics of expert panel and Delphi panel participants

| Professional Group | Expert Panel | | | | Delphi Panel | | | |
|---|---|---|---|---|---|---|---|---|
| | Female | Male | Total | Experience* | Female | Male | Total | Experience |
| **Anesthesiologists and Critical Care Specialists** | 3 | 3 | 6 | 18 years | 4 | 6 | 10 | 19 years |
| **Emergency Medicine Specialists** | 2 | 3 | 5 | 13 years | 2 | 3 | 5 | 16 years |
| **PhD Nurses** | 1 | 1 | 2 | 18 years | 1 | 1 | 2 | 17 years |
| **Hospital Triage Supervisors** | 1 | 1 | 2 | 17 years | 1 | 2 | 3 | 15 years |
| **Total** | 7 | 8 | 15 | — | 8 | 12 | 20 | — |

*: mean year of experience.

**Table 2:** Final Consensus-Based Criteria for ICU Admission During Mass Casualty Incidents Following the Delphi Study

| Components | Final Criteria for Patient Admission | Round 1 Delphi | | | Round 2 Delphi | | |
|---|---|---|---|---|---|---|---|
| | | Mean Score | SD | IQR | Mean Score | SD | IQR |
| **Respiratory System Disorders** | Respiratory rate | 4.50 | 0.51 | 1.00 | 4.55 | 0.51 | 1.00 |
| | Decreased oxygen saturation | 4.10 | 1.02 | 1.00 | 4.20 | 0.62 | 1.00 |
| | Need for intubation | 4.10 | 1.02 | 1.00 | 4.20 | 0.83 | 1.00 |
| | Need for a ventilator | 4.20 | 0.83 | 1.00 | 4.30 | 0.66 | 1.00 |
| **Cardiovascular System Disorders** | Abnormal blood pressure | 4.20 | 0.83 | 1.00 | 4.25 | 0.72 | 1.00 |
| | Abnormal heart rate | 4.30 | 0.66 | 1.00 | 4.35 | 0.59 | 1.00 |
| | Requirement for vasoactive medications | 4.10 | 1.02 | 1.00 | 4.10 | 1.02 | 1.00 |
| **Neurological System Disorders** | Decreased levels of consciousness | 4.30 | 0.66 | 1.00 | 4.30 | 0.66 | 1.00 |
| | Persistent seizures | 4.20 | 0.83 | 1.00 | 4.20 | 0.83 | 1.00 |
| **Trauma and Bleeding** | Head trauma | 4.10 | 1.00 | 1.00 | 4.10 | 1.02 | 1.00 |
| | Abdominal trauma | 4.05 | 1.00 | 1.00 | 4.05 | 1.00 | 1.00 |
| | Chest trauma | 4.05 | 1.00 | 1.00 | 4.05 | 1.00 | 1.00 |
| **Multisystem Disorders** | Burns | 4.10 | 1.02 | 1.00 | 4.10 | 1.02 | 1.00 |
| | Poisoning | 4.10 | 1.02 | 1.00 | 4.10 | 1.02 | 1.00 |
| | Severe temperature disturbances (hyperthermia and hypothermia) | 4.20 | 0.83 | 1.00 | 4.20 | 0.83 | 1.00 |
| **Special Clinical Considerations** | Pregnancy | 4.20 | 0.83 | 1.00 | 4.20 | 0.83 | 1.00 |
| | Likelihood of survival based on response to initial treatment and post-resuscitation status (post-CPR) | 4.00 | 1.03 | 1.25 | 4.00 | 1.03 | 1.25 |
| | Requirement for a high level of nursing care | 4.0 | 1.03 | 1.25 | 4.00 | 1.03 | 1.25 |

SD: Standard Deviation; IQR: Interquartile Range; ICU: Intensive Care Unit.

