First Aid in Disaster Nursing

Through Simulation-Based Education

EDITORS

Prof. Zeynep Özer | Prof. Sevilay Şenol Çelik

Avrupa Birliği tarafından finanse edilmektedir

First Aid in Disaster Nursing Through Simulation-Based Education

Editors

Prof. Dr. Zeynep Özer   Prof. Dr. Sevilay Şenol Çelik

March 2026

Enhancing Practices and Strengthening Core Competencies In Disaster Nursing through the Learning HUB (ECoDN-HUB)

2024-1-TR01-KA220-HED-000245267
Cooperation partnerships in higher education (KA220-HED)

ISBN 978-625-93972-0-7

PREFACE

This book, titled “Disaster Nursing and First Aid Through Simulation-Based Training”, has been developed within the scope of the ECoDN-HUB Project: Enhancing Practices and Strengthening Core Competencies in Disaster Nursing Through Multi-Modal Learning Tools. It aims to contribute meaningfully to education, practice, and research in the field of disaster nursing. In today’s world, where disaster risks and societal vulnerabilities are becoming increasingly complex, it is essential for healthcare professionals—particularly nurses—to possess comprehensive, up-to-date, and practice-oriented competencies in disaster preparedness, response, and recovery. In this context, simulation-based education emerges as an effective pedagogical approach, offering the ability to replicate real-life conditions within a safe learning environment.

This book offers a broad, expertise-oriented content ranging from the conceptual foundations of disaster nursing to applied skills training. It presents an integrated learning framework through the sections Disaster Nursing, First Aid in Disasters, Simulation and Scenario Development in Disaster Education, AR/VR Development Guide, and AR/VR Scenario Example. Theoretical knowledge, evidence-based approaches, and practice-oriented examples are provided to strengthen nursing roles across all phases of disaster management. In addition, the integration of augmented and virtual reality (AR/VR) technologies into education is explored as an innovative method for enhancing disaster response skills among healthcare professionals; detailed explanations of scenario design, technical development processes, and application examples are included.

This book serves as a significant resource for strengthening competency-based education in disaster nursing. We believe that the book will serve as a valuable reference for undergraduate and graduate students as well as professional healthcare providers, helping bridge the gap between theory and practice.

We extend our sincere appreciation to all researchers, academics, and project team members who contributed to the preparation of this work, and we hope that the book will support healthcare professionals involved in disaster preparedness and response.

Prof. Zeynep Özer **Prof. Sevilay Şenol Çelik**

CONTENT

CONTENT

AUTHORS LIST

Chapter 1. Disaster Nursing	
Nazife Öztürk Hatice Esen Koç	Antalya Training and Research Hospital
Andrea Hudáčková František Dolák Ivana Chloubová Valérie Tóthová	JihoceskaBudejovicich Univerzita Vceskych
Chapter 2. First Aid in Disasters	
Sevilay Şenol Çelik Zeynep Özer Gülcan Bağçivan Hande Nur Arslan Selma Turan Kavradım Leyla Muslu	Koç University Akdeniz University Koç University Koç University Akdeniz University Akdeniz University
Chapter 3. Simulation and AR/ VR Training	
Malin Andtfolk Susanna Nylund	Abo Akademi
Otniel Didraga Gabriela Mariutac	Universitatea De Vest Din Timisoara
Chapter 4. Guideline for Scenario Writing and AR/VR Development and AR/VR Scenario Examples	
František Dolák Andrea Hudáčková Ivana Chloubová Valérie Tóthová Otniel Didraga Gabriela Mariutac	JihoceskaBudejovicich Univerzita Vceskych Universitatea De Vest Din Timisoara
Sevilay Şenol Çelik	Koç University

Chapter 1A: Disaster Nursing

Nazife Öztürk, Hatice Esen Koç

"By failing to prepare, you are preparing to fail."

Benjamin Franklin

Disaster nursing is a specialised field within the nursing profession dedicated to providing care during and after catastrophic events, which include natural disasters, pandemics, and man-made crises. With the increasing frequency and severity of such disasters, driven by factors such as climate change, urbanisation, and global interconnectivity, the role of disaster nurses has become ever more vital. During disasters, nurses are responsible not only for delivering immediate medical assistance but also for coordinating care in chaotic environments, managing limited resources, and addressing the psychological needs of affected populations. The complexities inherent in disaster nursing demand a unique set of skills, including triage, crisis management, and cultural competency, to effectively meet the diverse needs of individuals and communities impacted by disasters. This chapter explores the foundations of disaster nursing, disaster preparedness, disaster response and triage, clinical care in disaster settings, and resource management as well as disaster recovery and rehabilitation.

1.1. Foundations of Disaster Nursing

Disaster nursing is a critical discipline that encompasses the principles of preparedness, response, and triage, requiring nurses to have a comprehensive skill set to manage and mitigate disaster impacts effectively. Its foundations involve a multifaceted approach that spans mitigation, preparedness, response, and recovery phases, with an emphasis on cultivating future leaders through education and leadership roles at various levels of disaster management (Sakashita, 2014). Disaster preparedness demands not only concrete knowledge but also mental, emotional, and ethical readiness to cope with the chaos characteristic of disaster situations. Increasingly, this preparedness is integrated into nursing curricula to equip nurses as frontline responders, as demonstrated during the COVID-19 pandemic and other recent crises (Anderson & Beach, 2022).

Moreover, the evolution of disaster nursing necessitates integrating technology and data analytics to enhance situational awareness and response effectiveness. For example, real-time data visualisation tools like the point grid map method enable nurses to monitor spatial and temporal disaster variations, supporting timely decision-making and resource allocation (Wu et al., 2021). Incorporating mental health support into disaster response strategies is also crucial, as the psychological effects of disasters can persist long after physical needs are addressed. This dual focus on immediate care and long-term recovery highlights the importance of interdisciplinary collaboration among healthcare professionals, mental health experts, and community organisations to foster resilience and holistic well-being in affected populations (Hilton & Allison, 2004). Given the increasing challenges posed by both natural and man-made disasters, the adaptability and preparedness of disaster nurses are pivotal for effective response and recovery efforts (Scrymgeour et al., 2016).

The history of disaster nursing dates back to the 19th century, with Florence Nightingale pioneering the field. Her work during the Crimean War laid the groundwork for modern nursing practices in disaster contexts (Fletcher et al., 2022; Murray, 2020). Over time, nurses' roles in disasters expanded, with significant contributions during World Wars I and II, and more recently in response to natural disasters such as earthquakes and hurricanes, as well as pandemics like COVID-19 (Murray, 2020; Mao et al., 2021).

The 20th century marked the formal establishment of disaster nursing as a distinct speciality, supported by professional organisations like the International Council of Nurses (ICN) and the development of competency frameworks (Fletcher et al., 2022; Santos et al., 2024). Military nurses have also contributed significantly, particularly in advancing triage systems and emergency response protocols (Murray, 2020).

Recent advances in disaster nursing respond to the increasing complexity of disasters—climate change, terrorism, and pandemics—which require new skills and strategies, including the adoption of digital technologies for real-time data collection and communication (Paudel & Kanbara, 2023; McEntee, 2004).

A global perspective on disaster nursing reveals significant variations across countries, shaped by socioeconomic resources, healthcare infrastructure, and national disaster policies. However, international frameworks from organizations such as the World Health Organization (WHO) and ICN offer unified guidelines. The ICN's *Core Competencies in Disaster Nursing* (2019) outlines the essential knowledge, skills, and ethical standards for nurses worldwide. For instance, Japan emphasizes post-disaster mental health integration within public health systems, while the United States supports large-scale federal simulation programs to enhance nurse preparedness. In contrast, lower-income nations often rely on humanitarian organizations for temporary disaster nursing services, highlighting the urgent need for globally equitable and sustainable capacity-building in this field (WHO, 2021).

Figure 1.1-1 has demonstrated two essential components of disaster nursing. The upper section presents the five core competency domains defined by the ICN (ICN, 2019), outlining the foundational knowledge and skills required for nurses in disaster settings. These include preparedness, response, recovery, leadership & communication, and ethical-legal awareness. The lower section illustrates the disaster management cycle—Preparedness, Response, Recovery, and Mitigation—and highlights specific nursing responsibilities at each stage, such as training, triage, psychosocial support, and community advocacy. Together, these elements provide a comprehensive overview of the roles and expectations of disaster nurses in global health emergencies.

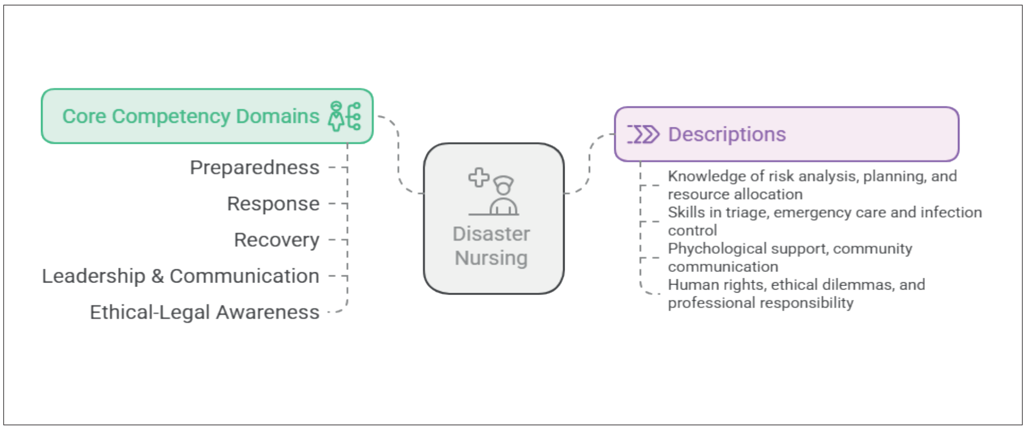


Figure 1.1-1. Core competency domains in disaster nursing

Core Competencies in Disaster Nursing

To effectively respond to disasters, nurses must develop key competencies that fall into several essential areas. Figure 1.1-2 shows a conceptual framework outlining the key competency areas that nurses must develop to respond effectively to disasters. Structured around the core domains of the foundations of disaster nursing, disaster preparedness, and triage, the model highlights the essential knowledge, skills, and attitudes required for nurses to play an active and effective role in the multidimensional phases of disaster response.

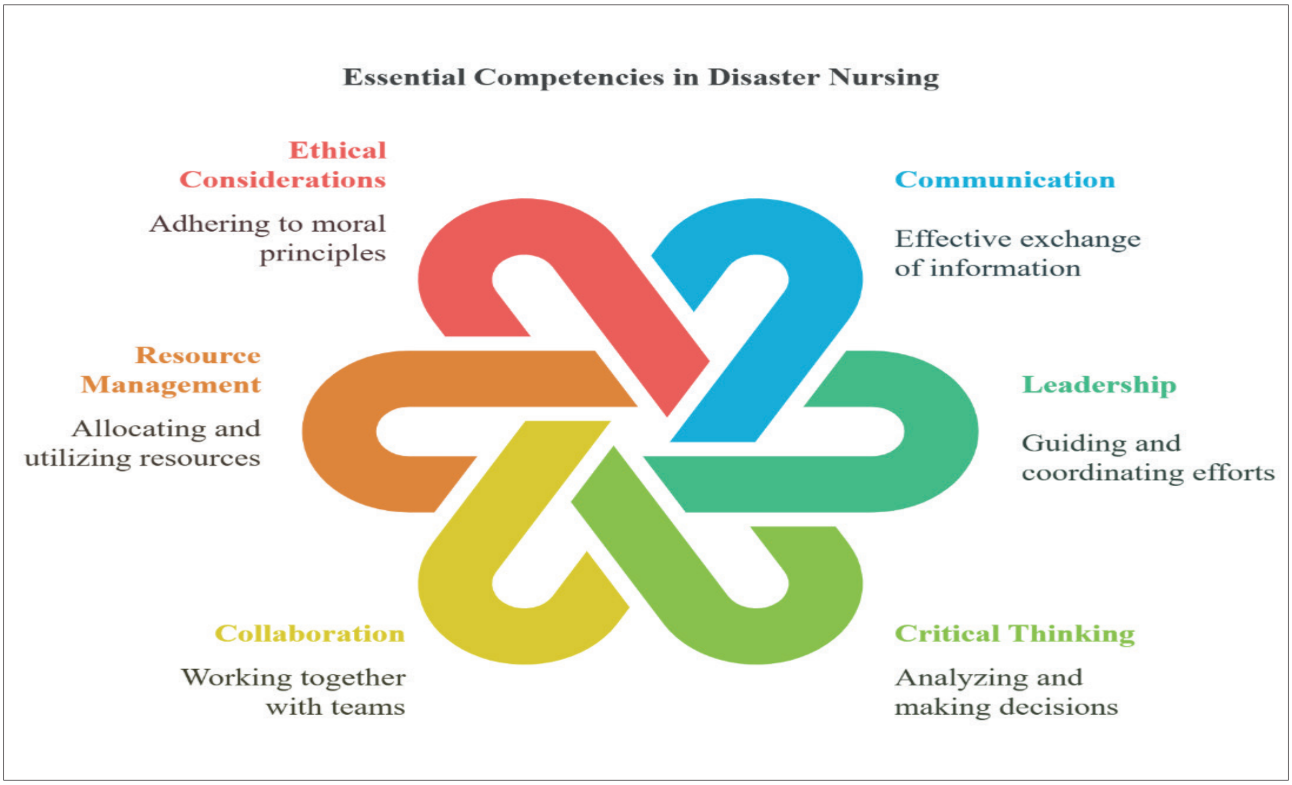


Figure 1.1-2. Essential competencies in disaster nursing

Nurses need to assess the needs of affected populations—including vulnerable groups such as children, the elderly, and those with chronic illnesses—by performing physical and mental health evaluations, prioritising care, and delivering appropriate interventions (Paudel & Kanbara, 2023; Santos et al., 2024). Strong communication skills are vital for coordinating care and collaborating with healthcare teams during disasters. Continued education and training ensure nurses remain prepared to face evolving emergency challenges (Hilmi et al., 2011). Effective communication is crucial within healthcare teams and with external stakeholders like emergency management officials and community leaders. Nurses must coordinate resources and services to facilitate a unified response (McEntee, 2004; Mao et al., 2021). Integrating ethical considerations and cultural sensitivity is vital for delivering holistic care to diverse populations (Lee & Chiang, 2010). Collaboration among healthcare professionals and community organisations enhances response effectiveness and builds resilience in affected communities (Nursing Experience on Disaster and Health Emergencies, 2022). Ongoing training and interdisciplinary collaboration are essential to meet the complex needs of disaster-impacted populations effectively. Integrating mental health support into disaster strategies addresses the psychological impacts on individuals and communities (Fletcher et al., 2022). Nurses must remain vigilant about risks in disaster environments, including physical dangers, infectious diseases, and psychological stressors. Ensuring personal safety and the safety of others is paramount (Mao et al., 2021). Disaster nursing requires comprehensive training in risk management and emergency protocols. A multifaceted approach to training—including clinical skills and emotional resilience—prepares nurses to navigate complex disaster scenarios (Nejadshafiee et al., 2020). Continuous education is necessary to face the unique challenges of disaster nursing.

Disaster nursing often involves difficult ethical decisions, such as allocating scarce resources and prioritising care. Nurses must be knowledgeable about ethical frameworks and legal standards to guide practice in these high-pressure situations (McEntee, 2004; Santos et al., 2024). The integration of ethical and legal frameworks supports informed decision-making during crises and enhances care quality for affected populations (Anderson & Beach, 2022; Hirani, 2023). Given the diversity of disaster-affected populations, nurses must provide culturally sensitive care that respects various beliefs, practices, and needs (Segev et al., 2024). Incorporating cultural competence into nursing education prepares future nurses to support diverse populations effectively in disaster contexts. Disaster nursing is an evolving discipline requiring ongoing education and adaptation to global challenges (Sakashita, 2014; Lee & Chiang, 2010). Embedding ethical frameworks into disaster nursing practice enables nurses to navigate moral complexities related to resource allocation and care prioritisation (Fithriyyah & Haryani, 2023). Disasters demand that nurses think critically and make rapid decisions with limited information. This requires adaptability and the ability to improvise solutions as circumstances change (Ziapour et al., 2024; Ma et al., 2024). Incorporating ethical decision-making enhances nurses' capacity to manage moral dilemmas inherent in resource allocation (Schroeter et al., 2008). Promoting a culture of ethical awareness empowers healthcare professionals to better address diverse needs during crises (Fithriyyah & Haryani, 2023). Preparing nurses with ethical frameworks ensures they can make informed decisions under pressure, leading to equitable care even in resource-constrained settings (Alanazi et al., 2024).

Providing psychological support to both victims and responders is a vital aspect of disaster nursing. This includes addressing trauma, stress, and anxiety, and fostering resilience and well-being (McEntee, 2004). Integrating psychological support enhances recovery efforts and resilience among affected populations and healthcare workers alike. Ethical decision-making frameworks also help nurses navigate the complexities of care prioritisation during crises (Fithriyyah & Haryani, 2023). Fostering ethical awareness ensures better care quality for disaster-affected individuals (Alrajhi, 2018). Including ethics education prepares nurses to face moral challenges in crises, improving outcomes for populations served (Shafer & Stocks, 2012). Nurses play a crucial role in promoting community health and preventing further harm following disasters. This includes educating the public on safety, disease prevention, and mental health support (Fletcher et al., 2022; Santos et al., 2024). Effective community health promotion requires collaboration with multiple stakeholders to provide comprehensive resources for affected populations (Schroeter et al., 2008). Engagement with local organisations and leaders is essential to establish support networks, aiding both immediate recovery and fostering long-term resilience. This highlights nurses' critical role in disaster management beyond acute care (Shafer & Stocks, 2012).

1.2. Disaster Preparedness

Disaster preparedness is a vital aspect of nursing practice that requires a proactive approach involving continuous training, resource management, and interprofessional collaboration to ensure effective responses during emergencies (Thrwi et al., 2024). Nurses must engage in ongoing education and participate in realistic simulation exercises to develop the competencies necessary for managing complex disaster scenarios effectively (Anderson & Beach, 2022).

The integration of technology, such as mobile applications for real-time data collection and communication, significantly enhances the efficiency of disaster response teams by enabling immediate feedback on resource availability and patient needs. This not only streamlines operations but also promotes a culture of collaboration among various stakeholders, including emergency services and healthcare providers, ultimately improving overall response outcomes (Anderson & Beach, 2022).

As disaster nursing continues to evolve, education must also encompass training in ethical decision-making and emotional resilience, preparing nurses to handle the multifaceted challenges encountered during crises (Lee & Chiang, 2010). Such comprehensive preparation empowers nurses to lead effectively, addressing both the immediate and long-term health needs of affected populations. Interdisciplinary collaboration is increasingly essential, involving social workers, mental health professionals, and local organizations to enhance community resilience and ensure holistic care during and after disasters (Holdo, 2021). Psychological support plays a critical role in mitigating long-term trauma, making partnerships with mental health experts indispensable for the recovery of both victims and responders. Community health promotion strategies integrated into disaster nursing further empower local populations by providing education and resources that foster preparedness and self-reliance, strengthening collective responsibility (Holdo, 2021). Furthermore, the use of social media platforms and mobile technologies facilitates rapid dissemination of crucial information, improving coordination among responders and informing affected communities in real-time (Sakashita, 2014; Alavi, 2014). These technologies also extend access to psychological support services, addressing the mental health impacts that often persist long after physical recovery (Munandar & Wardaningsih, 2018).

Effective disaster preparedness in nursing also involves establishing clear communication protocols and defining roles within multidisciplinary teams. This ensures that during an emergency, nurses can swiftly coordinate with other healthcare providers, emergency responders, and community leaders to optimize patient care and resource distribution (Gebbie & Qureshi, 2002). Training programs such as the Hospital Preparedness Program (HPP) and courses offered by organizations like the WHO and the Centers for Disease Control and Prevention (CDC) provide essential frameworks to standardize disaster preparedness education globally (WHO, 2020; CDC, 2018).

In addition, psychological preparedness is increasingly recognized as a fundamental component for nurses working in disaster settings. Mental resilience training helps nurses cope with the emotional toll of disaster response, reducing burnout and secondary traumatic stress (Benight & Bandura, 2004). Mindfulness-based stress reduction (MBSR) and critical incident stress debriefings (CISD) have shown effectiveness in promoting mental well-being among healthcare workers during and after crises (Regehr, Hill, Knott, & Sault, 2003).

Logistical preparedness, including stockpiling necessary medical supplies and ensuring accessibility to personal protective equipment (PPE), is vital to maintaining operational capacity during disasters, especially in pandemics or hazardous material events (Kaji, Koenig, & Bey, 2006). Nurses must also be trained in the use of emergency triage systems such as Simple Triage and Rapid Treatment (START), which help prioritize care in mass casualty incidents, ensuring optimal use of limited resources (Cone & Koenig, 2005).

Community engagement and education form a pillar of disaster preparedness. Nurses often serve as trusted figures who can disseminate information about disaster risks, preparedness steps, and available resources. Empowering communities through education not only enhances preparedness but also builds resilience, which is critical in reducing the overall impact of disasters (Houston et al., 2015).

Nurses Role During Disaster

The capacity to deliver care and ensure the protection of society's most vulnerable populations is heavily dependent on the disaster readiness of the nursing workforce. A wide range of elements—including education and training standards, licensure and credentialing, defined scopes of practice, mechanisms for rapid mobilization and deployment, occupational safety measures, crisis leadership competencies, and the integration of nursing roles within broader healthcare and public health infrastructures—collectively shape the effectiveness of nurses in disaster scenarios. Throughout all stages of a disaster—preparedness, response, and recovery—nurses work in tandem with physicians and interdisciplinary health teams to fulfill essential roles in clinical and community-based settings (Veenema, 2018) (Figure 1.2.-1). Nurses contribute significantly before, during, and after emergencies by offering health education, fostering community participation, promoting wellness, and executing interventions aimed at protecting public health (Songwathana et al., 2021; Firouzkouhi et al., 2021). Their responsibilities include delivering both basic and advanced medical care, administering emergency medications, conducting victim assessment and triage, managing the distribution of limited resources, and addressing both acute and long-term physical and mental health needs (Hasan et al., 2021). Additionally, nurses support institutional response efforts through the design of operational plans, implementation of safety and security protocols, and the analysis of health data at both individual and community levels (Bella Magnaye et al., 2011).

Figure 1.2-1. Disaster nursing timeline Flaubert et al., 2021; Veenema, 2018

1.3. Disaster Response and Triage

The term *triage* originates from the French word *trier*, meaning "to sort," and was first implemented in a formalized context by Dominique Jean Larrey, Napoleon Bonaparte's chief surgeon, during the late 18th century (Iserson & Moskop, 2007). Larrey introduced a system to classify battlefield casualties, prioritizing those who required immediate attention and could return to combat versus those needing prolonged care. Triage practices later evolved with the development of modern emergency medicine, particularly in military and civilian emergency departments in Europe and North America during the 20th century (Robertson-Steel, 2006).

Currently, triage is a fundamental component of disaster medicine, defined as the rapid categorization of patients based on the severity of their conditions and the allocation of scarce medical resources to maximize survival outcomes during mass casualty events (Jenkins et al., 2008). Its primary objectives include identifying victims with life-threatening injuries, assigning them to appropriate treatment areas, and ensuring the prompt initiation of medical interventions (Barbisch & Koenig, 2006). With the increasing frequency of natural disasters and terrorist attacks, the concept of disaster—once considered a rare event—has become central to public health preparedness. Mass casualty incidents, whether caused by terrorism, pandemics, or environmental catastrophes, require a robust and ethically grounded triage system to achieve the greatest good for the greatest number (Subbarao et al., 2008).

Triage is a systematic process used to prioritize patients based on the urgency of their medical needs. It determines whether a patient's condition is critical, limb-threatening, or requires immediate intervention to alleviate symptoms (Iserson & Moskop, 2007). In standard triage systems, patients suffering from life-threatening injuries or multiple-system trauma are prioritized for immediate treatment (Jenkins et al., 2008; Cone & Koenig, 2005).

According to the WHO, a disaster constitutes a large-scale, often abrupt ecological or man-made event that exceeds local healthcare capacities and requires external assistance (WHO, 2011). Disasters overwhelm regional healthcare systems and demand alternative, resource-sensitive strategies to deliver care. In such contexts, disaster triage becomes essential, designed to allocate limited resources to those most likely to survive with timely intervention (Subbarao et al., 2008).

Unlike routine triage, disaster triage aims not to optimize care for each individual but to maximize survival rates across the affected population. When the number of casualties surpasses available healthcare providers or supplies, priority is given to those with the highest likelihood of survival using minimal resources (Barbisch & Koenig, 2006). This utilitarian approach, although ethically complex, is grounded in public health principles aiming to reduce overall mortality and prevent further hospital overload (Kaji et al., 2006).

Disaster triage maintains the core categories of conventional systems, including color-coded prioritization to rapidly categorize patients. These commonly include (Jenkins et al., 2008; Koenig & Schultz, 2010):

Red (Immediate): Life-threatening conditions requiring urgent care

Yellow (Delayed): Serious but not immediately life-threatening conditions

Green (Minor): Patients with minor injuries who can wait or self-care

Black (Unexpectant/Deceased): Individuals who are deceased or whose survival is unlikely even with extensive medical intervention

Five-category systems sometimes include a "gray" or "expectant" classification for patients with minimal survival chances. These individuals may receive palliative care but are not prioritized for immediate resource-intensive interventions during peak crisis conditions (Lee, 2010).

In Türkiye, the color-coded triage systems such as START and NATO protocols—are utilized in disaster scenarios. These systems are also aligned with international emergency medicine standards and are applied consistently in prehospital care environments (AFAD, 2023).

Disaster triage differs significantly from routine triage in that decisions may shift based on the availability of resources. For instance, a patient assigned a red code in a typical hospital setting might receive a black code during a disaster due to the severity of injuries and poor prognosis relative to available resources. Although emotionally distressing, these decisions are guided by rational frameworks intended to protect the greatest number of lives (Subbarao et al., 2008).

The overarching goal of disaster triage is to manage scarce resources effectively while ensuring rapid, equitable care based on clinical status and expected outcomes. By implementing disaster triage, hospitals can prevent secondary disasters—such as system collapse—while reducing preventable deaths, complications, and long-term disabilities. Effective triage helps ensure that resources are distributed according to priority, maximizing the impact of available personnel, equipment, and time (Koenig & Schultz, 2010; Kaji et al., 2006).

Disaster Triage in the Field

Disaster triage systems are essential tools used to rapidly identify and prioritize critically injured individuals in mass casualty situations where time and resources are severely limited. These systems are designed for application in complex and chaotic environments and aim to maximize the number of lives saved by ensuring that patients receive care in accordance with the urgency of their condition (Jenkins et al., 2008; Cone & Koenig, 2005).

Most disaster triage systems categorize patients into four or five priority groups based on key physiological indicators. These indicators typically include the ability to walk, respiratory function, circulatory status, and level of consciousness (Navin et al., 2010). In scenarios where the number of casualties exceeds available medical and transportation resources, disaster triage becomes indispensable. It enables the equitable allocation of scarce resources and supports coordinated response planning (Iserson & Moskop, 2007).

Triage during a disaster response can be conducted in two main settings: at the scene (pre-hospital/field) and within healthcare facilities. The field triage process, in particular, plays a critical role in the implementation phase of disaster management, which also includes the phases of activation, mitigation, and recovery (WHO, 2020). As the initial step of medical intervention, field triage must be rapid, easy to apply, and free from complex scoring mechanisms to ensure effectiveness in high-pressure environments (Jenkins et al., 2008).

The core objective of field triage is to do "the greatest good for the greatest number," a principle that underpins most modern mass casualty response protocols. Triage tools are designed to quickly detect life-threatening injuries without requiring extensive diagnostic procedures (Cone & Koenig, 2005). Current triage models are built on a foundation of simple assessments using physiological criteria, particularly evaluating whether the patient can walk, their breathing rate, pulse quality or capillary refill, and responsiveness to verbal stimuli (START Triage, 2024).

Primary Disaster Triage in the Field

Primary disaster triage occurs immediately at the site of the incident. It involves the rapid classification of victims based on their physiological condition to determine the urgency of treatment. Multiple triage models have been developed globally, each tailored for efficient use in disaster environments. Among the most widely adopted systems are:

- **START** for adults
- **JumpSTART** for pediatric victims
- **SALT (Sort, Assess, Life-saving interventions, Treatment/Transport)** for adults and pediatric victims

Each of these methods offers a structured but flexible approach for frontline responders, including nurses, who are often the first to evaluate patients at the disaster site. For example, START enables first responders to assess and categorize victims within 30 to 60 seconds, based on criteria such as respiratory rate, capillary refill, and mental status (Christian, 2014).

Nurses are integral to the primary triage process. Their ability to assess patients rapidly, initiate basic life-saving interventions, and maintain calm under pressure is crucial for triage accuracy and efficiency. Furthermore, nurses often serve as team leaders in field triage operations, ensuring consistent application of protocols and directing resource allocation based on real-time assessments.

START Triage System

The START algorithm was originally developed in 1980 by the Newport Beach Fire Department in collaboration with Hoag Memorial Hospital in California (Lin et al., 2022; Bazyar et al., 2019). Since its inception, START has become one of the most widely adopted disaster triage methods globally, including in countries such as Türkiye, the United States, Canada, Australia, Japan, and Israel (Shackelford et al., 2022).

Designed for use in mass casualty incidents, the START system aims to evaluate all individuals over the age of 8 within 60 seconds or less, based on a predefined set of physiological criteria. The core components assessed in START include ambulatory status, respiratory function, perfusion, and level of consciousness. Based on these observations, patients are assigned to one of four color-coded triage categories (Bhalla et al., 2015).

The algorithm begins by instructing all patients capable of ambulation to move to a designated location. These individuals, presumed to have minor injuries, are initially categorized as green, but will subsequently undergo further assessment to rule out any underlying life-threatening conditions. Next, for those unable to walk, airway and spontaneous respiration are evaluated. If breathing does not resume after opening the airway, the patient is classified as black, indicating an expectant or deceased status. If the patient is breathing, the respiratory rate is measured:

- A rate exceeding 30 breaths per minute warrants red (immediate) categorization.
- If the rate is below 30, the next step is to assess perfusion, using either radial pulse palpation or capillary refill time.
  - Absence of a radial pulse or a refill time exceeding 2 seconds indicates compromised perfusion, and the patient is also categorized as red.
  - If perfusion is adequate, the final assessment involves determining the patient's mental status.

Patients unable to follow simple commands are assigned a red code, whereas those who are responsive and can obey commands are triaged as yellow (delayed). This structured process allows first responders to rapidly sort and prioritize care based on the severity of injuries and the likelihood of survival (Figure 1.3-1).

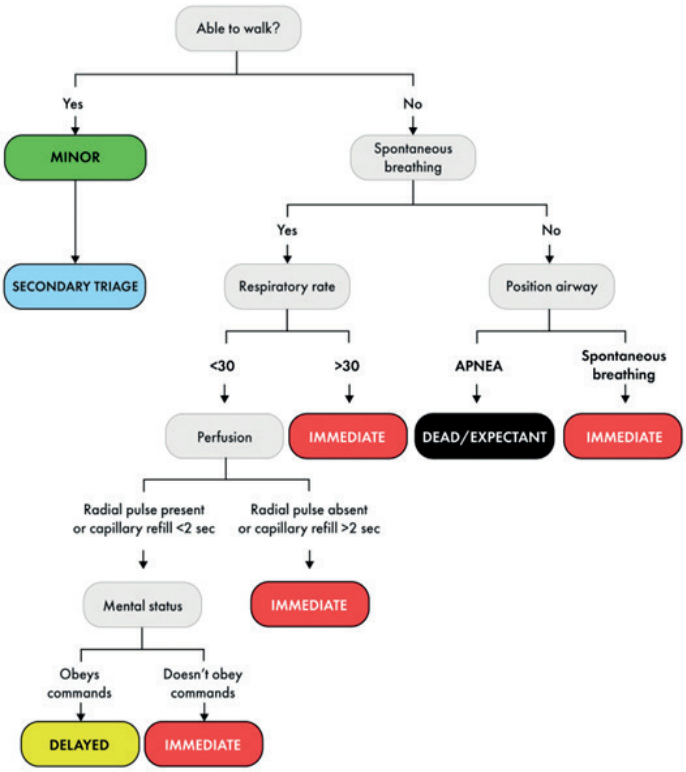


Figure 1.3-1. START algorithm

Jump START Triage System for Pediatric Patients

The Jump START triage system is a pediatric adaptation of the original START algorithm, developed to address the unique physiological characteristics of children, particularly in mass casualty incidents. Unlike adults, most pediatric cardiopulmonary arrests are primarily respiratory in origin. Recognizing this, Jump START modifies certain criteria to account for the distinct clinical needs of pediatric patients (ages approximately 1–8 years).

A key distinction from the adult START model lies in the assessment sequence. In Jump START, if a child is not breathing, circulatory status is assessed before assigning a "black" code. If no palpable pulse is found, the child is designated as black (deceased/expectant). However, if a pulse is present, five rescue breaths are administered to stimulate spontaneous breathing. Should respirations resume, the child is triaged as red (immediate). If breathing does not resume following rescue breaths, the child is assigned a black code. Another modification in Jump START is that children who are unable to walk are not automatically coded green, as in adult START. Instead, these non-ambulatory patients start with an initial triage code of yellow (delayed) until further assessment determines their precise status. This ensures that children who may be preverbal or developmentally unable to walk are not misclassified (Figure 1.3-2).

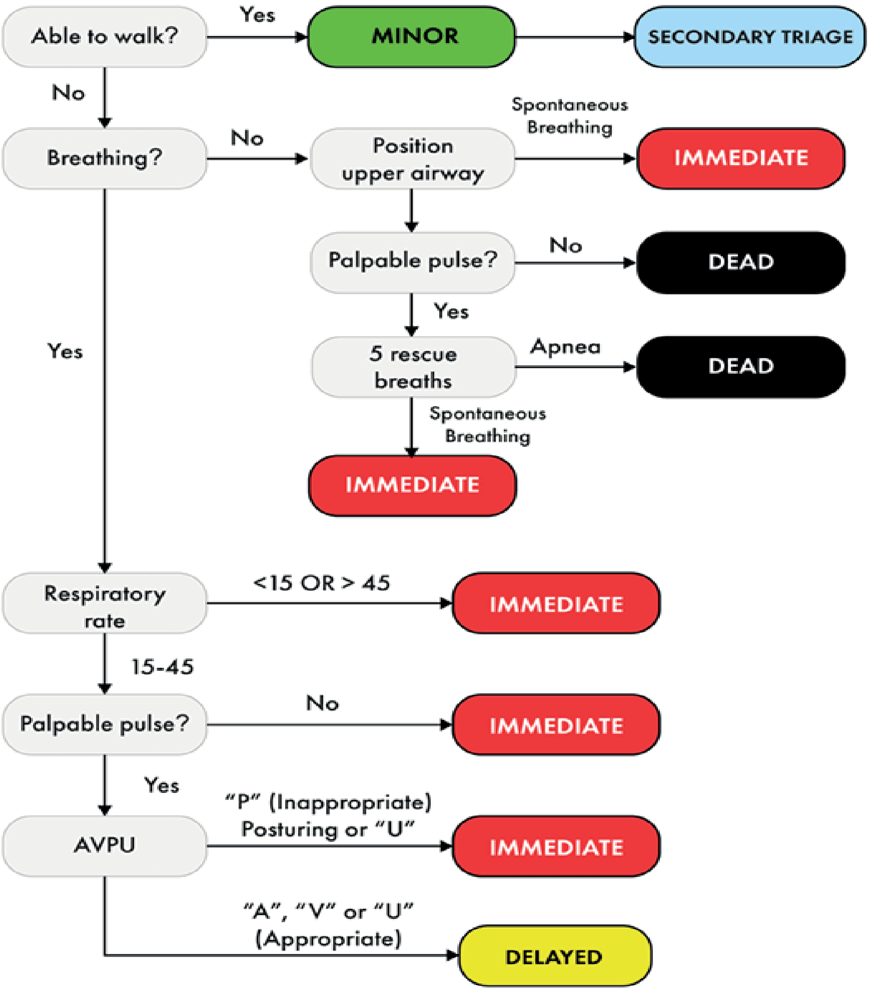


Figure 1.3-2. Jump START algorithm

SALT Triage System

Developed in 2008 by a CDC-led expert panel, the SALT triage system is recognized as one of the most evidence-informed and scientifically grounded mass casualty triage models. It is designed to be used for both adult and pediatric populations and has been endorsed as a national guideline in the United States (Lerner et al., 2010). The SALT system classifies patients into five categories, typically color-coded for operational clarity (Silvesstri et al., 2017):

Black (Dead): No signs of life or incompatible with survival

Gray (Expectant): Severely injured with poor prognosis despite maximal care

Red (Immediate): Requires urgent intervention to survive

Yellow (Delayed): Serious but not immediately life-threatening

Green (Minimal): Minor injuries, ambulatory patients

The SALT triage protocol is implemented through three structured steps (Nilsson et al., 2015):

Step 1: Global Sorting

Patients are first sorted based on their ability to move or respond purposefully. Those who can walk are directed to a designated area and preliminarily categorized as green. Patients showing purposeful movement but unable to walk are evaluated as a secondary priority, while non-responsive or immobile patients are considered the highest priority for assessment.

Step 2: Individual Assessment and Life-Saving Interventions

In this stage, responders evaluate each patient and administer immediate life-saving interventions if necessary. These interventions include:

- Control of major hemorrhage
- Airway management
- Chest decompression for tension pneumothorax
- Administration of antidotes via autoinjectors

If the patient remains apneic following these interventions, they are triaged as dead (black). For those who are breathing, additional evaluations are performed to assess:

- Level of consciousness
- Presence of a peripheral pulse
- Respiratory distress
- Presence of uncontrolled bleeding

If any of these assessments reveal significant abnormalities, the patient is classified as red. Green is assigned to those with stable vital signs and minor injuries, and yellow is used for patients with moderate, non-life-threatening conditions requiring treatment. A critical distinction in the SALT system is the inclusion of the gray category, or "expectant" group. These are patients unlikely to survive given the extent of their injuries and the current resource limitations. The management of patients in this group depends largely on available medical capacity and ethical guidelines in mass casualty situations.

Step 3: Treatment and/or Transport

The final stage focuses on prioritizing treatment and transport decisions based on the triage classification. The aim is to optimize survival rates while ensuring that limited resources are allocated where they can be most effective. The SALT system has demonstrated comparable effectiveness to Jump START in pediatric settings and is supported by numerous studies as a suitable tool for both adult and child triage during disaster responses.

Sieve Triage System

The Sieve triage system is commonly used in the United Kingdom, parts of Europe, and Australia, particularly in pre-hospital and mass casualty environments. While similar in structure to the START system, it includes an additional emphasis on heart rate assessment as a marker for circulatory status. In the Sieve approach:

- Patients with a heart rate of >120 bpm or <40 bpm are categorized as red (immediate).
- Those with a heart rate between 40–120 bpm are assigned the yellow (delayed) code, provided other vital signs remain within normal parameters.

Like START and SALT, the Sieve triage framework aims for rapid assessment and classification using straightforward physiological indicators. Its simplicity and alignment with emergency medical service protocols make it a practical choice in large-scale emergencies.

REFERENCES

AFAD (2023). Afet ve Acil Durum Yönetimi Başkanlığı 2023 Yılı Eğitim Rehberi. Ankara: T.C. İçişleri Bakanlığı. Retrieved from https://www.afad.gov.tr

Alanazi, N. E. G., Alanazi, W. S. A., Almutairi, F. N., Alshahrani, E. F., Elyafaoui, H. A., & Alotaibi, H. D. (2024). Ethical Dilemmas Faced by Nurses During Epidemic Crises. *Journal of International Crisis and Risk Communication Research*, *7*(S3), 657.

Alavi, N. M. (2014). Disaster: Are We Prepared? *Nursing and Midwifery Studies*. https://doi.org/10.17795/NMSJOURNAL19993

Alrajhi, A. (2018). *Perspectives on ethical nursing practice in disaster during the Hajj 2015*. https://doi.org/10.4172/2167-1222-C1-009

Anderson, M., & Beach, M. (2022). Nursing During a Disaster Starts with Education.*AACN Advanced Critical Care*. https://doi.org/10.4037/aacnacc2022966

Barbisch, D., & Koenig, K. L. (2006). Understanding surge capacity: Essential elements. *Academic Emergency Medicine*, 13(11), 1098–1102. https://doi.org/10.1197/j.aem.2006.06.041

Bazyar, J., Farrokhi, M., & Khankeh, H. (2019). Triage systems in mass casualty incidents and disasters: a review study with a worldwide approach. *Open access Macedonian journal of medical sciences*, *7*(3), 482.

Bella Magnaye, R., Muñoz, M., Muñoz, M., Muñoz, R., & Muro, J. (2011). The role, preparedness and management of nurses during disasters. *International Scientific Research Journal*, *3*(4), 269-94.

Benight, C. C., & Bandura, A. (2004). Social cognitive theory of posttraumatic recovery: The role of perceived self-efficacy. *Behaviour Research and Therapy, 42*(10), 1129–1148. https://doi.org/10.1016/j.brat.2003.08.008

Bhalla, M. C., Frey, J., Rider, C., Nord, M., & Hegerhorst, M. (2015). Simple Triage Algorithm and Rapid Treatment and Sort, Assess, Lifesaving, Interventions, Treatment, and Transportation mass casualty triage methods for sensitivity, specificity, and predictive values. *The American journal of emergency medicine*, *33*(11), 1687-1691.

Centers for Disease Control and Prevention (CDC), (2018). *Public health preparedness capabilities: National standards for state and local planning*. https://www.cdc.gov/cpr/readiness/capabilities.htm

Cone, D. C., & Koenig, K. L. (2005). Mass casualty triage in the chemical, biological, radiological, or nuclear environment. *Emergency Medicine Clinics of North America, 23*(2), 293-311. https://doi.org/10.1016/j.emc.2005.01.001

Christian, M. D., Sprung, C. L., King, M. A., Dichter, J. R., Kissoon, N., & Devereaux, A. V. (2014). Triage: Care of the critically ill and injured during pandemics and disasters. Chest, 146(4_suppl), e61S–e74S. https://doi.org/10.1378/chest.14-0736

Firouzkouhi, M., Kako, M., Abdollahimohammad, A., Balouchi, A., & Farzi, J. (2021). Nurses' roles in nursing disaster model: a systematic scoping review. *Iranian journal of public health*, *50*(5), 879.

Fithriyyah, Y. N., & Haryani, H. (2023). Trends and ethical issues in nursing during disasters: A systematic review. *Nursing Ethics*. https://doi.org/10.1177/09697330231155602

Flaubert JL, Le Menestrel S, Williams DR, ve diğerleri, editörler. The Future of Nursing 2020-2030: Charting a Path to Achieve Health Equity. Washington (DC): National Academies Press (US); 2021 Mayıs 11. Bölüm 8, Nurses in Disaster Preparedness and Public Health Emergency Response. Ulaşılabilir: https://www.ncbi.nlm.nih.gov/books/NBK573904/

Fletcher, K. A., Reddin, K. M., & Tait, D. (2022). The history of disaster nursing: from Nightingale to nursing in the 21st century. *Journal of Research in Nursing*. https://doi.org/10.1177/17449871211058854

Gebbie, K., & Qureshi, K. (2002). Emergency and disaster preparedness: Core competencies for nurses. *American Journal of Nursing, 102*(1), 46-51. https://doi.org/10.1097/00000446-200201000-00023

Hilmi, L. M., Bristow, R., Balsari, S., Anthony, D., Vortman, M., Cordi, H., Gonzales, D., & Heerboth, A. (2011). (A47) Disaster Nurses in Developing Countries: Strengthening Disaster Nurses' Competencies through Training and Disaster Drills. *Prehospital and Disaster Medicine*. https://doi.org/10.1017/S1049023X11000598

Hilton, C., & Allison, V. (2004). Disaster preparedness: an indictment for action by nursing educators. *Journal of Continuing Education in Nursing*. https://doi.org/10.3928/0022-0124-20040301-07

Hirani, S. A. A. (2023). Preparing next generation of nurses to care for disaster affected population: A call to action in nursing curriculum. *Teaching and Learning in Nursing*. https://doi.org/10.1016/j.teln.2023.04.009

Holdo, G.-M. (2021). *Disaster nursing or nursing in disaster: a case study approach to investigate the future requirements of disaster nursing in Norway.*

Houston, J. B., Spialek, M. L., Cox, J., Greenwood, M. M., McLaughlin, P., & First, J. (2015). The role of community engagement in disaster preparedness, response, and recovery. *American Journal of Public Health, 105*(8), e1-e9. https://doi.org/10.2105/AJPH.2015.302797 https://chemm.hhs.gov/startadult.htm

International Council of Nurses (ICN). (2019). Core competencies in disaster nursing version 2.0. https://www.icn.ch/system/files/documents/2020-07/ICN_Disaster-Comp-Report_WEB.pdf

Iserson, K. V., & Moskop, J. C. (2007). Triage in medicine, part I: Concept, history, and types. Annals of Emergency Medicine, 49(3), 275–281. https://doi.org/10.1016/j.annemergmed.2006.05.019

Jenkins, J. L., McCarthy, M. L., Sauer, L. M., Green, G. B., Stuart, S., Thomas, T. L., & Hsu, E. B. (2008). Mass-casualty triage: Time for an evidence-based approach. Prehospital and Disaster Medicine, 23(1), 3–8. https://doi.org/10.1017/S1049023X00005564

Kaji, A. H., Koenig, K. L., & Bey, T. (2006). Surge capacity for healthcare systems: A conceptual framework. *Academic Emergency Medicine, 13*(11), 1157-1159. https://doi.org/10.1197/j.aem.2006.06.015

Koenig, K. L., & Schultz, C. H. (2010). Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices. Cambridge University Press.

Lee, C. H. (2010):"Disaster and mass casualty triage." AMA Journal of Ethics 12.6; 466-470.

Lee, C.-L., & Chiang, L.-C. (2010). [Disaster response: essential competence for nurses]. *The Journal of Nursing (China)*.

Lerner, E. B., Schwartz, R. B., Coule, P. L., & Pirrallo, R. G. (2010). Use of SALT triage in a simulated mass-casualty incident. *Prehospital emergency care*, *14*(1), 21-25.