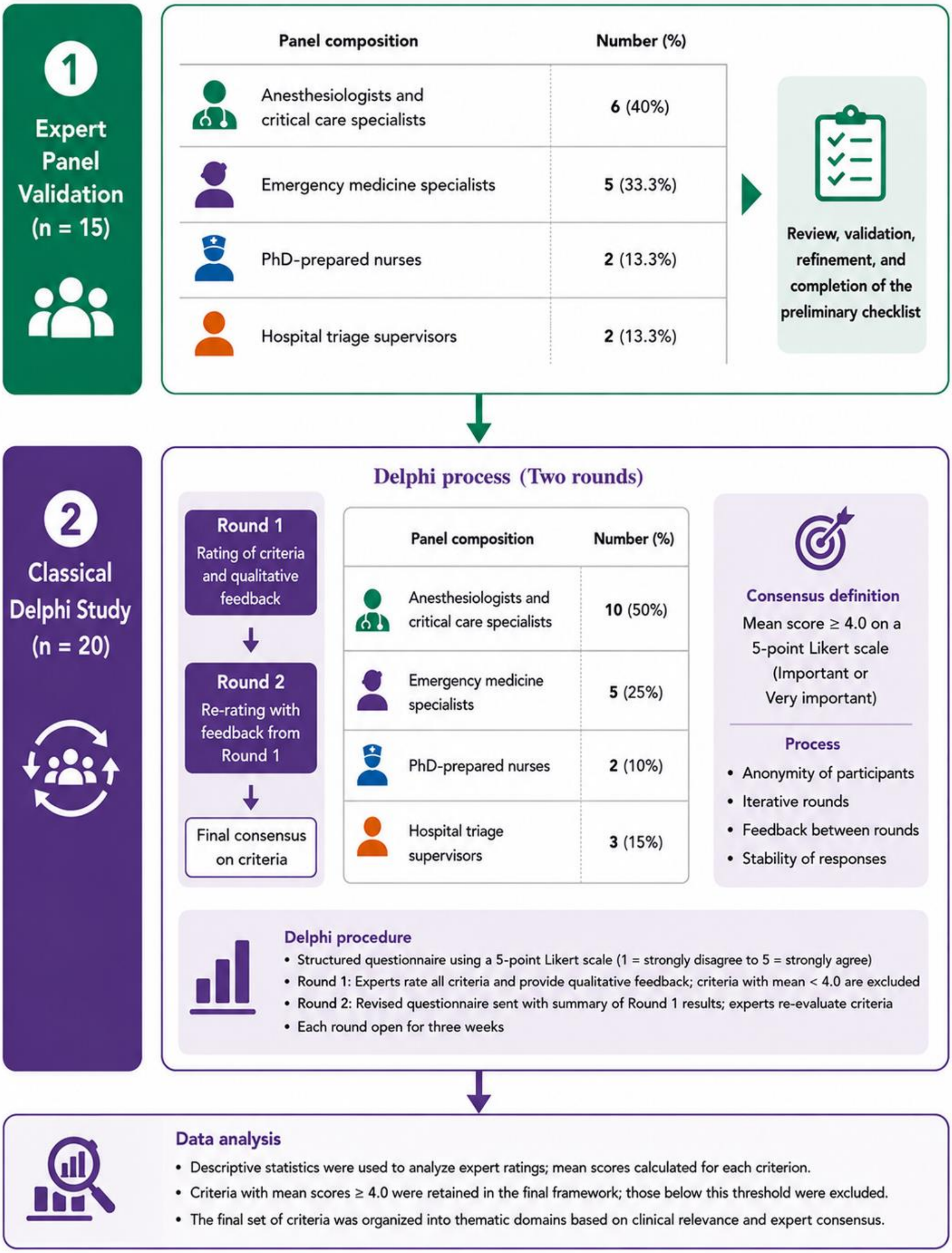


**Figure 1:** study design and methodological process (used generative AI tools to create this figure).

| Priority Category | Criteria for ICU Admission | Mean Score (1-5) |
| --- | --- | --- |
| **Priority I** Immediate ICU Admission *Life-threatening conditions requiring immediate ICU care.* | • Respiratory rate (RR) | 4.55 |
| | • Abnormal heart rate (HR) | 4.35 |
| | • Decreased level of consciousness (GCS/AVPU) | 4.30 |
| **Priority II** Urgent ICU Admission *Conditions with high risk of deterioration requiring urgent ICU care.* | • Need for a ventilator | 4.30 |
| | • Abnormal blood pressure (BP) | 4.25 |
| | • Decreased oxygen saturation ($SpO_2$) | 4.20 |
| | • Need for intubation | 4.20 |
| | • Persistent seizures | 4.20 |
| | • Severe temperature disturbances (hyperthermia and hypothermia) | 4.20 |
| | • Pregnancy | 4.20 |
| **Priority III** Conditional ICU Admission *Conditions requiring ICU care based on clinical judgment and available resources.* | • Requirement for vasoactive medications | 4.10 |
| | • Head trauma | 4.10 |
| | • Burns | 4.10 |
| | • Poisoning | 4.10 |
| | • Abdominal trauma | 4.05 |
| | • Chest trauma | 4.05 |
| | • Likelihood of survival based on response to initial treatment and post-resuscitation status (Post-CPR) | 4.00 |
| | • Requirement for a high level of nursing care | 4.00 |

RR = respiratory rate; BP = blood pressure; HR = heart rate; GCS = Glasgow Coma Scale;
AVPU = Alert-Verbal-Pain-Unresponsive; $SpO_2$ = peripheral oxygen saturation; CPR = cardiopulmonary resuscitation.

**Figure 2:** Consensus-Based Framework for Prioritizing ICU Admissions in Mass Casualty Incidents: Results of a Two-Round Delphi Study (used generative AI tools to create this figure).

## 8. Appendix

**Supplementary Table 1:** Components and Criteria for Admitting Patients to the ICU During Mass Casualty Incidents (End of Expert Panel Stage)

| Components | Practical Criteria for Patient Admission |
|---|---|