Lin, Y. K., Chen, K. C., Wang, J. H., & Lai, P. F. (2022). Simple triage and rapid treatment protocol for emergency department mass casualty incident victim triage. *The American journal of emergency medicine*, *53*, 99-103.

Ma, C., Qishan, Z., Wen, G., Weng, D., He, P.-B., Lai, J., Chen, H., Shao-juan, D., Deng, Q., & Tan, Y. (2024). *The core competencies in disaster nursing and influencing factors among clinical nurses in Guangzhou: a cross-sectional study based on latent profile analysis*. https://doi.org/10.21203/rs.3.rs-5201065/v1

Mao, X., Yang, Q., Li, X., Chen, X., Guo, C., Wen, X., & Loke, A. Y. (2021). An illumination of the ICN's core competencies in disaster nursing version 2.0: Advanced nursing response to COVID-19 outbreak in China. *Journal of Nursing Management*. https://doi.org/10.1111/JONM.13195

McEntee, M. A. (2004). Disaster Nursing and Emergency Preparedness for Chemical, Biological, and Radiological Terrorism and Other Hazards.*Nursing Education Perspectives*.

Munandar, A., & Wardaningsih, S. (2018). *Nursing Provision in Psychological Aspect Management of Natural Disaster*. https://doi.org/10.22219/JK.V9I2.5311

Murray, J. S. (2020). *History of Disaster Nursing*. https://doi.org/10.1007/978-3-030-43428-1_2

Nejadshafiee, M., Mirzaee, M., Aliakbari, F., Rafiee, N., Sabermahani, A., & Nekoei-Moghadam, M. (2020). Hospital Nurses' Disaster Competencies.*Trauma Monthly*. https://doi.org/10.30491/TM.2020.213440.1003

Nilsson, A., Åslund, K., Lampi, M., Nilsson, H., & Jonson, C. O. (2015). Improved and sustained triage skills in firemen after a short training intervention. *Scandinavian journal of trauma, resuscitation and emergency medicine*, *23*, 1-6.

Nursing Experience on Disaster and Health Emergencies. (2022). https://doi.org/10.1007/978-3-030-98297-3_7

Paudel, S., & Kanbara, S. (2023). Development of disaster nursing in Nepal: Opportunities and challenges for advanced practice. *International Nursing Review*. https://doi.org/10.1111/inr.12880

Regehr, C., Hill, J., Knott, T., & Sault, B. (2003). Social support, self-efficacy and trauma in new recruits and experienced firefighters. *Stress and Health, 19*(4), 189-193. https://doi.org/10.1002/smi.983

Robertson-Steel I. (2006). Evolution of triage systems. Emerg Med J. Feb;23(2):154-5. doi: 10.1136/emj.2005.030270. PMID: 16439754; PMCID: PMC2564046.

Sakashita, R. (2014). *Development in disaster nursing: The challenges of various research designs*. https://doi.org/10.24298/HEDN.2014-1.19

Santos, P., Rabiais, I., Frade, J., Coutinho, V. R. D., & Baptista, R. (2024). General nurse competencies in disaster: a delphi study. *Nurse Education in Practice*. https://doi.org/10.1016/j.nepr.2024.104037

Schroeter, K., Schroeter, K., & Schroeter, K. (2008). Nurses, Ethics, and Times of Disaster.*Perioperative Nursing Clinics*. https://doi.org/10.1016/J.CPEN.2008.04.006

Scrymgeour, G. C., Smith, L., & Paton, D. (2016). Exploring the demands on nurses working in health care facilities during a large-scale natural disaster: often an invisible role within a highly visible event. *SAGE Open*. https://doi.org/10.1177/2158244016655587

Shackelford, S. A., Remley, M. A., Keenan, S., Kotwal, R. S., Baker, J. B., Gurney, J., ... & Friedrichs, P. (2022). Evidence-based principles of time, triage and treatment: refining the initial medical response to massive casualty incidents. *Journal of trauma and acute care surgery*, *93*(2S), S160-S164.

Segev, R., Suliman, M., Gorodetzer, R., Zukin, L., & Spitz, A. (2024). Nursing roles in disaster zones: Experiences and lessons from Turkey's 2023 earthquakes. *International Nursing Review*. https://doi.org/10.1111/inr.12964

Shafer, M. R., & Stocks, L. (2012). Conducting ethically sound disaster nursing research. *Annual Review of Nursing Research*. https://doi.org/10.1891/0739-6686.30.47

Silvestri, S., Field, A., Mangalat, N., Weatherford, T., Hunter, C., McGowan, Z., ... & Papa, L. (2017). Comparison of START and SALT triage methodologies to reference standard definitions and to a field mass casualty simulation. *American journal of disaster medicine*, *12*(1), 27-33.

Songwathana, P., & Timalsina, R. (2021). Disaster preparedness among nurses of developing countries: an integrative review. *International emergency nursing*, *55*, 100955.

Subbarao, I., Lyznicki, J. M., Hsu, E. B., Gebbie, K. M., Markenson, D., Barzansky, B., ... & James, J. J. (2008). A consensus-based educational framework and competency set for the discipline of disaster medicine and public health preparedness. Disaster Medicine and Public Health Preparedness, 2(1), 57–68. https://doi.org/10.1097/DMP.0b013e31816564af

Thrwi, A. M., Hazmi, A. M. A., Kalfout, A. M., Kariri, H. M., Aldabyan, T. Y., & Alsalah, Z. H. (2024). Nursing leadership in disaster preparedness and response lessons learned and future directions. *International Journal of Community Medicine and Public Health*. https://doi.org/10.18203/2394-6040.ijcmph20241989

Veenema TG (2018). Disaster nursing and emergency preparedness for chemical, biological, and radiological terrorism and other hazards. 4th ed. New York: Springer Publishing Company; 2018.

Veenema, T. G. (2016). *Global disaster nurse preparedness: Moving from reserve to rapid action*. https://doi.org/10.24298/HEDN.2015-0018

World Health Organization. (WHO) (2011). Disaster risk management for health: Overview. Retrieved from https://www.who.int/hac/events/drm_fact_sheet_overview.pdf

World Health Organization (WHO). (2021). Strengthening health emergency preparedness: WHO guidance for countries. https://www.who.int/publications/i/item/9789240026095

World Health Organization. (WHO) (2020). *WHO health emergency and disaster risk management framework*. https://www.who.int/publications/i/item/9789240019787

Wu, C., Zhou, M., Liu, P., & Yang, M. (2021). *Analyzing COVID-19 Using Multisource Data: An Integrated Approach of Visualization, Spatial Regression and Machine Learning*. https://doi.org/10.1029/2021GH000439

Ziapour, A., Darabi, F., Rostami, F., Motevaseli, S., Sharma, M., Chaboksavar, F., Yıldırım, M., & Kianipour, N. (2024). Investigating perceived core disaster competencies of nurses in Iran: A case study of northwest hospitals. *Public Health Nursing*. https://doi.org/10.1111/phn.13367

Chapter 1B: Disaster Nursing

Hudáčková Andrea, Dolák František, Chloubová Ivana, Tóthová Valérie

1. 4. Clinical Care in Disasters

Disasters have become more frequent in recent decades and affect countries across all socio-economic conditions. Preparedness and planning are crucial since these events can occur anywhere and at any time (Clarkson & Williams, 2023). Disaster planning requires health organizations to be able to visualize events that may never occur, such as mass accidents with significant numbers of casualties. After many tragic events, large-scale disasters with numerous victims are now easy to imagine. As a result, disaster planning and preparedness have become a healthcare focus (AHIMA, 2016).

Disasters disrupt essential functions and services, such as patient care, electricity, water, and communications. Such interruptions can be severe and may result in the loss of critical services for extended periods. These outages can have a lasting impact on organizations as well as the entire community. A well-planned disaster response allows patient care to continue and essential operations to be maintained during and after the event (AHIMA, 2016).

Disaster and mass disaster medicine is an interdisciplinary medical field that uses the scientific knowledge and experience of other medical disciplines in emergencies and disasters as part of rescue, resolution or containment of the crisis, and prevention of disease spread due to poor sanitation or hygienic conditions. Unlike emergency medicine, disaster medicine deals with the treatment of multiple injured, wounded, and sick under the pressure of time, and usually with insufficient strength and resources. Practical procedures used in mass disasters and catastrophes, both natural and man-made, must always be subsequently analyzed to improve future responses. Disaster medicine aims to reduce the loss of human life, reduce the suffering of those affected, and minimize negative health outcomes (Šín, 2017).

The term "mega-disaster" is used for disasters in which there are huge losses of human life, and the entire economic infrastructure is destroyed and include events such as massive floods, earthquakes, tsunamis, etc. (Štětina et al., 2014). Such crises are addressed by the World Health Organization (WHO) and the United Nations Disaster Assessment and Coordination (UNDAC). These organizations provide disaster classifications, establish the scope of international aid, set standards for emergency management, outline essential medical care requirements, and compile the data needed to request global assistance. UNDAC serves as an international emergency response system for earthquakes or floods and is designed to assist the United nationals and local governments in disaster-stricken areas during the first phase of an emergency (UNDAC, 2025).

1.4.1. Crisis Preparedness of Hospitals

Crisis preparedness in the health sector refers to the capacity of territorially responsible state and local government bodies, along with health service providers, to deliver essential health care to the population during crises and emergencies. This is achieved through qualified health professionals to meet the needs of the population (Šín, 2017).

The entire medical rescue chain takes part in rescue and disaster containment. The first link in the chain is first aid, the second is professional pre-hospital emergency care, and the third is professional emergency care provided in hospitals. Crisis preparedness of a hospital includes not only preparedness for mass admission of patients, but also the ability to respond to emergencies inside and outside the hospital, as well as possible technology and energy outages. Adequate hospital crisis preparedness aims to ensure that facilities can respond effectively to a wide range of emergencies while minimizing the risk of being overwhelmed by unforeseen circumstances (Šín, 2017).

Crisis management systems serve as tools for the continuity of the operation of healthcare facilities during all types of emergencies and disasters. Hospital crisis preparedness includes activities aimed at managing mass admission of the injured and sick (traumatology and pandemic plans) and activities aimed at managing internal dangers or external threats to the facility, including the failure of technological systems, energy supplies, and other infrastructure failures that impact hospital operations (e.g., evacuation plans and crisis operation and administration procedures). Most crises require the involvement of all hospital departments, since changes in hospital procedures and routines apply to the entire facility. Additionally, all hospital staff are involved, not just medical staff. All employees need to transition to crisis mode, which can include freeing up beds, assuming some patient responsibilities in specific departments, supporting the activities of specific departments, and participating in managing hospital entrances or exits (Štětina et al., 2014).

1.4.2. Hospital Emergency Point Contact and Management

It is always important that hospitals have a single point of contact that operates around the clock, with the proper technical equipment and personnel, and that accepts calls and has the skill set to implement crisis plans. Optimally, the entire crisis event should be controlled from the same location. Adequate responses require both capability and sufficient reaction speed; it is necessary to have a system for mass or targeted notification of both on-site and off-site hospital staff (Štětina, et al., 2014).

As part crisis plan activation, the crisis team staff is convened, where each member has a predetermined function in crisis management with a specific area of responsibility. Crisis communication must be clear and prompt. Mass admission of patients or mass transfer of patients will likely involve many contractual entities not familiar with the hospital; therefore, entrances, exits, and routes must be very clearly marked using color coding. The color coding of routes, entrances, sectors, and corridors inside a hospital is based on generally accepted markings that indicate the severity of the condition, e.g., red, yellow, green, and black (Štětina et al., 2014).

1.4.3. Patient Triage

Triage of a large number of patients is crucial in mass disasters and disasters. It provides a structured approach for managing large numbers of injuries and effectively allocating limited resources, which can save lives and improve overall treatment outcomes. The aim is to ensure that patients with the greatest healthcare needs are treated first. Currently, due to the growing incidence of disasters and emergencies around the world and increases in the number of injured, modern and intelligent triage systems using artificial intelligence are starting to be used, while still dealing with the challenges of using traditional triage methods (Tahernejad et al., 2024).

Treatment at the scene of the incident is minimal during triage, which is contrary to common pre-hospital protocols, but the primary objective is to move patients from the scene of the incident to a medical facility, i.e., places with the resources for more comprehensive care. Most mass casualty triage systems use labels or color coding to categorize injured people. It is a dynamic and efficient process, but it requires a certain degree of knowledge and specific skills. Patients may initially be classified into one category and later reassigned due to changes in their clinical status. Many triage labels are designed to easily switch patients between categories. However, the main focus should be on a prompt initial assessment followed by rapid patient transfer (Clarkson & Williams, 2023).

There are various systems and protocols for patient triage, with the best known and most used being Simple Triage and Rapid Treatment (START) and JumpSTART, which is used for pediatric patients. Other hospital-based triage instruments include the Canadian Triage and Acuity Scale (CTAS), Sort, Assess, Lifesaving Interventions, Treatment/Transport (SALT), and the Australian Triage Scale (ATS). Mass casualty triage is a procedure used for systematic initial assessment and prioritization of patients based on the urgency of their condition. It helps determine treatment urgency and is often used in emergency centers or emergency departments. The CTAS was originally developed for use in emergency departments of Canadian hospitals as a tool to help determine patient needs. The ATS is a clinical instrument used to determine the maximum waiting time for a patient's medical examination and treatment. The goal of ATS is to ensure that patients who arrive at the emergency department are treated in order of clinical urgency and are assigned to the most appropriate area for assessment and treatment. ATS also helps describe the case mix or acuity profile in a ward (Mehta, 2024).

1.4.4. Admission of Large Numbers of Patients to a Hospital (Managing Increased Hospital Admissions during a Crisis)

After a disaster, hospitals experience a sudden increase in admissions. To optimally manage the surge, there must be effective triage of patients both at the scene and in the medical facility, sufficient resources and staff, and sufficient treatment space. Medical staff not present at the workplace are called in as soon as possible to supplement the hospital workforce (Gök et al., 2023).

Continuity of pre-hospital and hospital care is essential. This can be facilitated by color coding for easy orientation and movement within the hospital. Here is an example that includes standards used in systems like START and SALT (red, yellow, green, black) as well as some hospital-specific options (red-yellow, brown, grey, and blue)(Štětina, et al., 2014):

Red: Intended for critically ill patients requiring urgent vital function support

Red-Yellow: Intended for patients in need of urgent surgical intervention (without the possibility of stabilization)

Yellow: Intended for patients requiring medical intervention, but there is no immediate threat to vital functions, temporary treatment measures can stabilize the condition and postpone the definitive solution

Green: Intended for patients not needing urgent intervention, i.e., treatment can be postponed without risk

Black: Intended for deceased persons; routing leads to a designated burial site

Brown: Intended for patients with a highly virulent infection, the routing leads to the entrance of an isolation room or the infectious diseases clinic

Grey: Intended for patients with toxic, chemical, and radiation injuries, i.e., routing leads to an area intended for decontamination.

Blue: Intended for family members of admitted patients and representatives of the media

Entrances and entrance-attendants, and security guards must have their own detailed crisis manuals that clearly describe their duties and responsibilities when initiating a specific crisis plan. These include restricting or regulating traffic, preventing unauthorized entry, and ensuring passability both inside the hospital and around hospital grounds (Štětina et al., 2014). Patients brought by the emergency medical service, who come pre-sorted and color-coded, are admitted at predetermined and color-coded admission points – entrances. The number and composition of individual teams depend on the number of affected people. These numbers need to be adapted to the availability of staff and the availability of individual specialties (Štětina et al., 2014).

The triage team at the "red-yellow" entrance, for example, consists of the head of the emergency department, a general nurse, a chief traumatologist, or another intensivist, depending on the nature of the event. Each team consists of a doctor and a nurse according to the nature of the injuries and the causes of the emergency. The teams are complemented by doctors from other disciplines who perform consultations (e.g., neurosurgeon, neurologist, radiologist, orthopedic surgeon, among others). The psychological-psychiatric teams at the "green" entrance are made up of clinical psychologists and psychiatrists. The registration identification teams are composed of designated employees from the central patient register and other designated technical and administrative workers who keep records of patients admitted to the hospital. All members of individual teams are marked with a reflective vest with the designation of doctor, nurse, or the appropriate specialty (Štětina et al., 2014).

Admission points for "red," "red-yellow," and "yellow" patients are best located near the entrance to the emergency department and in such a way that a dedicated corridor can be created for the transfer of patients to operating theatres, intensive care beds, and other diagnostic and treatment areas, as well as to the green sector. Triage teams confirm or change the severity assessment of arriving patients as needed. When condition allows, teams try to obtain as much patient information as possible, but this activity should not delay treatment (Štětina et al., 2014). "Greens" admission points require a sufficiently large space but do not require special equipment (i.e., only chairs, seats, and couches are needed), but there needs to be a link to diagnostic and treatment areas, so it is usually located in outpatient and adjacent areas. Patients wait under constant professional supervision for final examinations and treatment, which begin as soon as diagnostic and treatment areas become available. Patients can then be placed on standard vacant beds for observation (Štětina et al., 2014).

When admitting a large number of patients, it is necessary to focus on bed capacity and bed occupancy rates at the time of disaster (Ceferino et al., 2020). Each hospital must therefore have a plan for increasing bed capacity and methods for transforming and optimizing the premises. Outpatient spaces can be transformed, for example, into rooms for hospitalized patients, and corridors can be used for "observation" beds (Gök et al., 2023).

The largest number of patients are admitted from 24–36 hours after a disaster (Eyler, 2022; Dursun, 2012; Alkan, 2001), and the highest number of surgical procedures usually occur two days after the disaster (Gök et al., 2023). Therefore, in the first days after a disaster, it is recommended to postpone non-urgent interventions in order to effectively use the capacity, resources, and staff of the hospital (Gök et al., 2023).

Collecting data from a large number of patients is challenging and chaotic. Especially if many of the patients are unidentified. It is therefore necessary to standardize the identification of unidentified patients, e.g., using sequential numbering. Furthermore, it is necessary to pay close attention to children brought in without their parents or whose parents died in the disaster (Gök et al., 2023). Individual admission points must be equipped with materials needed for use in the activation of the trauma plan, e.g., equipment and supplies, protective gear/decontamination materials, and communication and documentation tools (Štětina et al., 2014).

1.4.5. Medical Records and Documentation during a Disaster

Medical record management during disasters is a key element in ensuring healthcare continuity, patient protection, and effective coordination between medical and humanitarian response teams. Medical records serve as the primary means of communication for documenting a patient's medical condition. According to Smith & Macdonald (2006), disasters often significantly disrupt medical facility infrastructure, which can lead to lost or damaged medical records. An unexpected loss of medical records can be devastating for patients, the organization, and medical staff. A well-designed action plan will therefore help organizations restore or maintain operations in case of a disaster (Smith & Macdonald, 2006).

Smith & Macdonald (2006) further highlight the problem that patients may arrive undocumented, injured, disoriented, or unconscious, making it difficult to establish their medical histories. In such conditions, it is necessary to have standardized forms, simple and understandable procedures for quick registration, and ideally, backup electronic systems capable of operating in a limited offline mode. Recommended strategies include Business Continuity Planning (BCP) as part of health care facility plans, which utilize data backup to multiple locations, establish procedures for immediate recovery of operations, and clearly defined competencies for personnel responsible for medical records (Smith & Macdonald, 2006).

According to Oikawa et al. (2024), the trend in recent years has been the development of Personal Health Records (PHRs), which are stored and managed directly by the patient. The authors present PHRs as a valuable tool for ensuring continuity of care during and after disasters. If a patient has their medical records stored in digital form (e.g., in cloud storage or portable media), it allows healthcare professionals to quickly obtain critical information about diagnoses, allergies, medication, and previous procedures. However, access to personal health records during disasters is not without technical and organizational challenges. Not all patients have their records in portable form, not all formats are compatible with all healthcare systems, and not every location will have an internet connection. These barriers require comprehensive preparation, education of patients and healthcare staff, and the creation of integrated systems (Oikawa et al., 2024).

Cascella (2024) emphasizes the importance of electronic medical records during disasters. The availability of medical records in electronic form reduces the risk of medication errors, data loss, and delays in the provision of care, which are key factors in managing a crisis situation. However, according to Cascello (2024), the mere existence of electronic medical records is not enough if it is not part of a comprehensive plan for crisis preparedness and restoration of healthcare operations. Its successful use in a disaster requires a thorough integration of technology, procedures, and personnel. Developing and regularly updating a business continuity plan that includes backup scenarios, data backups, testing system recovery capability, and clearly defined employee competencies is crucial (Cascella, 2024).

Paper records can be physically destroyed, electronic systems can fail due to power outages, and servers can be destroyed or overloaded. Professional documentation of health data is essential not only for the immediate provision of care but also for legal, administrative, and epidemiological purposes. In summary, effective management of medical records during disasters requires a multi-stage, proactive approach. It is necessary to combine traditional and electronic systems, prepare backup scenarios, and even involve patients through personal health records. Such an approach ensures not only better continuity of care but also faster recovery of health systems after a disaster, more efficient analysis of crisis events, and better preparedness for future crises (Oikawa et al., 2024; Smith & Macdonald, 2006).

1.4.6. The Role of General Nurses in Disasters

The increasing frequency of natural and environmental disasters, coupled with public health emergencies such as the COVID-19 pandemic, highlights the critical importance of an adequately sized nurse workforce with all the specialized knowledge, skills, and abilities needed for an effective disaster response (NASEM, 2021).

Natural disasters have become almost commonplace in some areas. For example, Florida (USA) has experience in dealing with seasonal hurricanes, floods, and storms. In some cases, these disasters can have a cumulative effect, causing injury and death, while straining the clinical care infrastructure. The frequency of disasters is increasing the demand for nurses trained in disaster and emergency preparedness. There is a need for general nurses who can provide first aid, serve as the first line of triage, and ensure the continuation of normal hospital operations (UCF, 2025).

General nurses play a crucial role in providing healthcare during catastrophic events. Their responsibilities, as frontline health professionals, extend far beyond routine clinical activities and include vital roles in leadership, coordination, psychosocial support, and community activities (NASEM, 2021). After disasters, nurses often volunteer their time to help and strive to provide the best patient care despite challenging circumstances. They work in uncontrolled physical environments with limited resources to provide the best possible care during disaster relief efforts (UCF, 2025).

Their knowledge, skills, and ability to react quickly are essential for effectively managing situations where the health and lives of people are at risk. However, the ability to care for and protect the most vulnerable citizens depends to a large extent on their preparedness. In a wide range of clinical and community settings and in all phases of a catastrophe, general nurses play an important role in working with physicians and other healthcare team members. Before, during, and after disasters, nurses provide education, community engagement, health promotion, and public health interventions (NASEM, 2021).

In the preparedness phase, nurses play a vital role in disaster risk reduction through active involvement in risk assessment, capacity building, and the design of educational activities such as simulations and hands-on training. Their participation in developing national and institutional disaster management plans ensures that protocols reflect nursing-specific competencies and frontline realities.

Crisis preparedness is an especially important part of the education that general nurses receive since preparedness determines how well a potential crisis can be managed and resolved. Nurses should consider crisis activities as part of their basic duty and always be ready to provide health services; additionally, nurses need to stay up to date on the latest scientific advances in nursing care (Firouzkouhi et al., 2021).

During a disaster, nurses provide first aid, professional clinical care, assess and triage victims, allocate limited resources, and monitor the ongoing physical and mental health needs of affected citizens (NASEM, 2021). Their role also includes coordinating evacuations, ensuring patient transfers for treatment, and collaboration with multidisciplinary teams, including public health workers, emergency services, and logistics personnel (Firouzkouhi et al., 2021). Natural disasters can significantly increase the number of patients hospitals have to serve. Hospitals treat numerous emergency room cases and other patients daily, but a natural disaster can overwhelm services with additional patients in need of immediate care, straining both resources and staff (UCF, 2025). Nurses also play a role in organizational logistics. Disasters place unprecedented demands on healthcare systems and often put a nurse's knowledge, skills, abilities, and personal commitment to healthcare to the test. Thus, one of the most important aspects of the role of general nurses in crises emphasizes the quality of their education and training (NASEM, 2021).

In the field of public health, nurses provide care at the population level, such as preventing the spread of infections, maintaining hygiene, supervising sanitation, and being an education resource to the community, which is essential during prolonged crises (e.g., epidemics, infrastructure collapse, etc. (NASEM, 2021).

In the long-term reconstruction phase following a disaster, nurses play a crucial role in restoring community health and resilience. Their responsibilities include providing rehabilitation services, monitoring and managing chronic health conditions that may have been exacerbated by the crisis, assisting in shelter operations, and facilitating the reintegration of individuals into their communities (Al Thobaity, 2024; Firouzkouhi et al., 2021). Their activities also include evaluation of interventions, participation in after-action reviews, and contribution to the continuous improvement of plans and protocols (Firouzkouhi et al., 2021).

Core competencies in disaster nursing include ethical decision-making, crisis leadership, cultural sensitivity, resource triage, and communication skills; all are key to an effective response. Many studies report gaps in formal education in disaster nursing, so continuous education and training through simulations are essential (Al Thobaity, 2024). Well-trained nurses promote team coordination, trustworthy crisis communication, and resilience in stressful situations.

Despite their key role, nurses face many obstacles in the context of disasters: lack of resources, limited training, lack of role clarity, high physical and psychological stress, and ethical dilemmas regarding the allocation of limited resources (Al Thobaity, 2024; Farokhzadian, J., 2024). In low-resource environments, these barriers are even more pronounced due to weak infrastructure and underdeveloped national disaster management systems (Al Thobaity, 2024; Labrague, L. J., & Hammad, K., 2024).

Conclusion

Disasters are becoming more frequent and pose a serious challenge to health systems, regardless of their level of development. Anticipation and response planning are essential and must be based on scenarios involving both natural and non-natural threats, including mega-disasters. A well-prepared plan allows the maintenance of the organization's core functions and minimizes the long-term impact on the community. Crisis preparedness of hospitals includes not only the ability to handle mass admission of patients, but also resilience to technology failures and energy outages. It includes comprehensive crisis plans, trauma and pandemic procedures, evacuation scenarios, and setting up a crisis management system that effectively utilizes all departments and employees.

A well-equipped contact point plays a key role in coordinating the hospital's response, ensuring mass staff recall, and effective management of the crisis staff. Patient triage is a crucial tool in mass casualties since it allows the injured to be systematically triaged according to treatment urgency and allocates limited resources in ways that save the most lives. Modern triage systems, including Artificial intelligence (AI)-powered tools, enable rapid decision-making and flexible reassignment of patients as their condition changes. Management of medical records during disasters is crucial to ensure continuity of care and to meet legal and epidemiological requirements. The combination of paper records, electronic systems, and personal health records provides multi-layered protection against data loss. A well-designed business continuity plan, regular training exercises, and well-defined employee competencies make it possible to maintain operations even during infrastructure failures and can accelerate healthcare system recovery after a disaster. General nurses play a vital role in all phases of dealing with a catastrophic event. Nurses are on the front line in providing clinical and psychosocial assistance; they participate in triage, coordinate care with other team members, and ensure the continuity of hospital operations. Their competencies include not only clinical skills, but also crisis leadership, communication, ethical decision-making, and public health promotion.

Disaster management is a complex process requiring the integration of all of the healthcare system components, from hospital management to medical staff and from technical infrastructure to information systems. Successful disaster management requires pre-existing crisis infrastructure, clearly defined procedures, and continuous disaster training by all medical staff. This is the only way to minimize the loss of life, make efficient use of available resources, and ensure the resilience of the healthcare system both during and after emergencies.

1.5. Resource Management

Disaster resource management is an integrated set of processes for planning, organizing, distributing, and effectively utilizing human, material, information, financial, and spatial resources in crises. The aim is to maximize assistance to those affected, minimize losses, and achieve a resilient and renewable response. Emergencies and disasters cause huge economic losses, affect the lives of many people, and cause serious environmental damage. Efficient resource management during disaster preparedness and response plays an especially important role in improving the distribution of aid and services, thereby accelerating disaster relief operations (Geng, 2024).

According to the Federal Emergency Management Agency (FEMA, 2021), resource management preparedness involves four processes:

1. Sourcing, storage, and inventory
2. Identification and classification of resources
3. Qualifications, certifications, and credentials of personnel
4. Resource planning

These activities are part of any comprehensive emergency preparedness for jurisdictions or organizations and should be part of an annual or cyclical process. Resource management preparedness builds upon existing practices that many organizations and jurisdictions may already be engaged in, e.g., emergency operations planning (FEMA, 2021).

Resource management requires a comprehensive, interdisciplinary, and interdepartmental effort. It may require many separate organizations and the coordination of managers and operators, including engineers, scientists, and medical personnel from government, public, private, and nonprofit institutions. Additionally, resource management during emergencies must often function under unpredictable, time-constrained, and budget-restricted conditions. Therefore, good coordination between organizations managing emergency resources is critical for successful disaster operations (Geng, 2024).

Jurisdictions and organizations need to procure, store, and inventory resources for day-to-day operations, in addition to stockpiling resources for emergencies. It is a collaborative process in which departments, agencies, and organizations stockpile their own resources while jurisdictions/organizations coordinate with them to track and inventory broad operational capabilities and logistic requirements, such as warehousing. Effective resource management involves creating an inventory of resources and keeping them up to date, as well as keeping accurate records of the resources and their availability. By identifying and classifying resources, jurisdictions and organizations create shared knowledge regarding a particular resource, its use, and availability. The primary focus of this approach is on resources that are deployed across jurisdictional boundaries (FEMA, 2021).

Proactive collaboration between jurisdictions and organizations is essential to effectively plan for the identification, management, estimation, allocation, ordering, deployment, and demobilization of resources (i.e., releasing resources for use) before an emergency. The planning process involves determining resource requirements based on assessing threats and vulnerabilities of involved jurisdictions or organizations. Part of resource planning is to estimate current capabilities, assess resource management gaps, prioritize resource management planning, and develop mutual assistance agreements to address these gaps (FEMA, 2021).

One of the main issues that arises from disaster analyses is the recognition that available resources are insufficient to meet requirements. Furthermore, the nature of the deficiency or mismatch can be highly variable. A disaster can place remarkably high demands on certain resources, while sparing others. For example, earthquake responses place a high priority on heavy earthmoving equipment, search and rescue, and certain medical skills, to the point that these resources are almost always exhausted. In certain catastrophic situations, the effectiveness of one resource may be diminished or offset by limitations in other supporting resources. For instance, during a large-scale demand for emergency food supplies, the availability of food itself may be adequate, but the capacity to distribute it efficiently may fall short.

Resource gaps can also be caused by poor planning. Another area of resource planning that should be given sufficient attention in disaster response planning, organization, and training is the effective and smooth activation of the actual disaster plan (Carter, 2008). Synergies between organizations are essential to the optimal allocation of resources within affected areas. Lack of coordinated resource mapping can lead to uneven resource distribution, with one location having a surplus while other sites suffer from a lack of resources (Mondal et al., 2019).

1.5.1. The Role of Local Health Authorities in Disasters

The role of local health authorities in disasters is crucial because they are not only closest to the affected communities, but also have facilities capable of responding, especially during the first hours of a crisis, when federal or national aid has yet to arrive. Local health authorities have legal obligations set out in international frameworks and national laws that require them to create emergency plans, maintain a risk register, and organize a population alert system. These legal instruments give local authorities a solid framework for directing the primary response. In practice, this means that local public health authorities coordinate with police, firefighters, emergency services, and community structures to ensure a functional response based on well-defined roles and processes (NAC, 2020).

In the first phase of the crisis response, rapid activation of local crisis teams, initiating triage, and registration of the affected play an irreplaceable role. As reported by Elshami et al. (2025), local departments must be able to sustain a response on their own for at least the first 48 hours after a disaster while external assistance is still being mobilized. At the level of operational management, it is critical to have a dedicated crisis coordinator within the local health authority who not only manages planning and communication but also integrates all components of health, rescue, and community responses.

Communication is another essential function of local health authorities. During crises, there is a need to quickly provide public information, minimize dis- or misinformation, promote preventive behavior (wearing masks, boiling water, etc.), and adapt public information to different socio-demographic groups (language accessibility, disabled accessibility, etc.). Without targeted communication strategies, the many vulnerable groups may lack information, exacerbating the impact of the event (Savoia & Viswanath, 2013).

Local health authorities also often administer Medical Reserve Corps or similar volunteer units. These structures can deploy qualified volunteers in both healthcare and logistics in the early hours or days of a crisis, thereby complementing the agency's operational capacity (NAC, 2020). Such models have been shown to be effective as community solutions and have the ability to function without unnecessary overhead in a time of crisis.

1.5.2. The Role of International Organizations in Disasters

World Health Organization

The World Health Organization (WHO) plays a crucial role in the context of crises and disasters as a global coordinating authority in the health sector. Its mission is to save lives and alleviate suffering during crises, whether conflicts, natural disasters, pandemics, or other public health emergencies. The Health Emergencies Program, established in 2016, is the core of WHO's operational capacity to protect public health during crises. It is designed so that the organization can effectively support countries in prevention, preparedness, detection, response, and recovery (WHO, 2025).

One of the core functions of the WHO is to provide technical and strategic support to member states in capacity assessment and preparedness planning. The WHO helps identify critical gaps in health infrastructure, surveillance systems, and operational capabilities, then provides expert guidance for the development of national health emergency preparedness plans, including crisis management, logistics, and communications. It is thus a key advisor to countries by helping build systems resilience in areas of prevention, detection, and response to health threats (WHO, 2025).

Another key area of the WHO's work is monitoring and early warning. The organization operates global surveillance systems and analyzes ongoing epidemiological events to provide authoritative information, recommend actions, and inform the public and governments about health risks. In situations of international significance where the threat goes beyond national borders, the WHO activates the Public Health Emergency of International Concern (PHEIC) mechanism, which triggers a coordinated global response under the International Health Regulations (WHO, 2025).

When national emergency response abilities are insufficient, the WHO mobilizes Emergency Medical Teams (EMTs) that are capable of rapidly deploying to the field and providing life-saving health services. This function also includes coordinating deliveries of medicines, vaccines, medical supplies, and logistics in crisis-affected areas (WHO Foundation, 2025).

Crisis communication and public information play a key role in reducing panic and misinformation while spreading information to protect health. The WHO provides methodologies for communicating with different population groups, including vulnerable ones, and promotes transparent and sensitive transmission of essential information through the media, government institutions, and organizational partners. The WHO also instructs member states on how to strengthen health facilities and laboratories in disaster-affected areas. This includes the implementation of the HeRAMS (Health Resources Availability Mapping System), which is used to monitor health resource availability during humanitarian crises, enabling informed decisions on the distribution of supplies and care (WHO, 2025).

The WHO is also involved in ongoing crisis evaluation and follow-up and after-action reviews. After the acute phase of a disaster, the WHO analyzes response successes and failures and provides recommendations for strengthening future preparedness. This approach supports learning from crises and adapting systems based on facts (WHO, 2023).

As a global leader, the WHO also creates standards, technical guidelines, and recommendations that member states then adapt to their national contexts. This includes procedures for epidemic management, prevention of infectious and non-infectious threats, safety of health workers, and emergency operations (WHO, 2025)

The role of the WHO in crises and disasters is therefore multifaceted and consists of global coordination, provision of technical standards, support for preparedness, operational mobilization of resources and teams, communications management, and laboratory resilience. It also monitors humanitarian zones and conducts evaluations after a crisis has subsided. In doing so, the WHO creates a framework for robust and coordinated responses that minimize health losses, improve systems resilience, and promote sustainable development around the world.

The International Federation of Red Cross and Red Crescent Societies

The International Federation of Red Cross and Red Crescent Societies (IFRC) is the world's largest humanitarian network. The IFRC brings together 191 national societies that operate on the front line of disasters and health emergencies. Its main mission is to save lives, alleviate suffering, and protect human dignity, both during disasters and during long-term recovery of individuals and communities. The official IFRC website states that the organization focuses on working with local communities on issues like disaster prevention, preparedness, response, and recovery, while also working to strengthen system resilience (IFRC, 2025a).

The IFRC and its national affiliates are in a unique position thanks to their extensive network of volunteers and professionals directly within communities, which allows for quick and effective responses. In the event of a disaster, the IFRC carries out emergency needs assessments, i.e., needs and damage assessments that help prioritize things like drinking water, food, shelter, basic health care, and psychosocial support. This immediate intervention ensures that humanitarian aid is swift while prioritizing the most vulnerable populations (IFRC, 2025a).

For rapid deployment, the IFRC uses the emergency response unit system. These are modular units ready to provide key services such as field hospitals, mobile laboratories, water and sanitary systems, logistics support, and communication technologies within a few days. These units can remain in the affected areas for several weeks to a month until the situation stabilizes and local capacities are restored (IFRC, 2025a).

The disaster response emergency fund (DREF), which is administered by the IFRC, also plays a key role. The fund allows payments to national companies within 24–72 hours of an event, which is especially crucial in minor and medium-sized disasters where waiting for international funding would delay the response. Around 80% of DREF funds are distributed directly to national companies, thus promoting local intervention leadership and effectiveness (IFRC, 2025a).

The IFRC also plays a coordinating role in the field of emergency accommodation. As co-manager of the Shelter Cluster (except in armed conflicts, where UNHCR fulfills this role), the IFRC organizes the provision of shelter, statutes, emergency reconstruction materials, and coordinates standards and deliveries to ensure consistent and quality assistance (IFRC, 2025a).

The IFRC has a long history of promoting the principle of "build back better," i.e., rebuilding communities so that they are more resilient to future crises. This includes not only the restoration of physical infrastructure, but also the strengthening of community capacity, psychosocial support, and economic recovery, while anticipating climate risks. The organization also implements community adaptation programs under the global climate resilience platform, which mobilizes resources for projects to increase resilience to extreme weather and climate change (IFRC, 2025a).

The IFRC's ethical framework for interventions is enshrined in the code of conduct for the International Red Cross and Red Crescent Movement, as well as in the Code of Conduct for other humanitarian aid non-governmental organizations involved in disaster relief. The framework sets out ten basic principles of humanitarian aid, including prioritizing needs over policy, neutrality, respect for local culture, and community involvement in decision-making. This code is key to maintaining trust, quality, and accountability in the provision of aid (IFRC, 2025a).

The IFRC is also expanding its activities to new arenas such as extreme temperature events, which are becoming more common, for instance, in Silopi, Türkiye, where the temperature hit 50.5 °C on 25 July 2025. The organization launched the first global initiatives to prevent the health impacts of heat waves, including early warning systems, the creation of "cooling corridors" in cities, and the promotion of community-based education about climate risks (IFRC, 2025a).

The IFRC thus represents a key actor in the global humanitarian system, combining a local presence with global support, to produce long-term resilience. Thanks to its network of national societies and volunteers, it can respond quickly, in a coordinated and sustainable way, helping to save lives and restore hope on a global scale (IFRC, 2025a).

The IFRC, as part of its Emergency Response Framework, defines a single framework for coordinating and supporting crisis operations, linking the IFRC Secretariat with national organizations to achieve strategic priorities. This document does not serve as an operations manual, but as strategic and unified guidance for the IFRC Response System. It defines key mechanisms, procedures, roles, and responsibilities across all structures of the Secretariat, ensuring transparency, accountability, and consistency between the management and support systems of national organizations. Overall, the document offers a flexible and strategically aligned IFRC crisis response framework that ensures coordination between different levels of the organization, supports local humanitarian efforts, and increases the effectiveness and transparency of interventions in complex and multi-level crisis scenarios (IFRC, 2025b).

Doctors Without Borders

Doctors Without Borders (Médecins Sans Frontières: MSF) is an international, independent medical humanitarian organization that provides integrated medical assistance to those in crisis – whether caused by conflicts, epidemics, natural disasters, or exclusion from healthcare. Its goal is to provide impartial, independent medical care where it is most urgently needed, without regard to nationality, religion, political affiliation, or ethnicity. Founded in 1971 in Paris by a group of doctors and journalists, the organization has grown into a global network of over 67,000 professionals working in more than 70 countries. It is composed not only of doctors and paramedics, but also of workers in logistics, administration, communication, and other related professions – all in accordance with the Charter, the principles of medical ethics, and the principles of impartiality, neutrality, and independence. MSF provides health care in many forms – from basic outpatient care and vaccinations to surgical interventions, to the treatment of epidemics, emergencies, psychosocial support, and patient rehabilitation (Médecins Sans Frontières, 2025b).

During natural disasters such as earthquakes, floods, and hurricanes, MSF immediately deploys mobile teams capable of providing surgical care, basic medical equipment, field hospitals, sanitation tools, and rapid distribution of life-saving interventions. The organization emphasizes that it has more than 40 years of experience in rapid disaster response and is therefore able to deploy an integrated medical-logistics solution during the first days of a crisis. MSF regularly conducts exploratory missions to disaster-stricken areas to independently assess the extent of damage and prioritize interventions, including where additional humanitarian aid is needed. This independent approach allows for a neutral assessment of the situation. Coordination during a health crisis is key to avoiding duplication, fragmentation, and gaps in response. The organization invests in coordination between all stakeholders, including governments, other organizations, and local communities, to ensure quality, accountability, and effectiveness of care. MSF's role in disasters also includes operating in conflict zones, where it provides medical care, including surgery and treatment of victims of violence, often putting MSF professionals under direct threat. MSF is also significant in regional humanitarian crises that are not strictly catastrophes — such as conflicts or epidemics — but require quick and effective mobilization of health services. From an ethical point of view, MSF states in its Charter and Code of Conduct that it intervenes independently of political, religious, or ethnic differences, thus being able to provide care where other organizations might be rejected or delayed by partisan governmental barriers (Médecins Sans Frontières, 2025a).

1.5.3. Ethical Dilemmas in Resource Allocation

Ethical issues permeate virtually every aspect of disaster response (Biddison et al., 2014). Natural disasters often bring an acute shortage of key resources, e.g., ventilators, intensive care beds, personal protective equipment, and, last but not least, qualified medical staff. Decisions on resource allocation are made under intense time and emotional pressure, and often without complete information, which increases the risk of errors, ethically problematic priorities, and violation of the moral integrity of the system (Biddison et al., 2014).

The Tennessee State Government's guidance for the ethical allocation of scarce resources during a community-wide public health emergency outlines principles to assist decision-makers in planning for and responding to emergencies. These include the duty to plan, the duty to care, the principle of reciprocity, an emphasis on responsible resource management, respect for human dignity, and the importance of communication (Tennessee State Government, 2020)

Duty to plan: Healthcare professionals are responsible for allocating scarce resources in situations where there is a substantial risk of injury or death. Without clear guidelines, decision-making can fall to exhausted frontline workers, who are exposed to excessive pressure and psychological stress during large-scale disasters.

Duty to care: Healthcare professionals have a special obligation to provide care even in medical emergencies. The main goal of their activities, as well as the activities of health care institutions, is to protect the health of society as a whole, not just individuals.

Reciprocity: Clearly defined directives regarding the obligations of health facilities, professionals, and support staff, and the community are essential. This includes fair service schedules, protective measures for workers, and clearly defined competencies and responsibilities to minimize the risk of unfairly burdening certain groups.

Stewardship of resources: In crises, limited resources must be used prudently and efficiently. It is not always possible to provide all the procedures and treatments that would be standard under normal conditions. Resource allocation and triage must be guided by efforts to reduce morbidity and mortality, while continuously assessing whether the use of a particular scarce resource will benefit the entire community.

Respect for human dignity: Individual value and dignity, regardless of age, gender, race, faith, social status, health, or abilities, must be respected. This principle requires that both contingency plans and triage procedures be clearly and comprehensibly defined for all those involved and that there is no discrimination. The criteria for access to care must be objective and based only on relevant medical and ethical indicators.

Communication: The process of making decisions about triage and allocation of resources must always be open, understandable, and based on community values. Since crisis directives represent a deviation from standard care, it is critical that the deviations be explained and justified to the public. The cooperation of medical staff, institutions, and the community is key to an effective and legitimate response. Regular communication, professional training, and guided discussion with the public can increase community trust and emergency preparedness (Tennessee State Government, 2020).

Conclusion

Effective disaster management requires a comprehensive and well-coordinated approach to resource management, healthcare organization, and cooperation between local and international actors. A key element of a successful response is quality resource management, including planning, inventory, identification and classification of resources, staff qualifications, and thoughtful allocation of resources.

Local health authorities are the backbone of effective crisis management, since they are closest to affected communities and can respond in the first few hours while national or international aid is still being mobilized. Their role includes rapid activation of the crisis team, triage and registration of those affected, coordination with other IRS units and community partners, and ensuring effective crisis communication. International organizations can complement and expand the local response, especially in situations where local or national capacities are insufficient.

An important dimension of disaster response is the ethical dilemmas associated with allocating scarce resources. Medical staff have to make decisions under pressure, often without complete information or under intense time or emotional pressure. Ethical principles such as the duty to plan and provide care, the principle of reciprocity, the economic use of resources, respect for human dignity, and transparent communication are key to maintaining the moral integrity of the system and strengthening public trust in times of crisis.

Overall, effective disaster management is only possible with a combination of quality resource management, functional local infrastructure, international support, and an ethical framework for decision-making.

1.6. Post-Disaster Recovery and Rehabilitation

1.6.1. Disaster Recovery

The frequency of disasters and the associated damage is on the increase (Puri et al., 2024). The devastating impact of natural disasters is more pronounced in poorer or developing countries compared to their prosperous counterparts (Panwar & Sen, 2020). Countries with higher incomes, better education systems, and robust financial systems tend to have fewer adverse and long-term impacts from natural disasters compared to countries that perform lower on these indicators (Toya & Skidmore, 2007). A quick recovery is key to good long-term recovery. In a large-scale study, Puri et al. (2024) identified 223 challenges to the management of post-disaster recovery projects, with many issues receiving far less attention than needed. Resource issues are cited most often, followed by governance and cooperation issues and contractual, legislative, and policy issues.

Resource problems include a lack of resources, logistics (personnel and material), and increasing resource costs. Problems in management and collaboration include the inability to coordinate and integrate the work of different stakeholders and implementation partners who have their own goals and expectations, which, if left unaddressed, can lead to duplication of work, wasted resources, and incomplete implementation. It also includes the lack of technical and managerial capacity within local institutions and humanitarian organizations to manage reconstruction. Contractual, legislative, and policy challenges include insufficient or absent government legislation and policies in the field of disaster management, a lack of proper planning, and a lack of government preparedness (Puri et al., 2024).