| **Respiratory system disorders** | • **Respiratory rate (RR)**<br>• Decreased oxygen saturation (SpO2)<br>• Need for a ventilator<br>• Need for intubation<br>• pulmonary diseases<br>• Severe hypoxemia<br>• Cyanosis<br>• Respiratory arrest<br>• Severe respiratory distress |
| **Cardiovascular system disorders** | • **Abnormal blood pressure (BP)**<br>• Heart rhythm disorders (dysrhythmia)<br>• **Abnormal heart rate (HR)**<br>• Cardiogenic shock<br>• heart disease<br>• Requirement for continuous cardiopulmonary monitoring<br>• **Requirement for continuous invasive arterial blood pressure monitoring**<br>• Requirement for vasoactive medications<br>• **Extracorporeal membrane oxygenation (ECMO)**<br>• **Intra-aortic balloon pump (IABP)**<br>• Cardiac arrest<br>• **Need for a pacemaker**<br>• Cardiovascular surgery<br>• Heart attack |
| **Neurological system disorders** | • Decreased levels of consciousness (GCS, AVPU, etc.)<br>• Pupillary disorders<br>• Increased intracranial pressure (ICP)<br>• Persistent seizures<br>• Stroke |
| **Trauma and bleeding** | • **Head trauma**<br>• **Abdominal trauma**<br>• **Chest trauma**<br>• Severity and degree of injury<br>• Severe arterial bleeding<br>• Severe limb trauma and multiple fractures<br>• Trauma to vital organs |
| **Multisystem disorders** | • Liver failure<br>• Severe renal failure<br>• Multiple organ failure<br>• Severe water and electrolyte imbalances<br>• Severe acid-base disorders (ABG)<br>• **Severe temperature disturbances (hyperthermia and hypothermia)**<br>• Systemic infections (sepsis)<br>• Poisoning<br>• Burns<br>• Severe metabolic disturbances (acidosis, hyperglycemia, and hypoglycemia) |
| **Special clinical considerations** | • **Pregnancy**<br>• **Likelihood of survival based on response to initial treatment and post-resuscitation status (post-CPR)**<br>• **Age**<br>• **Requirement for a high level of nursing care** |
| **Diagnostic and paraclinical assessments** | • Abnormal diagnostic imaging findings (ultrasound, CT, MRI, chest X-ray, etc.)<br>• Abnormal laboratory findings |

Items shown in bold indicate additions, modifications, or reclassifications introduced by the expert panel relative to the preliminary checklist derived from the scoping review.