1.6.2. Sustainability and Recovery of Healthcare Systems after Disasters

The post-disaster recovery planning phase serves several key purposes. First of all, it is important for evaluating the crisis itself and the response to it. Such an assessment is not only useful for organizations but also serves as a valuable learning and prevention tool for other healthcare facilities. Follow-up plans help to rebuild the organization's activities while supporting all participants involved in the response to the crisis. These plans must include an assessment of the damage incurred and an initial determination of what repairs and interventions will be needed. This process also includes a thorough inventory and evaluation of any damaged or missing medical data, for example, paper medical records, other medical record storage, information techonology infrastructure including any data that has not been backed up or has been corrupted as a result of a disaster, paper records stored off-site, other files such as legal documents, personnel files, committee documents, and any electronic systems containing health information (AHIMA, 2016).

Recovery plans should incorporate the deployment of emergency services—such as police and firefighters—on the ground, along with building inspections to ensure safety and operational standards are met. They should also include protocols for identifying and salvaging essential equipment and records, assigning a recovery manager to oversee the entire process, cleaning and restoring facilities, and providing support services. Additionally, plans must address the preservation of medical records, documentation of patient care during the crisis, and the proper disposal of disaster-related materials, waste, and residue (AHIMA, 2016).

Once the critical phase is over, the focus shifts to managing the data created during the emergency. It is necessary to conduct a thorough analysis of the documentation process, i.e., to analyze in detail how the data was recorded and managed. This analysis should include all data management decisions, an overview of what documentation has been created, what systems have been used to generate information and data, the scope of emergency measures, including the disaster timeframe, the number of patients treated, and, if possible, staff schedules (AHIMA, 2016).

Based on the feasibility and risk vs. benefit assessment as set out in the disaster plan, decisions will be needed regarding whether documentation created during the disaster will be integrated into routine patient medical records or separated, which will likely depend on what will best facilitate access to the records in the future. Furthermore, funds may need to be allocated to supplement the documentation process, for example, collecting demographic data, diagnoses, signatures, and discharge reports (AHIMA, 2016).

Recovering damaged documents requires careful assessment and planning. If medical records cannot be recovered using electronic data recovery, by obtaining copies from an associated medical information network, or through a specialized corrupted document recovery company, it becomes necessary to use all available options to reconstruct as much information as possible, e.g., transcribing original documents if there are voice recordings, documentation from primary source systems, or from treating physicians. It is also important to evaluate the costs associated with restoration, including the time required to recreate records and the potential to restore systems for which backups are available. It is also possible to retrieve data from uncorrupted databases, such as patient reception systems, transcription of medical, laboratory, and radiology reports, or data backup services.

If it is not possible to reconstruct part or all of a patient's medical records, the date of the patient's record must be clearly shown, as well as what information was lost, and what caused the loss. Any reconstruction of the medical information must be properly documented, including a description of the method used. The new record created through these procedures must be authenticated under the organization's internal rules and policies. The healthcare facility must prepare a detailed record of the entire event, which includes at least a list of affected patient records, measures taken to restore them, and the results of the efforts. Organizations should also keep a log of lost or destroyed records so that information can be easily substantiated during legal or accreditation checks. If a facility provides medical documentation that contains missing or reconstructed data due to a disaster, the date, nature of the loss, and the reconstruction must also be attached to the record (AHIMA, 2016).

A recovery plan must consider that patient management and care provision may begin to suffer immediately after a disaster occurs. The ability of electronic systems to transmit patient information deteriorates rapidly in case of power outages. If records are kept on paper or in a hybrid form, some health information may be lost forever. For an organization to effectively recover from a disaster or unplanned disruption of information and financial systems, management needs to allocate funds in advance to maintain the operation of these systems. Disaster planning should anticipate that disaster victims will start arriving at hospitals almost immediately after the disaster event. During this time, hospital operations may be forced to temporarily switch to paper medical records until the system is fully restored (AHIMA, 2016).

1.6.3. Psychological Aspects of Emergencies

Each person has a different degree of resistance to the effects of a disaster, and everyone copes differently. The reactions of victims to an emergency are different and show high individual variability over time. The first reaction is always to protect one's own life, to protect loved ones, and one's property. At this point, all emotions leave the person, but during the initial impact phase, we can encounter a wide range of behaviors and actions. These include inner paralysis, the illusion of centrality, feelings of unreality, automatic behavior, severe anxiety, feelings of guilt, ambivalence, emotional and cognitive instability, and extreme reactions.

Emotional and psychological phases of emergency and disaster response are as follows:

- **Stun and shock phase –** Initial paralysis and disbelief
- **Scream phase –** Emotional outbursts or internal panic
- **Meaning-making phase** – Searching for understanding and context
- **Denial and reliving phase –** Replaying events and resisting acceptance
- **Post-traumatic phase** – Long-term psychological effects, including anxiety, guilt, and emotional instability

As a result of experiencing an emergency, the affected people develop stress reactions such as anxiety, anger, aggression, apathy, and depression, which can be an acute reaction to stress or a form of post-traumatic stress disorder, and is a very serious condition. An individual suffering from post-traumatic stress disorder has impaired work performance, impaired social inclusion, and reduced physical limits. They experience symptoms such as insomnia, chronic pain, gastro-intestinal disturbances, and lightheadedness (Šín, 2017).

Mitigating the psychosocial consequences of an emergency is essential. This begins with acknowledging that a serious and life-altering event has occurred, one that, for many individuals, may permanently reshape their sense of the world. It is crucial to support victims as they gradually integrate the experience into their narrative and find pathways that help them reintegrate into society. Equally important is creating space for the traumatic stimulus to lose its overwhelming emotional charge, allowing it to be processed over time and eventually regain a non-traumatic place within the individual's memory and meaning-making (Šín, 2017).

1.6.4. Psychosocial Crisis Assistance for Intervening Health Professionals

Healthcare professionals responding to crises, including pandemics, natural disasters, or humanitarian crises, are clearly at high risk of psychological stress, secondary traumatization, burnout, as well as post-traumatic stress disorder (PTSD). Studies systematically confirm that psychological and physical stress in healthcare professionals leads to reduced performance, increased absenteeism, and poorer clinical decision-making. Certain groups, including women, less experienced workers, and individuals with prior trauma exposure, have been found to exhibit higher rates of anxiety, depression, or chronic stress symptoms following emergencies (Ottisova et al., 2022). These findings highlight the need for targeted psychosocial support.

When dealing with an emergency, these psychosocial impacts on response teams must be considered. The need to provide help does not depend only on the severity of the situation and the number of people affected, but it is also necessary to consider the current condition of the responding individuals and their individual needs. Members of response teams should have access to several forms of assistance to aid in coping with the overwhelming stress associated with disaster relief situations. Of course, prevention is also important (Šín, 2017).

According to a systematic review by Ottisova et al. (2022) on psychosocial interventions for healthcare workers during disasters, cognitive behavioral therapy (CBT), whether delivered individually or in group settings, has the strongest evidence for effectiveness. CBT is associated with statistically significant reductions in symptoms of PTSD, anxiety, depression, burnout, and sleep disturbances. In contrast, one-off psychological debriefings and brief stress management workshops demonstrate little to no measurable impact on these outcomes.

Psychological first aid (PFA) plays a significant role. Although this approach cannot be considered a full-fledged therapeutic tool, a systematic review of studies by Hermosilla et al. (2023) showed that in people exposed to traumatic events, PFA contributes to reducing anxiety, depression, and stress, while increasing feelings of security, belonging, and control. For healthcare professionals, PFA is often part of broader crisis intervention procedures, especially in the acute phase (Hermosilla et al., 2023).

Atkins and Burnett (2016) emphasize the value of specialized disaster behavioral health training, including individual, peer-to-peer, and group-based crisis intervention techniques. Their findings suggest that professionals who undergo such training tend to exhibit greater resilience and experience lower levels of burnout and compassion fatigue.

The psychosocial environment of disaster relief organizations significantly affects the effectiveness of the interventions. The concept of a psychosocial safety climate shows that a clear, supportive, and communicative employer policy that prioritizes workers' mental health over performance reduces stress and burnout and increases overall resilience. It is therefore crucial that the role of psychological support is embedded in organizational cultures (Cairns et al., 2021).

Another effective approach is peer support, i.e., systematic support between colleagues. Peer systems allow for safe sharing of experiences, reduce the feeling of isolation, and increase confidence in the ability to seek help without stigmatization. For first-line response teams, peer-to-peer interventions can tutor, debrief, or function as informal check-ins, which improve mental resilience (Karimi Dehkordi et al., 2021).

The available data show that the most effective psychosocial support for health professionals in crisis conditions combines several layers: immediate support in the acute phase (Psychological first aid, defusing, i.e., immediate emotional relief and prevention of long-term psychological harm), short follow-up interventions (peer-to-peer debriefing, critical incident stress management), and structural organizational measures supporting a positive psychosocial climate.

1.6.5. Post-Traumatic Growth

Posttraumatic growth (PTG) is associated with experienced trauma. It represents an adaptive process to traumatic events, where the individual not only overcomes psychological trauma, but also experiences deep positive changes in the perception of oneself and the world around them. It is characterized by positive changes in an individual's cognitive, educational, and emotional life. It arises as a result of an individual's struggle with a significant life crisis (Šín, 2017). PTG research after natural disasters – such as earthquakes, tsunamis, or floods – shows that people can develop new values, inner strength, and meaning in life after an initial challenge to their beliefs, sometimes described as "shattered assumptions." Basic models of this concept are described by Tedeschi and Calhoun, who define post-traumatic growth as "positive psychological changes resulting from a struggle with trauma or from highly challenging life situations" (Tedeschi & Calhoun, 2004).

A change occurs when the individual transcends their existing level of adaptation, psychological functioning, and understanding of life. As a result of the experienced trauma, personal growth can be driven by the traumatic experience and coping process. Post-traumatic growth often reveals itself through enriched relationships, marked by deeper engagement with others and a renewed sense of connection. It also manifests as strengthened inner resilience, the emergence of new life opportunities sparked by fresh interests, and personal development characterized by increased self-confidence, heightened gratitude, and profound spiritual transformation, all contributing to a deeper appreciation of one's own life. Post-traumatic development occurs not only in disaster victims but also in the members of the disaster response team (Šín, 2017).

Post-traumatic growth is not an automatic result of trauma, but a complex process that can be supported through targeted therapeutic and social interventions. Crucial factors supporting PTG include social support, optimism, introversion/extraversion, meaningful thinking, resilient character, and openness to life changes (Prati & Pietrantoni, 2009). Amiri et al. (2021) monitored the level of post-traumatic growth in people who experienced earthquakes. It was found that adults achieved more PTG compared to children and adolescents, with PTG intensity generally decreasing after the event (Amiri et al., 2021). Thus, cultural and age variability is significant: adolescents generally exhibit lower PTG than adults, which was confirmed by the meta-analysis mentioned above. Children and adolescents often do not mature to reflect on or process trauma to the same extent as adults. The key factors are social support and perception of competence, influenced both by family support and one's belief in their ability to overcome difficulties (Cryder et al., 2006).

From the point of view of clinical practice, post-traumatic growth is not only a descriptive phenomenon, but also the goal of therapeutic action, because its support can contribute to the improvement of psychological well-being and long-term adaptation of the individual after a disaster. One of the main recommendations is to strengthen adaptive coping and trauma processing through cognitive-behavioral approaches. Trauma-focused cognitive-behavioral therapy and cognitive trauma processing are "best practices" that can reduce symptoms of post-traumatic stress disorder while also facilitating post-traumatic growth by guiding individuals to identify and reevaluate maladaptive thought patterns (APA, 2025).

Other recommendations promote the development of personal resilience and self-efficacy. This can be achieved by interventions aimed at strengthening one's belief in competence to cope with difficulties and stressful situations, both of which can support post-traumatic growth and long-term mental health. Resilience training programs, including relaxation techniques, mindfulness, exposure to gradual stress management and planning, have also been shown to have a positive effect on the development of PTG after disasters (Bonano et al., 2015).

Overall, therapeutic support for post-traumatic post-disaster growth requires a comprehensive approach combining psychological, social, and existential (meaning-making) interventions. Effective therapy leads to a gradual reframing of trauma, building internal and external resilience, developing a sense of purpose in life, and actively engaging in relationships and community. Together, these processes create conditions in which trauma is more than simply something to be overcome, but can also be a source of deeper personal transformation.

1.6.6. Future and Post-Disaster Perspectives – Recommendations for Policy Development

In the 21st century, disasters pose an increasingly complex threat. They include natural disasters such as earthquakes, floods, hurricanes, droughts, and wildfires; biological disasters like epidemics, pandemics, and infestations; and technological disasters, including industrial accidents, nuclear failures, and cyberattacks. Human-caused disasters, such as armed conflicts, terrorism, and forced displacement, add further layers of disruption. Nowadays, hybrid disasters are increasingly encountered, where natural and human-made factors combine, and cascading disasters, where one event triggers another, compounding the damage. Complex disasters involve multiple overlapping crises, such as war-induced famine or disaster zones with simultaneous environmental and social breakdowns. Each type can occur independently or interact, with far-reaching impacts on infrastructure, economies, ecosystems, and public health. In the coming decades, climate extremes, unplanned urbanization, migration waves, and geopolitical tensions are expected to intensify these risks (UNODRR, 2025).

The global disaster risk landscape has changed dramatically in recent decades. The Global Assessment Report 2025 (GAR 2025), published by the United Nations Office for Disaster Risk Reduction (UNDRR) in cooperation with the International Institute for Applied Systems Analysis (IIASA), provides the most comprehensive analysis of the current state and future scenarios of disasters and their economic, social, and environmental impacts. The key feature of the report is “Resilience Pays – Financing and Investing for Our Future,” which expresses the need to understand resilience not only as a necessary expense but as a strategic investment in a sustainable future for humanity (UNODRR, 2025).

The global assessment report 2025 is based on extensive datasets covering the last 50 years of natural and anthropogenic disaster development, economic losses, insurance coverage, and policy responses. The report states that direct annual losses from disasters now amount to around $202 billion, more than double the values from the 1980s. But when indirect impacts – supply chain losses, declines in labor productivity, damage to ecosystems, and long-term development effects – are included, the total cost is more than $2.3 trillion per year, or about 2.5% of global GDP. This creates an ever-deepening spiral of fiscal vulnerability.

The main concept of the global assessment report 2025 is the so-called three spirals of unsustainable development:

1. A spiral of debt and falling incomes, in which repeated disasters reduce state revenues, increase debt, and reduce the ability to finance prevention.
2. A spiral of unsustainable risk transfer, when the availability of insurance narrows due to rising losses, and “risk transfer” grows. Insurance gaps threaten the stability of real estate markets and credit systems.

3. A Response-Repeat spiral where states and the international community spend significant resources on response and recovery instead of risk prevention and reduction.

The global assessment report 2025 also notes that without a fundamental change in approach, i.e., integrating disaster risk reduction (DRR) into all levels of planning and financing, the economic and humanitarian impacts of disasters will become unsustainable by the middle of the 21st century. UNDRR warns that the current model of global development is "de facto risk-dependent" because growth is often supported by activities and investments that overlook climate and natural risks, leading to the accumulation of hidden debts in the form of future damage.

GAR 2025 also offers a positive perspective: investments in resilience have a positive return. Analyses show that every dollar invested in DRR can save $4–$15 in future losses, and in some specific cases (such as flood control measures in cities), the ratio is even higher. This economic argument becomes crucial for policy decisions, since it demonstrates that resilience is not a cost, but an investment in future stability and prosperity (UNODRR, 2025).

The UNODRR (2025) also highlights the need for public-private collaboration, the use of innovative financial instruments (e.g., parametric insurance, green bonds, risk funds), and open data for risk predictions. Without this, the world will fall into an "insurability crisis," where some property and infrastructure cannot be insured, putting financial systems and investment flows at risk. The Global Assessment Report 2025 thus poses a clear challenge – transform the way we plan, finance, and manage development so that disaster resilience is a fundamental and integral part. This transformation is necessary not only economically, but also socially and ethically, if the goal is to protect lives, reduce inequalities, and promote sustainable development.

The Global Assessment Report 2025 analyzes in detail how national and international policies should evolve to ensure greater resilience of society, infrastructure, and health systems. It stresses that without a coordinated approach that connects local, national, and global levels, most plans will remain fragmented and inadequate (UNODRR, 2025).

Policy for disaster risk reduction needs to be based on international commitments, dominated by the Sendai Framework for Disaster Risk Reduction 2015–2030. Policies should set out four priority areas: understanding risks, strengthening risk governance, investing in resilience, and improving preparedness and recovery. GAR 2025 emphasizes that even ten years after the adoption of the framework, key challenges remain, especially in its implementation at the national and regional level. International cooperation is also supported by the Paris Climate Agreement (2030 Agenda) and the Sustainable Development Goals (SDGs), in particular Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action).

Policy direction is further influenced by the activities of institutions such as the WHO, which, after the COVID-19 pandemic, emphasized the integration of health systems into national DRR plans. The Global Assessment Report 2025 also stresses that the future of disasters is increasingly intertwined with the political capacity of states and their ability to integrate scientific knowledge into decision-making processes. For effective policy implementation, they note the essentialness of a functional national risk management framework that includes interdepartmental cooperation, regular updating of data and risk analyses, and private sector involvement.

Countries that have strong policies and legal frameworks can respond more quickly to disasters and minimize disaster impact (UNODRR, 2025).

Health systems are key components of social resilience to disasters. Societies not only receive the brunt of extreme events they also function as the first line of defense in protecting the population. According to GAR 2025, the health of a society is intricately linked to adaptation to the increasing frequency and intensity of disasters. Healthcare is part of a community's critical infrastructure; however, it is highly vulnerable to both natural and anthropogenic risks (i.e., risks arising directly from human activities). The increasing frequency and intensity of natural and anthropogenic risks are fundamentally changing the role of healthcare infrastructure. Health systems are no longer just passive providers of care; they have become a critical, active part of disaster risk reduction strategies for ensuring the continuity of healthcare during disasters and the protection of public health. Policy direction in this area should include several key elements:

Integrated resilience planning for healthcare facilities: It includes strengthening infrastructure, backup power and water sources, availability of telemedicine, and robust supply chains.

Strengthening human capacities and training: Creating flexible teams ready for emergencies, regular simulations of crisis scenarios, and cross-border cooperation.

Financial security and insurance: Implementing mechanisms that allow for the rapid release of funds for the recovery and continuation of health care even during disasters.

The COVID-19 pandemic and the subsequent humanitarian crises from 2020 to 2023 have demonstrated that health systems are often the most vulnerable link in the chain. GAR 2025 emphasizes the need to link health planning with climate adaptation and urban policy, since extreme temperatures, floods, or the spread of infectious diseases can have a direct impact on public health (UNODRR, 2025).

According to GAR 2025, healthcare is one of the primary sectors where the spiral of unsustainable development is expected to intensify. Disasters not only destroy health infrastructure but also cause secondary and long-term health effects that can cripple the system even years after the event. The COVID-19 pandemic has shown how fragile even advanced health systems can be in the face of a confluence of epidemiological, economic, and environmental pressures (WHO, 2022).

Disasters have direct and indirect impacts on healthcare. Natural disasters such as floods, cyclones, earthquakes, and extreme heat can have immediate physical effects such as the destruction of healthcare infrastructure, interruptions in electricity and water supplies, and disruption of logistics chains for pharmaceuticals and medical supplies. According to the Global Assessment Report 2025, extreme heat, whose frequency and intensity are rising due to climate change, is a major driver of increased hospitalization and mortality, particularly among older adults and individuals with cardiovascular and respiratory conditions. The health burden is compounded by the indirect effects of disasters, which often prove even more severe. These include spikes in infectious diseases such as cholera following floods, interruptions in care that worsen chronic illnesses, and profound psychological and psychiatric impacts on both affected populations and healthcare workers. Additionally, disasters can trigger long-term nutritional deficiencies and immunological stress, especially in vulnerable communities. Together, these cascading impacts strain healthcare systems and deepen the spiral of unsustainable development. The global assessment report 2025 report proposes several key policy steps needed over the next decades:

- Moving towards proactive risk management– prioritizing prevention over disaster response
- Integration of DRR into development strategies and fiscal policy– including resilience in budget and public investment planning
- Digitization and use of data analytics– strengthening predictive models, open data, and AI for rapid risk identification
- Global and regional cooperation– pooling resources, expertise, and coordinating cross-border responses
- Resilient healthcare as a priority– including health systems in all stages of planning from prevention to recovery

The Global Assessment Report 2025 report also recommends strengthening the four pillars of health resilience:

Resilient infrastructure: building hospitals in safe zones and according to circumstance standards, back-up power and water sources, protecting information, and communication systems from cyber threats

Securing supply chains: strategic stockpiling of pharmaceuticals and materials, diversification of suppliers, and use of local production capacities

Human resources resilience: crisis management training, psychosocial support for health professionals, and international cooperation for sharing and exchanging resources

Integration of health care into DRR strategies: participation of healthcare in the development of national and regional plans, monitoring and sharing of health data in real time, simulations and exercises for multi-hazard scenarios

Policy decisions over the next decade will be crucial in determining whether the world embarks on a path of increasing resilience and stability, or whether it faces an escalating spiral of crisis and loss. The strategic direction of DRR policies is thus not only a question of security, but also of economic and social survival. Without fundamental reforms, healthcare systems risk becoming one of the limiting factors of social resilience. Projections suggest that by 2050, economic losses from disasters may be compounded by a wave of health crises if health resilience is not prioritized in national policies. Integrating healthcare into DRR strategies is therefore a strategic necessity (UNODRR, 2025).

Conclusion

Disasters can profoundly impact infrastructure, health and healthcare, and social stability. Effective disaster management requires a rapid and well-coordinated response. Successful recovery is based on effective resource management, timely planning, and cooperation between local and international actors. A key priority is the swift delivery of healthcare services, the restoration of critical infrastructure, and the protection of medical records to ensure continuity of care and minimize secondary harm.

Psychosocial support is essential for both disaster-affected individuals and the healthcare professionals who assist them, with the latter being at risk of secondary traumatization and burnout. The most effective approach is multi-layered, combining immediate interventions such as psychological first aid, structured peer debriefings, and organizational measures that foster a climate of psychosocial safety. This integrated strategy strengthens team resilience, mitigates stress, and supports long-term recovery for both patients and providers.

The foundation for effective future disaster response lies in the integration of three key pillars: efficient resource management, systematic psychosocial support, and strategic measures to strengthen the resilience of health systems and communities. This integrated approach minimizes the impact of crises and helps societies withstand future emergencies.

REFERENCES

Alkan, N., Elmas, I., Karakuş, M., & Akkay, E. (2001). Doğal afetler sırasında karşılaşılan sorunlar: bir anket çalışmasi [Problems encountered during natural disasters: a questionnaire study]. Ulusal travma dergisi = Turkish journal of trauma & emergency surgery: TJTES, 7(3), 195–199.