Supplementary Table 2: Excluded ICU admission criteria due to sub-threshold mean scores (< 4.0)

| # | Criteria | N | Mean | SD | IQR |
|---|---|---|---|---|---|
| 1 | Pulmonary diseases | 20 | 2.55 | 0.83 | 1.00 |
| 2 | Heart diseases | 20 | 2.55 | 0.89 | 1.00 |
| 3 | Severe hypoxemia | 20 | 2.50 | 1.10 | 1.00 |
| 4 | Severe arterial bleeding | 20 | 2.45 | 0.69 | 1.00 |
| 5 | Cyanosis | 20 | 2.40 | 0.88 | 1.00 |
| 6 | Abnormal laboratory findings | 20 | 2.40 | 1.05 | 1.00 |
| 7 | Increased intracranial pressure (ICP) | 20 | 2.35 | 0.99 | 1.25 |
| 8 | Respiratory arrest | 20 | 2.35 | 0.81 | 1.00 |
| 9 | Severe respiratory distress | 20 | 2.25 | 0.79 | 1.00 |
| 10 | Extracorporeal membrane oxygenation (ECMO) | 20 | 2.25 | 0.72 | 1.00 |
| 11 | Severity and degree of injury | 20 | 2.20 | 0.77 | 1.00 |
| 12 | Intra-aortic balloon pump (IABP) | 20 | 2.20 | 0.77 | 1.00 |
| 13 | Trauma to vital organs | 20 | 2.20 | 0.62 | 1.00 |
| 14 | Requirement for continuous cardiopulmonary monitoring | 20 | 2.20 | 1.06 | 2.00 |
| 15 | Cardiovascular surgery | 20 | 2.15 | 0.75 | 1.00 |
| 16 | Stroke | 20 | 2.15 | 0.81 | 1.25 |
| 17 | Heart rhythm disorders (dysrhythmia) | 20 | 2.10 | 0.79 | 1.25 |
| 18 | Severe renal failure | 20 | 2.10 | 0.72 | 0.00 |
| 19 | Systemic infections (sepsis) | 20 | 2.10 | 0.72 | 1.00 |
| 20 | Liver failure | 20 | 2.10 | 0.72 | 1.00 |
| 21 | Severe limb trauma and multiple fractures | 20 | 2.10 | 0.79 | 1.25 |
| 22 | Need for a pacemaker | 20 | 2.10 | 0.79 | 1.25 |
| 23 | Pupillary disorders | 20 | 2.10 | 0.79 | 0.25 |
| 24 | Abnormal diagnostic imaging findings (ultrasound, CT, MRI, chest X-ray, etc.) | 20 | 2.05 | 0.60 | 0.00 |
| 25 | Requirement for continuous invasive arterial blood pressure monitoring | 20 | 2.05 | 0.83 | 2.00 |
| 26 | Severe metabolic disturbances (acidosis, hyperglycemia, and hypoglycemia) | 20 | 2.00 | 0.73 | 0.50 |
| 27 | Heart attack | 20 | 2.00 | 0.86 | 1.25 |
| 28 | Cardiogenic shock | 20 | 2.00 | 0.92 | 2.00 |
| 29 | Age | 20 | 2.00 | 0.86 | 1.25 |
| 30 | Cardiac arrest | 20 | 1.95 | 0.83 | 2.00 |
| 31 | Multiple organ failure | 20 | 1.90 | 0.72 | 1.00 |
| 32 | Severe acid-base disorders (ABG) | 20 | 1.90 | 0.64 | 0.25 |
| 33 | Severe water and electrolyte imbalances | 20 | 1.70 | 0.57 | 1.00 |

SD: Standard Deviation; IQR: Interquartile Range; ICU: Intensive Care Unit.