Al Thobaity, A. (2024). Overcoming challenges in nursing disaster preparedness and response: an umbrella review. BMC Nurs 23, 562. https://doi.org/10.1186/s12912-024-02226-y

American Health Information Management Association. (AHIMA) (2016). Disaster planning and recovery toolkit. (online, pdf). ISBN 9781584265634 https://www.ahima.org/media/pe2jgldi/disaster-planning-and-recovery-toolkit-2016-version-_axs.pdf

Amiri, H., Nakhaee, N., Nagyová, I., Timková, V., Okhovati, M., Nekoei-Moghadam, M., & Zahedi, R. (2021). Posttraumatic growth after earthquake: A systematic review and meta-analysis. The International journal of social psychiatry, 67(7), 867–877. https://doi.org/10.1177/0020764021995856

American Psychological Association. (2025). Clinical practice guideline for the treatment of posttraumatic stress disorder (PTSD) in adults. (online – pdf). https://www.apa.org/ptsd-guideline/treatments

Atkins, C. D., & Burnett, H. J., Jr (2016). Specialized disaster behavioral health training: Its connection with response, practice, trauma health, and resilience. Disaster health, 3(2), 57–65. https://doi.org/10.1080/21665044.2016.1199151

Biddison, L. D., Berkowitz, K. A., Courtney, B., De Jong, C. M., Devereaux, A. V., Kissoon, N., Roxland, B. E., Sprung, C. L., Dichter, J. R., Christian, M. D., Powell, T., Task Force for Mass Critical Care, & Task Force for Mass Critical Care (2014). Ethical considerations: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. Chest, 146(4 Suppl), e145S–55S. https://doi.org/10.1378/chest.14-0742

Bonanno, G. A., Romero, S. A., & Klein, S. I. (2015). The temporal elements of psychological resilience: an integrative framework for the study of individuals, families, and communities. psychological inquiry, 26(2), 139–169. https://doi.org/10.1080/1047840X.2015.992677

Burkle, F. (2018). Disaster Nursing and Emergency Preparedness Disaster Nursing And Emergency Preparedness for Chemical, Biological, and Radiological Terrorism and Other Hazards. 4 Edition: Tener Goodwin Veenema. ISBN: 978-0-8261-4422-5

Cairns, P., Aitken, G., Pope, L. M., Cecil, J. E., Cunningham, K. B., Ferguson, J., Gibson Smith, K., Gordon, L., Johnston, P., Laidlaw, A., Scanlan, G. M., Tooman, T. R., Wakeling, J., & Walker, K. (2021). Interventions for the well-being of healthcare workers during a pandemic or other crisis: scoping review. BMJ open, 11(8), e047498. https://doi.org/10.1136/bmjopen-2020-047498

Cascella, L. M. (2024). Electronic health records as a tool for disaster recovery. © 2024 MedPro Group. (online-pdf) https://www.medpro.com/documents/10502/2820774/Article_Electronic%2BHealth%2BRecords%2Bas%2Ba%2BTool%2Bfor%2BDisaster%2BRecovery.pdf

Carter, N. W. (2008). Disaster Management - A Disaster Manager's Handbook. Asian Development Bank, 2008. ISBN 978-971-561-006-3

Clarkson L, Williams M. (2023). EMS Mass Casualty Triage. [Updated 2023 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 1/2025. URL: https://www.ncbi.nlm.nih.gov/books/NBK459369/

Ceferino, L., Mitrani-Reiser, J., Kiremidjian, A., Deierlein, G., & Bambarén, C. (2020). Effective plans for hospital system response to earthquake emergencies. Nature communications, 11(1), 4325. https://doi.org/10.1038/s41467-020-18072-w

Cryder, C. H., Kilmer, R. P., Tedeschi, R. G., & Calhoun, L. G. (2006). An exploratory study of posttraumatic growth in children following a natural disaster. The American journal of orthopsychiatry, 76(1), 65–69. https://doi.org/10.1037/0002-9432.76.1.65

Dursun, R., Görmeli, C. A., & Görmeli, G. (2012). 2011 Van depremi sonrası Van bölgesi Eğitim ve Araştırma Hastanesine başvuran olguların değerlendirilmesi [Evaluation of the patients in Van Training and Research Hospital following the 2011 Van earthquake in Turkey]. Ulusal travma ve acil cerrahi dergisi = Turkish journal of trauma & emergency surgery: TJTES, 18(3), 260–264. https://doi.org/10.5505/tjtes.2012.05863

Elshami, S., Ibrahim, M., Abdel-Rahman, M. et al. (2025). Developing and evaluating a Disaster Management Assessment Tool for Health Care Practitioners. BMC Emerg Med 25, 41. https://doi.org/10.1186/s12873-025-01199-8

Eyler, Y., Kılıç, T. Y., Atilla, Ö. D., & Berksoy, E. (2022). Analysis of patients admitted to health sciences university tepecik education and research hospital emergency clinics after the İzmir earthquake on October 30, 2020. Anatolian Journal of General Medical Research. 32(3):372-77. DOI: 10.4274/terh.galenos.2021.62347

FEMA (2021). National Incident Management System Guideline for Resource Management Preparedness. 1/2021. 27 p. URL: www.fema.gov/sites/default/files/documents/nims-guideline-resource-management-preparedness.pdf

Farokhzadian, J., Mangolian Shahrbabaki, P., Farahmandnia, H. et al. (2024). Nurses' challenges for disaster response: a qualitative study. BMC Emerg Med 24, 1st https://doi.org/10.1186/s12873-023-00921-8

Firouzkouhi, M., Kako, M., Abdollahimohammad, A., Balouchi, A., & Farzi, J. (2021). Nurses' Roles in Nursing Disaster Model: A Systematic Scoping Review. Iranian journal of public health, 50(5), 879–887. https://doi.org/10.18502/ijph.v50i5.6105

Geng, S., Gong, Y., Hou, H. et al. (2024). Resource management in disaster relief: a bibliometric and content-analysis-based literature review. Ann Oper Res 343, 263–292. https://doi.org/10.1007/s10479-024-06324-7

Gök, M., Melik, M. A., Doğan, B., & Durukan, P. (2023). Hospital crisis management after a disaster: from the epicenter of the 2023 Türkiye-Syria earthquake. Türkiye-Suriye deprem merkezinden afet sonrası hastane kriz yönetimi. Ulusal travma ve acil cerrahi dergisi = Turkish journal of trauma & emergency surgery: TJTES, 29(7), 792–797. https://doi.org/10.14744/tjtes.2023.44449

Hermosilla, S., Forthal, S., Sadowska, K., Magill, E. B., Watson, P., & Pike, K. M. (2023). We need to build the evidence: A systematic review of psychological first aid on mental health and well-being. Journal of traumatic stress, 36(1), 5–16 https://doi.org/10.1002/jts.22888

International Federation of Red Cross and Red Crescent Societies. (IFRC) (2025a). Disasters, climate and crises. Retrieved from https://www.ifrc.org/our-work/disasters-climate-and-crises

International Federation of Red Cross and Red Crescent Societies. (IFRC) (2025b). Emergency response framework (Version 2.0). IFRC. https://www.ifrc.org/sites/default/files/2025-01/IFRC%20Emergency%20Response%20Framework%202025.pdf

Karimi Dehkordi, N., Abbasi, A. F., Radmard Lord, M., Soleimanpour, S., & Goharinezhad, S. (2021). Interventions to improve the willingness to work among health care professionals in times of disaster: a scoping review. Inquiry: a journal of medical care organization, provision and financing, 58, 469580211059959. https://doi.org/10.1177/00469580211059959

Labrague, L. J., & Hammad, K. (2024). Disaster preparedness among nurses in disaster prone countries: A systematic review. Australasian Emergency Care, 27(2), 88–96 https://doi.org/10.1016/j.auec.2023.09.002

Médecins sans frontières. (2025a). Natural disasters. Retrieved from https://www.msf.org/natural-disasters

Médecins sans frontières. (2025b). Who we are. Retrieved from https://www.msf.org/who-we-are

Mehta, S., R. (2024). Textbook of Emergency Disaster and Trauma Nursing Book. 160 p. https://www.slideshare.net/rsmehta

Mondal, T., Boral, N., Bhattacharya, I., Das, J., Pramanik, P. (2019). Distribution of deficient resources in disaster response situation using particle swarm optimization. International Journal of Disaster Risk

National Association of Counties (NAC). https://www.naccho.org/uploads/downloadable-resources/factsheet-mrc-Sept-2015.pdf

Reduction, Volume 41. ISSN 2212-4209. https://doi.org/10.1016/j.ijdrr.2019.101308.

National Academies of Sciences, Engineering, and Medicine. (NASEM) (2021). The Future of Nursing 2020-2030: Charting a Path to Achieve Health Equity. Washington, DC: The National Academies Press. URL: https://www.ncbi.nlm.nih.gov/books/NBK573904/

Oikawa, Koh & Murakami, Michio & Ochi, UAE. (2024). Use of personal health records during and after a disaster, including a nuclear accident: A scoping review. International Journal of Disaster Risk Reduction. 111. 104698. doi:10.1016/j.ijdrr.2024.104698

Ottisova, L., Gillard, J. A., Wood, M., Langford, S., John-Baptiste Bastien, R., Madinah Haris, A., Wild, J., Bloomfield, M. A. P., & Robertson, M. (2022). Effectiveness of psychosocial interventions in mitigating adverse mental health outcomes among disaster-exposed health care workers: A systematic review. Journal of Traumatic Stress, 35(2), 746–758. https://doi.org/10.1002/jts.22780

Panwar, V., Sen, S. (2020). Fiscal repercussions of natural disasters: stylized facts and panel data evidences from India. Nat. Hazards Rev., 21 (2) (2020), Article 04020011. doi:10.1061/(ASCE)NH.1527-6996.0000369

Pourhosseini, S. S., Ardalan, A., & Mehrolhassani, M. H. (2015). Key aspects of providing healthcare services in disaster response stage. Iranian journal of public health, 44(1), 111–118

Prati, G., & Pietrantoni, L. (2009). Optimism, social support, and coping strategies as factors contributing to posttraumatic growth: A meta-analysis. Journal of Loss and Trauma, 14(5), 364–388. https://doi.org/10.1080/15325020902724271

Puri, A., Elkharboutly, M., Ameer Ali N. (2024). Identifying major challenges in managing post-disaster reconstruction projects: A critical analysis. *International Journal of Disaster Risk Reduction*. Vol. 107, 2024, 104491. ISSN 2212-4209. https://doi.org/10.1016/j.ijdrr.2024.104491

Savoia, E., Lin, L., & Viswanath, K. (2013). Communications in public health emergency preparedness: a systematic review of the literature. Biosecurity and bioterrorism: biodefense strategy, practice, and science, 11(3), 170–184. https://doi.org/10.1089/bsp.2013.0038

Smith, E., & Macdonald, R. (2006). Managing health information during disasters. Health information management: journal of the Health Information Management Association of Australia, 35(2), 8–13 https://doi.org/10.1177/183335830603500204

Štětina J., et al. (2014). Health care and integrated rescue system in mass disasters and disasters. Prague: Grada. ISBN 978-80-247-4578-7

Šín R. (2017) Disaster Medicine. Prague: Galén. ISBN 978-80-7492-295-4

Tedeschi, R. G., & Calhoun, L. G. (2004). Posttraumatic growth: conceptual foundations and empirical evidence. Psychological Inquiry, 15(1), 1–18 https://doi.org/10.1207/s15327965pli1501_01

Tahernejad, A., Sahebi, A., Abadi, A. S. S., & Safari, M. (2024). Application of artificial intelligence in triage in emergencies and disasters: a systematic review. BMC Public Health, 24(1), 3203. https://doi.org/10.1186/s12889-024-20447-3

Tennessee State Government (2020). Guidance for the Ethical Allocation of Scarce Resources during a Community-Wide Public Health Emergency as Declared by the Governor of Tennessee. Developed by the Tennessee Altered Standards of Care Workgroup. Version 1.6 6/2016 (revised 2020) https://www.tn.gov/health/cedep/cedep-emergency-preparedness/surge-management/planning-resources.html

Toya, H., Skidmore, M. (2007). Economic development and the impacts of natural disasters Econ. Lett., 94 (1): 20-25. https://doi.org/10.1016/j.econlet.2006.06.020

United Nations Disaster Assessment and Coordination (2025). This is UNDAC. (brochure PDF). URL: https://undac.un.org/en

United Nations Office for Disaster Risk Reduction. (UNODRR) (2025). Global Assessment Report 2025: Resilience Pays: Financing and Investing for our Future. Geneva, Switzerland (pdf). ISBN: 9789211576740. https://www.undrr.org/gar

University of Central Florida. (UCF) (2025). Disaster Nursing and Emergency Preparedness: The Role of Nurses in Saving Lives (online). URL: https://www.ucf.edu/online/healthcare/news/disaster-nursing-emergency-preparedness/

World Health Organization. (WHO). (2019). Health emergency and disaster risk management framework. World Health Organization. (pdf-eng.) ISBN: 9789241516181 https://www.who.int/publications/i/item/9789241516181

World Health Organization. (WHO). (2022). Health systems resilience toolkit: a WHO global public health good to support building and strengthening of sustainable health systems resilience in countries with various contexts. World Health Organization. (online-pdf. ISBN 978924004875. https://iris.who.int/handle/10665/354177. License: CC BY-NC-SA 3.0 IGO

World Health Organization (WHO). (2023). WHO's response to health emergencies: Annual Report 2022. (pdf) https://reliefweb.int/report/world/whos-response-health-emergencies-annual-report-2022

World Health Organization. (WHO) Foundation. (2025). Health emergencies. (online). https://who.foundation/health-emergencies/

World Health Organization. (WHO). (2025). Emergencies: WHO's role. (online). https://www.who.int/newsroom/questions-and-answers/item/who-s-role-in-emergencies

Chapter 2: First Aid in Disasters

Sevilay Şenol Çelik, Zeynep Özer, Gülcan Bağçivan, Hande Nur Arslan, Selma Turan Kavradım, Leyla Muslu

2.1. General First Aid Information

Disasters are extraordinary situations that frequently restrict access to medical care and delay emergency responses. In such critical scenarios, the timely application of first aid can be the determining factor between life and death. According to the 2021 European Resuscitation Council (ERC) guidelines, first aid in disasters encompasses essential, life-saving interventions performed by first witnesses (bystanders) in cases of sudden injuries, unconsciousness, respiratory failure, bleeding, and shock (Olasveengen et al., 2021). These immediate actions, often carried out before professional help arrives, serve as the first link in the chain of survival.

The importance of first aid becomes even more evident in disaster contexts, where the number of victims is high, healthcare resources are overwhelmed, and emergency services may take longer to arrive. Reducing mortality and morbidity rates is largely dependent on the timely and appropriate administration of first aid. Rapid intervention at the scene, especially when performed by individuals with basic training, can stabilize victims, prevent conditions from worsening, and significantly increase the chances of survival. Moreover, these early efforts help reduce the burden on the healthcare system by minimizing the need for intensive care or prolonged hospitalization (Haider et al., 2017). In this context, promoting first aid training among the general population is not only a public health priority but also a crucial component of disaster preparedness and community resilience.

2.1.1. Definition and Scope of First Aid

First aid means emergency interventions to maintain vital functions and prevent the situation from declining in the event of an illness or injury until professional healthcare teams arrive on the scene. According to the ERC 2021 guideline, first aid refers to all life-saving interventions that do not require medical training and are performed by bystanders on the scene. These interventions include BLS, bleeding control, airway opening, and shock prevention (Olasveengen et al., 2021).

The scope of first aid does not only include interventions in emergencies such as loss of consciousness, respiratory or circulatory arrest, external bleeding, burns, fractures, sprains, drowning, and poisoning, but also basic protective measures such as psychological support for the patient, protection from environmental hazards, and proper positioning. First aid procedures may differ depending on the individual's age, overall health, and the nature of the incident. For example, while ensuring airway patency is more important in infants and children because their respiratory systems are more sensitive, circulatory disorders and associated diseases may differentiate interventions in the elderly (Mtiraoui et al., 2025).

In disaster settings, the complexity of first aid stems from multi-casualty scenes, resource limitations, and evolving hazards.

Because of disasters, professional health teams may take some time to arrive at the scene; there could be more than one injured person on the scene; shortages in materials and human resources are common, and the environment is typically not physically or psychologically safe.

Consequently, implementing first aid in a disaster setting should be based on multifaceted competencies like problem-solving, crisis resolution, quick decision-making, ethical sensitivity, and medical knowledge. In addition to ensuring they are safe throughout the intervention, the first responder should prioritize tasks based on the circumstances to maximize benefits. “Psychological first aid” should be a component of first aid used in disaster situations. People at the scene may need intervention and refuse help due to conditions like post-traumatic stress disorder, panic attacks and disorientation. As a result, the first aid plays a critical role in disaster situations by providing physical assistance, empathy, composure, and a comforting demeanor (Peng et al., 2024; Bayageldi and Binici, 2024).

2.1.2. Role and Responsibilities of the First Aider

In disaster environments, under extraordinary conditions such as uncertainty, lack of resources, and many casualties, the role of first aiders is vital. Despite not being medical personnel, with appropriate training and guidance, they play a crucial role in saving lives. ERC defines a first aider as an individual who can ensure safety at the scene, recognize life-threatening situations, and apply basic interventions. In disasters, this role expands even further; it includes multidimensional responsibilities such as environmental awareness, ethical decision-making, communication and promoting social solidarity (Warbung et al., 2024). According to the ERC 2025 guideline, expectations from a first aid provider include ensuring safety, calling for help, and using only the equipment/medicines for which they are trained (Djarv et al., 2025). These roles are given below.

- The first aider’s primary and crucial responsibility is to assess the scene’s safety before any intervention. This step is vital to determine whether ongoing threats such as aftershocks, fire, flooding, collapse, power lines, or chemical risks exist. If the environment is unsafe, the first aider should refrain from intervention, call for help, and continue monitoring from a safe distance. Given the dynamic nature of environmental risks, this assessment should be constantly updated (Peng et al., 2024).
- Upon reaching the scene, the first aider should swiftly assess the number of injured, the physical conditions of the environment, and the available resources. When professional teams cannot reach or are insufficient in number, the first aider can step into a temporary leadership role and direct those around. This includes coordinating tasks such as calling for help, supplying materials, controlling the crowd, and opening access routes for the injured. This role of coordination empowers the first aider and ensures effective situation management (Pek et al., 2023).
- Clear, reassuring communication is a cornerstone in managing panic and chaos in a di-

saster environment. The first aider's ability to explain the planned intervention before executing it and to ensure the safety of individuals through their words is paramount. Effective communication, especially with children, older adults, or people with mental disabilities, not only aids in physical recovery but also in psychological healing. Even in cases where the communication infrastructure is damaged, the first aider's ability to use alternative methods such as hand gestures, loud voice guidance, and assigning tasks can make a significant difference (Giarratano et al., 2019).

- The first aider can perform basic interventions at the scene per the "Check-Call-Care" approach. Applications such as opening the airway, respiratory and circulatory assessment, bleeding control, and appropriate positioning of the unconscious individual are included in this scope. In cases where resources are limited, it may be necessary to produce improvised solutions with available materials (Peng et al., 2024).
- Ethical responsibilities in disaster conditions are at least as important as physical interventions. The first aider must observe basic moral principles such as not harming, providing benefits, respecting the dignity and privacy of the individual, informing, and obtaining consent if possible. In cases where obtaining consent is not possible, such as loss of consciousness, and if there are life-threatening risks, intervention is acceptable in terms of medical ethics (West et al., 2021).
- The first aider is a part of social solidarity during, before and after the incident. Increasing first aid awareness in society, disseminating training, participating in drills, and awareness activities for disaster preparedness ensure the sustainability of this role. In this respect, the first aider is an element of social resilience, not an individual (Mtiraoui et al., 2025).

2.1.3. Evaluation of The Incident Scene

Disaster environments present a unique set of challenges, far more complex than those encountered in ordinary traffic accidents or individual injuries (Randolph et al., 2019). These environments are characterized by (Owen et al., 2024):

- There may be ongoing dangers such as aftershocks, fire, flooding and collapses.
- The stability of physical structures may be impaired, roads may be inaccessible.
- The number of injured is high, and it may not be possible to call for help.
- The person intervening may have been affected by the incident.

Effective disaster first aid necessitates dynamic risk analysis and physical control. Before initiating any intervention, the first aider must identify potential environmental hazards and act in a manner that does not compromise their safety (Jang et al., 2022) Hazards such as fire, gas leaks, power lines, and debris should be the first consideration. If the scene is deemed unsafe, no intervention should be attempted. Instead, a call for help should be made, and the situation should be monitored from a safe location (Werner et al., 2024).

Since disaster settings often involve mass casualty incidents, the scene must be assessed with a broader perspective. The distribution and apparent condition of casualties may guide the responder in planning subsequent actions, but no individual prioritization should be made until the scene is declared safe (Tran et al., 2024).

In a disaster environment, the first aid provider is responsible for holistically assessing the scene before starting the intervention. This assessment not only ensures physical safety but also enables the organizational management of the process, which involves coordinating resources, prioritizing tasks, and maintaining communication. Systematic assessment of the scene protects the safety of both the helper and the injured individuals and ensures the sustainability of the intervention (Olorunfemi and Adesunloye, 2024). The following are the recommended incident scene assessment steps to be followed by a first aider arriving at the disaster site:

- Before approaching the scene, a general observation should be made about the type of disaster, the area affected, the current hazards, and the environmental conditions. It should be assessed whether the situation is stable, variable, or dangerous (Randolph et al., 2019; Tang and Chen, 2021).
- The safety of the first aider is the priority. The intervention should not be initiated if threats such as falling parts, toxic gases, fire risk, power lines, or environmental aftershocks exist. An intervention without ensuring safety may also cause harm to the aider (Dadashzadeh et al., 2019).
- Physical, chemical, biological, or structural risks should be checked. For example, a building about to collapse, a corridor full of smoke, a floor covered with water, or the unpredictable crowd behavior may make the scene unsuitable for intervention (Schwartz and McNutt, 2020).
- Safe entrance and exit routes should be observed; if there are any obstacles, debris, or a crowded crowd, a route plan should be made. If necessary, alternative routes should be evaluated (Dadashzadeh et al., 2019).
- Before approaching any casualties, a rapid visual scan should be conducted to determine how many people are affected and how these people are distributed to the scene. Whether the injured are in groups or scattered also affects the intervention plan (Heller et al., 2023).
- Witnesses or individuals willing to help at the scene should be observed; individuals who can contribute to the intervention process should be separated. These individuals can be used as guides in the scene management (Schwartz and McNutt, 2020).
- In case the communication lines are damaged, alternative communication methods such as voice warnings, hand signals, or physical guidance should be considered (Heller et al., 2023)
- If there is panic, chaos, or confusion in the environment, this situation may need to be calmed down first in order for the intervention process to be carried out healthily. In this context, it is important to show a reassuring presence at the scene, to be guided, and to calm the environment (Heller et al., 2023).
- Even after the initial assessment, the dynamic nature of the environment may continue. It should not be forgotten that new risks may arise, and the first aider should constantly re-observe the environment (Pareja et al., 2020).

- After the entire assessment is completed and it is determined that the scene is safe enough for intervention, the injured individuals should be approached. This decision should be made not only according to environmental factors but also according to the aider's knowledge, skills, and available opportunities (Randolph et al., 2019).

2.1.4. Evaluation of the Patient

Once the scene is secured, the first aid provider must conduct a systematic assessment of the individual in need of assistance. This assessment is crucial for identifying life-threatening situations and establishing the order of interventions. The process involves two main stages: the primary assessment and the secondary assessment (Zemaitis et al., 2019; Alesi et al., 2023).

Primary Assessment

The first assessment is performed to rapidly assess the individual's vital functions and prioritize life-threatening situations. According to the ERC, the individual's level of consciousness is first assessed in this process, followed by airway, breathing, and circulation control. This systematic assessment is important in determining the intervention order in disaster environments (Alesi et al., 2023).

During the initial assessment, the individual's state of consciousness is one of the most critical indicators for the first aider arriving at the scene. The level of consciousness is checked through observation and verbal/physical stimuli to determine whether the person responds to their surroundings and reacts to stimuli (Heller et al., 2023).

- Is eye contact established?
- Do they respond to verbal stimuli?
- Is there a response to painful stimuli?
- Are they completely unresponsive?

The AVPU scale, which is a fast and practical method for assessing consciousness, can be used (Rahmania and Dhomiri, 2020):

A – Alert: The individual is fully awake and responding to their surroundings.

V – Verbal: Only responding to verbal stimuli

P – Pain: Responding to painful stimuli

U – Unresponsive: No response to any stimuli

If the individual is "Unresponsive," rapid intervention should be initiated as there is a high probability of airway obstruction, respiratory arrest or circulatory failure. In this case, the airway should be opened, and, if necessary, Cardiopulmonary resuscitation (CPR) should be started. Consciousness assessment at the disaster site is also one of the basic criteria for the triage process. Unconscious individuals are usually placed in the highest priority group. The Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach is a systematic approach to the immediate assessment and treatment of critically ill or injured patients (Alesi et al., 2023; Djarv et al., 2025).

A – Airway: The first step is to check the patency of the airway, especially in people with loss of consciousness. Retraction of the tongue, foreign bodies in the mouth or trauma-related deformities can obstruct the airway.

- If there is loss of consciousness, the head-chin position should be applied, the chin should be lifted, and oral secretions should be cleared.
- Do not move the person unless they are in an unsafe situation.
- If there is a suspicion of neck trauma, only the jaw thrust maneuver should be applied.

B – Respiration: The presence, depth and regularity of breathing should be observed. Chest movements should be monitored; respiratory sounds should be listened to and air coming out of the nose/mouth should be tried to be felt.

- If unresponsive and not breathing normally, call your local emergency number and start CPR according to dispatcher instructions.
- If suspected anaphylaxis, if trained, administer adrenaline 0.5 mg intramuscular.
- If suspected choking gives back blows and abdominal thrusts.
- If trained and indicated, administer oxygen to improve oxygen saturation to 94–98 %.

C – Circulation: Circulatory parameters such as pulse control (carotid or radial artery), skin color, humidity, temperature and capillary refill time are assessed.

- Make the person comfortable.
- If suspected cardiac chest pain – administer 150–500 mg chewable aspirin.
- Consider the use of passive leg raising as a temporising measure while waiting for advanced emergency medical care.
- Continue to monitor person carefully for deterioration or loss of responsiveness (possible cardiac arrest).
- If there are no signs of circulation, consider performing CPR.
- If there is severe external bleeding, control it first (by applying direct pressure, using a tourniquet, or applying pressure to the bleeding point).

D – Disability: Common causes of unconsciousness include profound hypoxia, hypercapnia, cerebral hypoperfusion, or the recent administration of sedatives or analgesic drugs.

- If suspected concussion, – remove from physical activity.
- If suspected hypoglycaemia, administer glucose or dextrose tablets (15–20 g) via mouth.
- If suspected opioid overdose, – administer nasal naloxone

E – Exposure: To examine the patient properly full exposure of the body may be necessary. Respect the patient's dignity and minimize heat loss.

- Prevent hypothermia remove wet clothes and use blankets.
- Hyperthermia – start active cooling.
- Preserve amputated parts in cooled container and bring them to the same hospital as the injured person.

These steps are not just a sequence, but also a critical prioritization process. In the event of multiple casualties, this rapid assessment, carried out in the order of the ABCDE approach, determines who needs immediate intervention. The first aider decisions here can significantly impact patient outcomes.

Secondary Assessment

Once the life-threatening situation has been brought under control by the initial assessment, it is possible to further assess the casualty. This phase aims to detect physical trauma, internal bleeding, fractures or other complications (McAuley et al., 2023). The second assessment consists of two components:

1. Systematic physical examination (head to toe assessment): The person is examined from head to toe in a systematic order (Zemaitis et al., 2019).

Head and face: Bleeding, swelling, open wound, pupil asymmetry and consciousness

Neck: Limited movement, swelling, tracheal displacement and neck venous distension

Thorax: Chest wall movements, rib fracture, asymmetric breathing and chest pain

Abdominal: Tenderness, swelling and signs of internal bleeding

Pelvis: Stability check (limited), tenderness and bleeding

Extremities: Swelling, deformity and loss of circulation-feeling-motion

Back: For spinal cord injury, it should be assessed if possible and safe

2. History taking (SAMPLE Method): A brief and targeted history should be taken in conscious individuals (Aciksari et al., 2024).

S (Signs and symptoms): What is the complaint? What symptoms are present?

A (Allergies): Are there any known allergies?

M (Medications): Are there regular medications?

P (Past medical history): Are there known illnesses and past surgeries?

L (Last oral intake): When was the last meal or drink consumed?

E (Previous events): What led to this situation?

Time, resources, and manpower are limited in disaster settings. Therefore, a secondary assessment may not be applicable to every individual. Priority should be given to recognizing and managing life-threatening situations. Individuals with minor injuries can undergo a secondary assessment later; stable individuals can be monitored, and resources can be created for other injured individuals. In addition, the impact of psychological status on physical assessment should be considered, and individuals in panic or shock should be given time to communicate and cooperate (McAuley et al., 2023).

2.1.5. Bystander Effect on First Aid

In extraordinary situations such as disasters, individuals present at the scene but do not intervene, namely “bystanders,” are the invisible but decisive actors of the first aid process. The bystander effect is when an individual feels the need to help in an emergency but does not act because others are there. This psychological phenomenon is explained by the decrease in individual responsibility in a crowd and can cause delays in life-saving interventions, especially in times of disaster (Nida, 2020).

Definition and Characteristics of the Bystander Effect

The bystander effect, first defined by social psychologists John Darley and Bibb Latané, can be summarized as "the decrease in the likelihood of individuals to help when a large number of people witness an event." (Firdaus and Mardiawan, 2024). This effect may occur in disaster environments as people are stunned by the event's magnitude, "not knowing how to help," or think "someone is already taking care of it." This situation becomes even more evident in crowded environments, and "diffusion of responsibility" behavior develops.

Factors Affecting Helping Behavior

There are some psychological and environmental factors that increase the severity of the bystander effect (Firdaus and Mardiawan, 2024).

- Fear of doing something wrong or getting hurt while trying to help
- Not knowing what to do or thinking not equipped enough
- The expectation that "someone else will do it" that legitimizes non-helping behavior
- The tendency to wait for the reaction of those around before taking action.
- The more people there are, the less individual responsibility feeling

The Role of the Trained Bystander in a Disaster Scene

Research has shown that helping behavior increases significantly in individuals who receive first aid training (Rovira et al., 2021). Education provides the ability to stay calm in times of panic, to know simple but effective interventions, and, most importantly, the idea that "I should take the first step." Educated individuals can reduce the bystander effect and at the scene:

- Initiate first aid
- Organize others who can help
- Assume the critical bridge role until professional help arrives

In this respect, first aid training provides information and allows individuals to take an active rather than passive position in a disaster environment. It can take time for professional teams to reach disasters. During this period, quickly organizing and consciously guiding people in the vicinity plays a critical role in effective response (Tian et al., 2024). Bystanders can call 112, provide materials, control the crowd and support the person administering first aid. These contributions increase the effectiveness of the intervention while also allowing social solidarity to be strengthened. As a result, the bystander effect emerges as a vital variable in disaster environments. The most effective way to reduce this effect is to strengthen society with first aid training and ensure that people see themselves as active first aiders rather than ineffective witnesses (Rovira et al., 2021).

2.1.6. Consent Process and Ethical Responsibilities

Obtaining the individual's consent before starting the intervention in first aid practices is a fundamental principle in both ethical and legal terms. According to the guidelines published by the Ministry of Health of the Republic (MoH) in Türkiye, first aid practitioners must obtain explicit consent from the individual who is planning to be intervened or from their parent or legal representative if the individual is under the age of 18 to prevent possible legal and ethical problems. Consent can be obtained verbally or expressed with an approving head movement or gesture (Chougule et al., 2025). The consent process varies depending on the individual's age and level of consciousness as follows:

Conscious Individuals and Over the Age of 18

If the individual is conscious and over 18, brief and understandable information about the procedure must be provided before the intervention, followed by explicit consent. If the offer of assistance is rejected, the individual's decision must be respected; however, the intervention area must not be left, and professional health services must be requested via the 112 Emergency Call Center (Zhong et al., 2019).

Conscious Individuals and Under 18 Years of Age

In interventions targeting individuals under 18, the parent or legal guardian should be contacted, and consent should be obtained from them. If the offer of assistance is rejected, the individual should be kept under observation, and an emergency call for professional support should be made via the 112 Emergency Call Center (Kaye et al., 2019).

Unconscious Individuals (for All Age Groups)

In the event of loss of consciousness, the individual's life is considered under threat, and consent is deemed given within the ethical framework (implied consent). In this case, the necessary interventions should be initiated using the relevant first aid information, the individual should be accompanied throughout the process, and the practices should continue until the healthcare teams arrive (Stassen et al., 2022).

In terms of ethical practice, it is recommended that only necessary and appropriate interventions be made during first aid, that the individual's privacy be considered, and that the procedures performed when consciousness is regained be explained briefly. The process of obtaining consent, especially in complex and chaotic environments such as disasters, may not always be carried out ideally; however, the practices must be continued most humanely and ethically (Prescott et al., 2022).

2.2. Basic Life Support

Basic life support (BLS) covers essential medical interventions applied in life-threatening emergencies such as cardiac arrest, respiratory failure, or upper airway obstruction until advanced life support can be provided. These time-sensitive situations require immediate action, and BLS serves as the foundation of emergency medical care. BLS practices include vital steps such as assessing the patient's level of consciousness, ensuring airway patency, supporting effective breathing, and maintaining circulation through chest compressions when necessary. These simple yet life-saving actions can be performed by both healthcare professionals and trained laypersons, making them critical in bridging the time gap before advanced care becomes available (Olasveengen et al., 2021)

Importantly, BLS constitutes the first step in the chain of survival and plays a pivotal role in improving the outcomes of critically ill or injured individuals. Early and correct intervention dramatically increases the chances of survival, reduces the risk of permanent organ damage, and can determine the quality of life after recovery (Grabmayr et al., 2024). In mass casualty incidents or disasters, where rapid access to professional medical care may be delayed, the ability of bystanders or first responders to perform BLS can significantly reduce preventable deaths. Therefore, widespread BLS training and public awareness are vital components of an effective emergency response system and a resilient society (Olasveengen et al., 2021)

2.2.1 Recognition of Respiratory and Cardiac Arrest in Disaster Settings

Early recognition of respiratory and cardiac arrest is the cornerstone of effective BLS. In disaster settings where time is critical, and resources are limited, rapid and accurate identification of life-threatening situations is both a clinical and logistical imperative (Olasveengen et al., 2021). The ability to distinguish between normal, agonal, and absent breathing and to assess consciousness rapidly can determine the survival trajectory of victims in mass casualty incidents (Grabmayr et al., 2024).

Clinical Indicators of Cardiac Arrest

Cardiac arrest should be suspected in any unresponsive individual who is not breathing normally. According to the European Resuscitation Council (ERC), the diagnostic approach in the context of BLS should prioritize two observations:

Unresponsiveness: The individual does not respond to verbal commands or physical stimuli (e.g., shouting, tapping). The absence of purposeful movements, vocalizations, or eye-opening indicates significant central nervous system dysfunction.

Abnormal or absent breathing: The presence of breathless, slow, irregular, or noisy breathing (agonal breathing) should not be confused with normal breathing. A *"look-listen-feel"* approach is recommended, in which the first aider observes chest movement, listens to breath sounds, and feels for air exchange for no more than 10 seconds.

If both criteria are met, cardiopulmonary arrest should be assumed, and resuscitative efforts should be initiated immediately. Pulse checks are not recommended for laying first aiders due to the high error rate and time consumption. The presence or absence of a pulse is not required to initiate BLS (Olasveengen et al., 2021; Molnár et al., 2023).

Respiratory Arrest in Disaster Settings

Respiratory arrest, defined as the cessation of effective breathing while cardiac output is still present, is also common in disaster situations. It may result from smoke inhalation (fire in confined spaces), chest trauma (from collapsed buildings or debris), drowning (from floods or tsunamis) and obstructive airway conditions (dust, foreign body aspiration). In these cases, respiratory arrest can rapidly progress to cardiac arrest if ventilatory support is not provided. Therefore, an accurate assessment of respiratory effort is essential (Gomes et al., 2020).

Special Considerations for Infants and Children

Recognition of arrest in infants and children varies in both presentation and urgency. In pediatric patients, respiratory failure is a more common primary cause of cardiac arrest than arrhythmia. Symptoms include no response to stimuli, hypotonia, central cyanosis, apnea or bradypnea. In infants, agonal breathing may be subtle and easily missed in chaotic and catastrophic conditions. Observation of chest rise and auscultation for breath sounds may be unreliable if the environment is noisy or the child is covered in debris or dust. Rapid tactile stimulation and vocalization ("Are you OK?") may trigger a response (Kragh et al., 2024).

Recognition Barriers in Disaster Settings

Disaster environments present unique challenges that can prevent rapid recognition of arrest:

- Environmental noise can mask auditory cues such as breath sounds or gasps.
- Poor lighting or dust can prevent visual assessment of chest movement or skin tone.
- Emotional overload, panic, and cognitive fatigue among first aiders can reduce observation accuracy.
- Multiple casualties can overwhelm first responders, leading to triage errors or delays in assessment.

Therefore, training and repeated simulation in disaster-specific scenarios are essential to improve recognition accuracy. Guidelines recommend that first aider s err on the side of action; if in doubt, initiate BLS (Lafrance et al., 2023).

Protocols Used in Cardiopulmonary Resuscitation

Clinical protocols are structured evidence-based sets of instructions developed to guide healthcare interventions. In the context of CPR, such protocols are formulated by expert committees based on the most current scientific evidence and are periodically updated. Adherence to standardized CPR algorithms significantly improves patient outcomes by ensuring consistency, safety, and efficacy during resuscitation efforts (Santos-Folgar et al., 2022).

The Chain of Survival

The "chain of survival" represents a sequence of time-critical actions that, when performed effectively and in a coordinated manner, significantly enhance survival following cardiac arrest. Each link in the chain is essential, and deficiencies in any one step can compromise the overall outcome (Amagasa et al., 2023). According to the 2021 ERC Guidelines, the chain of survival differs slightly between out-of-hospital and in-hospital cardiac arrests (Olasveengen et al., 2021). Generally, it consists of the following steps in adult out-of-hospital scenarios.

- Early recognition and call for help
- Early CPR with high-quality chest compressions
- Early defibrillation
- Post-resuscitation care in specialized centers

2.2.2. Techniques Used in BLS Algorithms for Adults

During BLS, first aid providers are expected not just to acquire but also to deeply understand a series of life-saving techniques that are systematic and evidence-based. Before implementing the complete resuscitation algorithm, it is essential to comprehend each component's theoretical foundations and clinical significance. The subsequent sections will explore the core elements of CPR, namely chest compressions, airway management, rescue breathing and the utilization of an automated external defibrillator (AED) (Olasveengen, 2020).

Chest Compressions

Chest compressions are a fundamental component of BLS, designed to restore systemic perfusion by mechanically simulating the heart's pumping function. When external pressure is applied to the sternum, intrathoracic pressure increases, compressing the cardiac chambers and propelling blood into the major vessels. This forward flow is supported by the functional integrity of cardiac valves, which prevent retrograde movement and facilitate unidirectional circulation. During compressions, blood from the left ventricle is directed toward vital organs such as the brain, while blood from the right ventricle is transported to the pulmonary circulation. The term venous return describes the passive flow of blood back to the heart during the recoil phase, a critical process for maintaining cardiac output during resuscitation efforts (Chandran et al., 2024).

Although oxygen may still be present in the bloodstream during the early stages of cardiac arrest, circulation typically ceases entirely. Therefore, the immediate goal is to re-establish perfusion, not oxygenation. For this reason, current BLS algorithms prioritize continuous chest compressions—particularly in single-rescuer scenarios—over ventilation. In such cases, "compression-only" or "hands-only" CPR is recommended, especially when the first aider is untrained in or unwilling to provide rescue breaths. This approach has been shown to improve outcomes by minimizing delays and interruptions in perfusion (Catalisano et al., 2024).

Technique for Performing Chest Compressions

Chest compressions should be administered with proper body mechanics, a crucial aspect that ensures effectiveness and first aider safety. The first aiders should position themselves by standing or kneeling beside the patient, leaning slightly forward stably and comfortably. The heel of one hand—typically the non-dominant hand—should be placed firmly on the lower half of the sternum, specifically at the level of the xiphisternum. The heel of the other hand—usually the dominant hand—should be placed directly over the first, interlocking the fingers or keeping them elevated to avoid pressure on the ribs. The first aider's arms must remain straight, with shoulders aligned directly above the hands to allow vertical force transmission. Compressions should be delivered by pressing vertically down on the sternum to a depth of at least 5 centimeters (approximately 2 inches) in patients while ensuring that full chest recoil occurs after each compression to allow venous return. Compression rate should be maintained at a minimum of 100 compressions per minute, with an optimal range of 100 to 120 compressions per minute, as current resuscitation guidelines recommend (Olasveengen, 2020; Russell et al., 2021) (Figure 2.2-1).

Factors Influencing the Effectiveness of Chest Compressions

Several critical factors, including compression depth, full chest recoil, surface stability, and minimization of interruptions, determine the efficacy of chest compressions during CPR. Mastery of these elements is essential for ensuring optimal perfusion during resuscitative efforts.

Compression Depth

Effectual cardiac output during external compressions is contingent upon adequate compression depth. Current international guidelines recommend a depth of at least 5 cm (approximately 2 inches) in patients (Olasveengen, 2020; Thaker et al., 2024). This means the chest should be compressed to a depth of at least 5 cm to ensure effective blood circulation. While compressions exceeding 6 cm may increase the risk of rib fractures or internal injuries, evidence suggests that suboptimal compression depth is a more frequent issue in practice. Therefore, emphasis should be placed on delivering compressions with sufficient force to reach the recommended depth (Thaker et al., 2024) (Figure 2.2-2).

In individuals with reduced upper limb strength or musculoskeletal limitations (e.g., arthritis), a modified hand technique may enhance compression depth. This involves placing the heel of the non-dominant hand on the lower half of the sternum and grasping the wrist of that hand with the dominant hand. This adjustment provides additional wrist support and can facilitate deeper compressions with improved control. (Machbub et al., 2022).

Figure 2.2-1. Chest Compression Rate

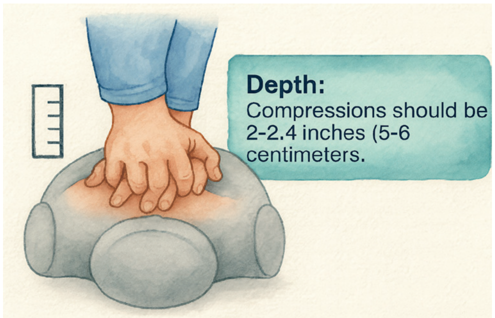


Figure 2.2-2. Depth of each compression

Chest Recoil

Complete chest recoil after each compression is imperative for venous return to the heart. Incomplete recoil reduces ventricular filling, decreasing the stroke volume and the effectiveness of subsequent compressions. First aiders must, therefore, avoid leaning on the chest between compressions and ensure that complete thoracic expansion is permitted after each downward thrust (Lakomek et al., 2020; Chandran et al., 2024). (Figure 3).

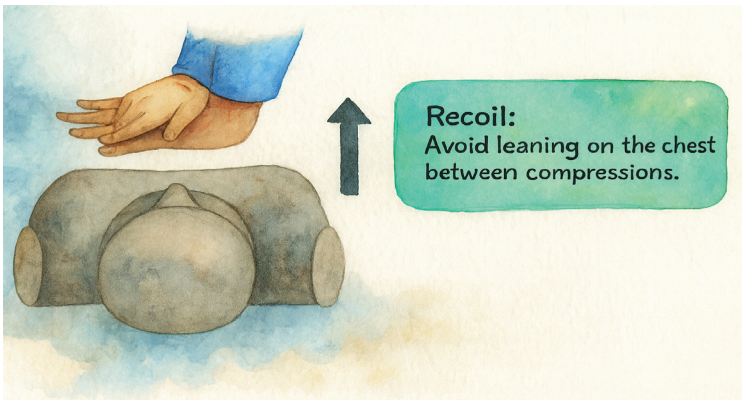


Figure 2.2-3. The chest recoling after each compression

Surface Firmness

The patient should be placed on a hard, flat surface prior to initiating chest compressions. Performing compressions on a soft or yielding surface (e.g., a mattress) diminishes their effectiveness by absorbing the downward force and limiting actual thoracic displacement (Olasveengen, 2020). The patient should be moved to the floor whenever possible, or a backboard should be placed beneath them (Sanri and Karacabey, 2019).

Minimizing Interruptions

Continuous delivery of compressions is essential for maintaining coronary and cerebral perfusion pressures. Interruption of compressions, even briefly, leads to a significant decline in blood flow to vital organs such as the brain. Furthermore, once compressions are restarted, several cycles are required before adequate circulation is re-established. Thus, minimizing interruptions—especially for activities like pulse checks or ventilation—is crucial for improving survival and neurological outcomes (Catalisano et al., 2024).

Airway Management and Rescue Breathing

Respiratory arrest may occur as a primary event or as a consequence of cardiac arrest. In cases of respiratory arrest, two fundamental interventions are required to support or temporarily replace pulmonary function: airway management and rescue ventilation (Mohamed, 2022).

Effective airway patency is a prerequisite for successful rescue breathing. Techniques for opening the airway vary depending on the cause of obstruction and the patient's condition (Erfanian et al., 2024).

In cardiac arrest scenarios, current guidelines from the ERC prioritize high-quality chest compressions over ventilation, particularly in the early stages of resuscitation. When only a single first aider is present, "hands-only CPR" —involving uninterrupted chest compressions without rescue breaths—is recommended (Pujalte-Jesús et al., 2020).

However, rescue breathing becomes essential under specific clinical circumstances:

- Unresponsive patients with a palpable pulse who are either apneic or exhibiting agonal respirations require rescue breathing at a rate of 1 breath every 5–6 seconds (approximately 10–12 breaths per minute) (Olasveengen, 2020).
- In prolonged cardiac arrest, particularly after approximately 13 minutes or 400 chest compressions, the oxygen reserve in the bloodstream becomes insufficient to support organ perfusion. At this point, the addition of rescue breaths is warranted (Olasveengen, 2020; Wawrzynek and Mścisz, 2024).
- When two trained first aiders are available at the scene immediately following cardiac arrest, coordinated resuscitation should be performed. One first aider delivers chest compressions, while the other provides ventilatory support at a ratio of 30:2 (30 compressions to 2 breaths) by standard BLS protocols (Pujalte-Jesús et al., 2020).

Airway Management

Prior to the initiation of rescue breathing in patients with cardiac arrest, it is essential to ensure airway patency. Obstruction of the airway by secretions, blood, vomitus, or debris can significantly compromise ventilation and must be promptly addressed (Mohamed, 2022). Visible materials in the oral cavity should be removed using a gloved finger with a sweeping motion or by employing suction equipment if available. Specific dislodgement techniques must be employed for larger obstructions, such as food particles or foreign bodies resulting in choking, which are discussed in a subsequent section (Penketh and Nolan, 2023).

Once the airway is cleared of visible obstructions, it is critical to maintain its openness to facilitate adequate ventilation. This can be achieved using one of two manual maneuvers: the head-tilt/chin-lift or the jaw-thrust maneuver (Carlson and Wang, 2020).

The *head-tilt/chin-lift maneuver* is indicated in patients without suspected cervical spine injury. To perform this technique, one hand is placed on the patient's forehead to gently tilt the head backward, while the fingers of the other hand are positioned under the bony part of the lower jaw to lift the chin upward and forward. Care must be taken to avoid excessive pressure on the soft tissues beneath the chin, as this reflexively occludes the airway. Additionally, the patient's mouth should remain slightly open to allow adequate air entry during ventilation (Carlson and Wang, 2020; Erfanian et al., 2024) (Figure 2.2-4).

The *jaw-thrust maneuver* is the preferred method in cases where spinal trauma is suspected, as it avoids head movement. The first aider positions themselves behind the patient's head, stabilizing their elbows on a firm surface. Both hands are placed just behind the angles of the mandible, and the jaw is manually thrust forward to displace the tongue away from the posterior pharynx (Wawrzynek and Mścisz, 2024). As with the previous technique, the mouth should remain partially open. Both maneuvers aim to prevent posterior tongue displacement, thereby maintaining airway patency during rescue breathing efforts. The selection of the appropriate maneuver should be based on clinical assessment, particularly the likelihood of cervical spine involvement (Bartos et al., 2023) (Figure 2.2-5).

Figure 2.2-4. Head tilt chin lift technique

Figure 2.2-5. Jaw thrust technique

Rescue Breathing

Rescue breathing is a critical intervention in BLS that temporarily assumes the ventilatory function of the lungs. By manually delivering breaths into the patient's airway, the first aider facilitates the entry of oxygen into the alveoli, supporting gas exchange and maintaining the oxygenation of circulating blood (Mohamed, 2022). Although the air delivered during rescue breathing originates from the first aider's exhalation, it still contains approximately 16–17%

oxygen—sufficient to sustain cellular function temporarily until advanced medical assistance becomes available (Pujalte-Jesús et al., 2020). Despite the presence of carbon dioxide in exhaled air, the residual oxygen is adequate for life-saving purposes during the initial stages of cardiopulmonary resuscitation.

Mouth-to-mouth ventilation remains the most widely recognized method of rescue breathing; however, this direct approach carries a risk of exposure to potentially infectious body fluids. As a result, barrier devices are recommended to enhance safety and hygiene (Tangpaisarn et al., 2023). The two most commonly employed barrier devices are face shields and pocket masks. A face shield is a compact, flat, and portable plastic sheet designed to cover the patient's mouth and nose. It features a central one-way valve or filter that allows airflow in one direction while preventing fluid backflow. Its portability makes it popular among lay first aiders and non-healthcare personnel trained in BLS (Gaszyński et al., 2021) (Figure 2.2-6).

Pocket masks, on the other hand, are pear-shaped masks that cover the patient's nose and mouth, forming a seal to deliver adequate ventilation. Typically used by healthcare professionals and emergency responders, these masks include a one-way valve and may also feature an oxygen port for supplemental oxygen administration (Jeong et al., 2024). The ERC recommends replacing face shields with pocket masks whenever possible due to their superior protection and efficacy (Olasveengen, 2020). Without barrier devices, bystanders should not hesitate to perform rescue breathing when clinically indicated. The estimated risk of disease transmission during CPR is approximately 1 in 17 million; thus, the benefit of prompt intervention far outweighs the minimal risk (Michel et al., 2019) (Figure 2.2-7).

Figure 2.2-6. Face shield

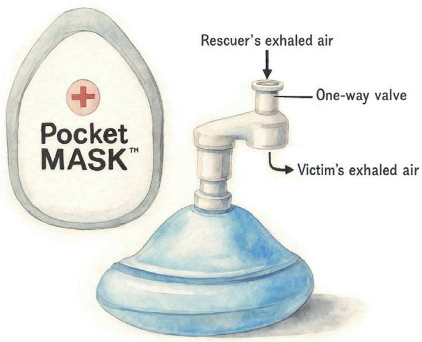


Figure 2.2-7. Pocket mask

To perform rescue breathing effectively, the first aider should stand or kneel beside the patient. A barrier device should be positioned over the patient's mouth and/or nose if available (Wawrzynek and Mścisz, 2024). Depending on the likelihood of cervical spine injury, the first aider then opens the airway using either the head-tilt/chin-lift or the jaw-thrust maneuver. After taking a normal breath—not a deep one—the first aider pinches the patient's nose (if no device is used), creates a tight seal with their mouth over the patients, and exhales steadily into the airway (Otero-Agra et al., 2020). Each breath should be delivered over one second, just enough to cause a visible chest rise, confirming that air is reaching the lungs. Excessive volume or force may lead to gastric insufflation, increasing the risk of regurgitation and aspiration. If the chest fails to rise after two attempts, the first aider should resume chest compressions immediately (Skříšovská et al., 2024) (Figure 2.2-8).

Ventilation may also be administered using a bag-mask device (BVM), which is often preferred due to its ability to deliver room air (21% oxygen) or, when connected to a supplemental oxygen source, a higher oxygen concentration (Bartos et al., 2023). To use a BVM, the first aider should position themselves at the head of the patient. After performing a head tilt to open the airway, the mask should be placed over the patient's nose and mouth, guided by the nasal bridge for proper positioning (Otero-Agra et al., 2020). The mask is secured using the E-C clamp technique: the thumb and index finger of the dominant hand form a "C" shape to hold the mask in place and maintain a seal, while the remaining three fingers form an "E" shape to lift the mandible and open the airway (Gerber et al., 2021). Once the mask is secured, the non-dominant hand squeezes the bag over one second per ventilation. As with manual rescue breathing, visible chest rise should be observed with each breath to confirm adequate ventilation (Borremans et al., 2023) (Figure 2.2-9).

Figure 2.2-8. The first aider pinches the patient's nose

Figure 2.2-9. Use of bag-mask device

Automated External Defibrillator: Rationale and Application

Contemporary CPR protocols mandate the incorporation of an automated external defibrillator (AED) in the management of cardiac arrest. The AED is a portable, computerized device specifically designed to be used by lay first aiders. It is indicated in cases of cardiac arrest where the underlying cause is an abnormal cardiac rhythm (Elhussain et al., 2024).

Under normal physiological conditions, the heart beats steadily and rhythmically. This rhythm is governed by electrical impulses that originate spontaneously from the sinoatrial (SA) node in the upper part of the right atrium. These impulses travel through a specialized conduction system, ensuring the synchronized contraction of cardiac muscle. Periodic generation and conduction of these electrical signals are critical for the heart to function effectively (van der Maarel et al., 2023).

However, disturbances in generating or propagating these impulses can lead to arrhythmias. When electrical activity becomes excessively rapid or erratic, the heart beats irregularly and is often ineffective. Such rapid, disorganized rhythms are referred to as arrhythmias. Among the various types of arrhythmias, two are particularly lethal and are the most common causes of sudden cardiac arrest: ventricular fibrillation and pulseless ventricular tachycardia (Dryja et al., 2024).

Ventricular fibrillation is characterized by chaotic electrical activity within the ventricles, resulting in complete loss of synchronized contraction. Instead of pumping blood effectively, the ventricles quiver ineffectively, leading to the cessation of cardiac output. Pulseless ventricular tachycardia involves extremely rapid ventricular contractions that are so inefficient that no palpable pulse can be generated, thereby failing to sustain systemic perfusion (Stupca et al., 2022). When these shockable rhythms are identified, the administration of an electrical shock can restore a normal cardiac rhythm. This is achieved using a defibrillator, which delivers a controlled dose of electrical energy to the heart. It is crucial to recognize that only certain arrhythmias are responsive to defibrillation (supraventricular tachycardia, ventricular fibrillation, supraventricular tachycardia). Asystole (complete absence of electrical activity) and pulseless electrical activity (PEA) are also commonly encountered during cardiac arrest; however, these are not shockable rhythms and are managed using advanced life support measures rather than defibrillation. For this reason, it is imperative to assess the cardiac rhythm via a monitor before delivering a shock in order to determine whether the rhythm is indeed shockable (Pham et al., 2023).

AED for Out-of-Hospital Use

A significant proportion of cardiac arrests occur outside healthcare facilities. The AED has been specifically developed for such situations, allowing trained individuals to initiate defibrillation without delay (Lipchak et al., 2022). The device is lightweight, portable, and commonly found in public areas where many people gather, such as shopping centers, airports, sports stadiums, and amusement parks. Staff at these venues are typically trained in BLS and in the use of the AED (Pham et al., 2023).

How the AED Works

An AED is a battery-operated, computerized device that analyzes the heart's rhythm and determines whether a shock is indicated. The system includes adhesive electrodes (pads) that are attached to the patient's chest. These electrodes detect the heart's electrical activity and transmit it to the device's internal computer, which performs rhythm analysis. If a shockable rhythm is detected, the device prompts the first aider to deliver a shock (Didon et al., 2024). Upon activation of the shock button, a high-energy electrical pulse is delivered through the pads, aimed at depolarizing the myocardial cells and interrupting the arrhythmia, with the goal of allowing the heart's natural pacemaker to reestablish an organized rhythm.

Most modern AEDs are equipped with audio and visual prompts that guide the first aider through every step of the procedure. This design ensures that even individuals without medical training can use the device confidently and effectively. Despite the variation among models, there are fundamental operational steps common to all AEDs (Shirazi Nejad et al., 2024; Aldaas and Birgersdotter-Green, 2024).

Technique of Using an AED

In a typical emergency response, the AED is brought to the scene by a second first aider, while chest compressions are already being performed by the first responder. These compressions must continue uninterrupted unless the AED instructs otherwise. The steps involved in using an AED are as follows (Lupton et al., 2024; Elhussain et al., 2024; Missel et al., 2025).

- Remove the AED from its carry case and power it on. In some models, opening the lid automatically turns on the device.
- Select the appropriate set of adhesive pads. Adult pads are indicated for patients older than 8 years of age. Peel off the adhesive backing to prepare the pads for placement.
- Place the pads as instructed by the AED's voice prompts and/or as illustrated on them. The most common configuration is anterolateral placement, where one pad is applied to the right upper chest, just below the clavicle, and the other is placed on the left lateral chest wall, approximately 7 to 8 centimeters below the armpit, near the lower rib margin. Alternatively, anteroposterior placement may be used in some instances. In this approach, one pad is placed on the anterior chest, to the left of the sternum, and below the nipple, while the second pad is positioned on the patient's back, adjacent to the spine. It is important to note that this method requires repositioning the patient and is less commonly employed in out-of-hospital scenarios (Figure 2.2-10) (Figure 2.2-11).

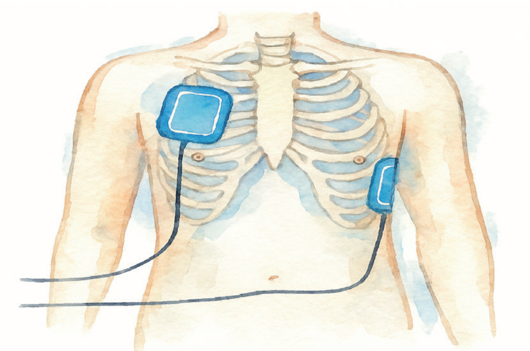


Figure 2.2-10. Anterolateral placement

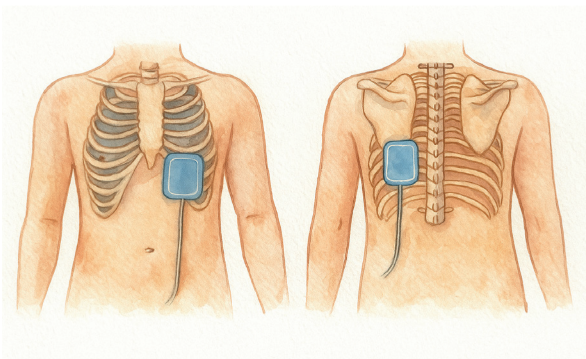


Figure 2.2-11. Anteroposterior placement

- Once the pads are correctly positioned, ensure that no one touches the patient and allow the AED to analyze the heart rhythm. Some models perform this automatically, while others require the first aider to press a designated analysis button.
- If the AED determines that the rhythm is shockable, the first aider will deliver a shock. At this point, the first aider must again confirm that no individual is in physical contact with the patient.
- Press the shock button to deliver the electrical pulse.
- Immediately resume CPR following the shock, starting with chest compressions. It is critical not to delay compressions, as perfusion must be restored promptly to minimize ischemic injury (Figure 2.2-12).

Modern AEDs simplify this process through real-time guidance, increasing the likelihood of effective bystander intervention and improving survival rates from out-of-hospital cardiac arrest. The simplicity, portability, and effectiveness of AEDs make them essential components of any public access defibrillation strategy.

Figure 2.2-12. Simple steps in using an AED

2.2.3. Techniques Used in BLS Algorithms for Infants and Children

The technique of chest compressions must be adapted according to the patient's age and body size to ensure adequate perfusion while minimizing the risk of injury. Both the hand placement and the depth of compressions differ between children and infants.

Chest Compressions in Children

In small children, standard two-handed adult chest compression techniques may result in excessive force. Therefore, single-handed compressions are often recommended. The first aider should place one hand on the lower half of the sternum and deliver compressions to a depth of approximately 5 cm, corresponding to one-third of the anteroposterior diameter of the chest. It is important to ensure that adequate depth is achieved with one hand. If this cannot be accomplished, the first aider should switch to a two-handed technique, using caution to avoid excessive force (Kowal et al., 2024) (Figure 2.2-13).

Figure 2.2-13. One handed CPR in children

Chest Compressions in Infants

Infants require more delicate and specialized techniques for chest compression. The choice of technique depends on whether there is a single first aider or a two-first aider team. When only one first aider is present, the two-finger technique is used. This involves the following steps (Lee et al., 2019) (Figure 2.2-14).

- The first aider uses the index and middle fingers of the dominant hand.
- The fingers are placed on the lower part of the sternum, just below the nipple line at the center of the chest.
- Compressions should be delivered vertically to a depth of approximately 4 cm, corresponding to one-third of the chest's anteroposterior diameter.

The two-thumb encircling hand technique is preferred due to its superior physiological outcomes. This technique allows for more consistent compression depth, improved coronary perfusion, and higher generated blood pressure. The steps for this technique are as follows (Vandamme et al., 2024).

- The first aider uses both hands to encircle the infant's chest. The opposing thumbs rest on the lower half of the sternum, just below the nipple line, while the remaining fingers support the infant's back.
- Chest compressions are delivered by pressing both thumbs downward on the sternum.
- As with the two-finger technique, compressions should reach approximately 4 cm or one-third of the infant's chest depth (Figure 2.2-15).
- Although this method yields more effective compressions, it requires a second first aider to provide ventilation, as the first aider performing compressions cannot easily disengage their hands.

Figure 2.2-14. Two finger CPR

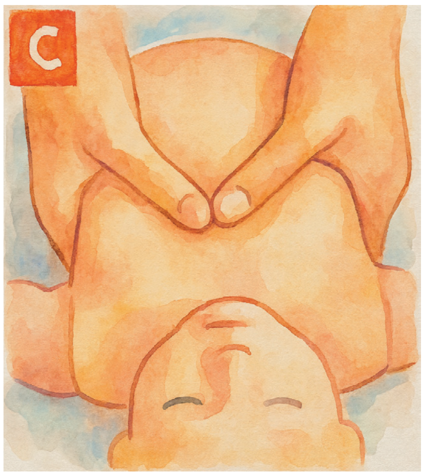


Figure 2.2-15. Two thumb encircling hands CPR

Airway and Rescue Breathing in Infants and Children

Airway management and rescue breathing in child patients are similar to adult techniques, with essential modifications to account for anatomical differences. Also, in infants, particular care must be taken to avoid hyperextension of the neck, which can lead to airway obstruction. The head should be kept neutral; excessive tilting may compress the trachea. A practical anatomical guide is to align the external ear canal with the shoulder level, ensuring a midline, neutral alignment. In addition, in infants, the first aider should cover the patient's mouth and nose with their own mouth to create a tight seal (Amagasa et al., 2023).

When using a pocket mask or a bag-valve-mask (BVM) device for ventilation, selecting an appropriately sized mask that fits securely over the child or infant's nose and mouth is critical. Emergency response kits typically contain multiple mask sizes. A well-fitted mask prevents air leakage and delivers positive pressure ventilation effectively (Borremans et al., 2023) (Figure 2.2-16).

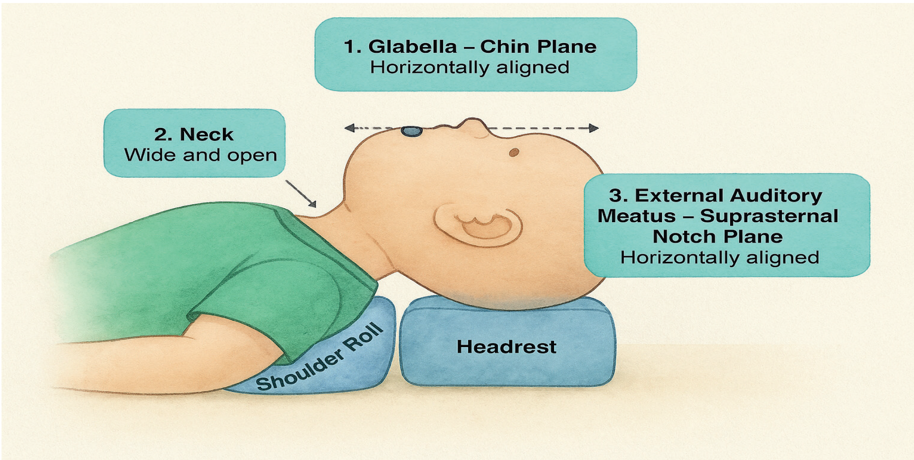


Figure 2.2-16. Head tilt in infants

Automated External Defibrillator in Children Below 8 Years of Age

Standard AEDs are designed to deliver electrical energy appropriate for adults and children above 8 years of age. However, in younger children, this energy level may be excessive and potentially harmful. Certain modifications or pediatric-specific accessories are required to adapt AED use for this population to ensure safe and effective defibrillation. These modifications are as follows (Amagasa et al., 2023).

- A built-in preprogramming option that automatically reduces the delivered energy dose.
- A dose attenuator, which limits the energy output by approximately one-third of the standard adult dose.
- Special pediatric cables are used to interface with the AED to control the energy delivered.

In addition to these electrical modifications, pediatric-specific adhesive electrode pads are also used. For children, pads should be placed in the anterolateral position: one pad is applied to the upper right side of the chest, above the breast, and the second pad is positioned on the left side of the chest, below the armpit (Borremans et al., 2023).

Anteroposterior pad placement is recommended for infants under 1 year of age: one pad is placed on the center of the upper chest, and the other on the back, between the scapulae (et al., 2023).

A manual defibrillator is preferred in infants, as it allows precise adjustment of the delivered energy dose based on body weight and clinical condition. However, manual defibrillators require advanced training and are typically operated by healthcare professionals (Santos-Folgar et al., 2022).

An AED modified for pediatric use may be used in settings where a manual defibrillator is unavailable. Without pediatric-specific modifications, a standard AED may still be applied to children under 8. In such cases, delivering a full-dose shock is considered preferable to withholding defibrillation altogether, as timely shock administration is critical for survival in cases of ventricular fibrillation or pulseless ventricular tachycardia (Borremans et al., 2023) (Figure 2.2-17).

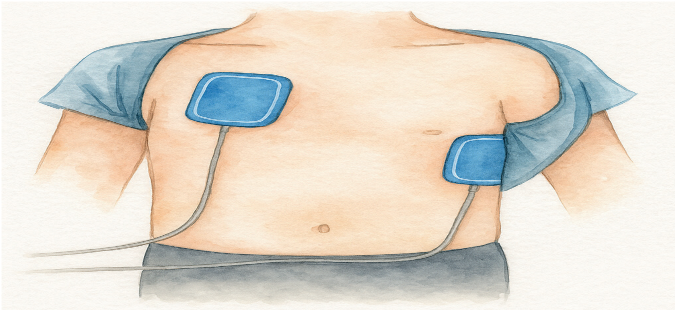


Figure 2.2-17. Anterolateral placement of child AED pads

2.2.4. ERC's BLS Protocol for Adults

The ERC's BLS protocol varies depending on the number of responders at the scene. When multiple trained first aiders are present, tasks can be shared efficiently. However, in many real-life scenarios, only one trained first aider may be immediately available. In both cases, the core steps of adult BLS remain consistent (Lim et al., 2021; Olasveengen and Semeraro, 2021).

One-First Aider Protocol

When only a single trained first aider is present, the following sequence must be followed.

Phase 1: Scene safety and situation assessment: Before initiating CPR, the first aider must assess the safety of the environment for both the patient and them. If hazards are present—such as fire, gas, structural instability, or electrical risks—the patient should be moved only if it is safe. First aider s should not endanger themselves, as doing so may result in additional casualties.

Upon confirming the scene's safety, the first aider must assess the patient's responsiveness. If the patient is unresponsive and not breathing normally, the first aider should immediately shout for help and request the nearest person to call emergency medical services and retrieve an AED. If alone, the first aider must call emergency services before starting CPR, using a mobile phone on speaker mode if necessary (Chaudhary et al., 2023).

Phase 2: Assessment of breathing and circulation: ERC 2021 recommends assessing breathing and signs of circulation simultaneously for no more than 10 seconds. The first aider should check for normal breathing by observing chest movement and listening for air sounds. Occasional gasping is not considered normal breathing and should be treated as a sign of cardiac arrest.

Simultaneously, the first aider may check for signs of circulation, such as purposeful movements or normal breathing. Routine pulse checks by laypersons are no longer emphasized, and even healthcare providers are advised not to delay CPR in uncertain cases. According to ERC, if the patient is unresponsive and not breathing normally, CPR should be initiated immediately without waiting to confirm the presence or absence of a pulse (Almojarthe et al., 2021).

Phase 3: Initiation of CPR: If the patient is not breathing normally, the first aider should immediately start chest compressions. The clothing over the chest should be removed to improve hand placement and to allow prompt application of AED pads when the device becomes available.

The CPR protocol for adults follows the 30:2 compression-to-ventilation ratio, regardless of the number of first aiders. Compressions should be at a depth of 5–6 cm and a rate of 100–120 per minute. Rescue breaths should be delivered approximately 1 second each, ensuring visible chest rise (Nagao et al., 2021).

Rescue breaths may be omitted if the first aider is unwilling or unable to provide them; in this case, continuous chest compressions should be performed (i.e., compression-only CPR) until professional help arrives or an AED is applied. In such cases, hands-only CPR with continuous chest compressions is recommended, especially for lay responders, as emphasized by ERC 2021. This approach increases the likelihood of intervention and improves survival in adult sudden cardiac arrests of cardiac origin (Bielski et al., 2021).

Use of AED and role rotation: Once the AED is brought to the scene, the first aider should follow the voice prompts exactly. While one first aider continues chest compressions, the other applies the AED pads. If the AED advises a shock, the patient must be cleared before pressing the shock button. Immediately after shock delivery (or if no shock is advised), CPR should be resumed without delay (Tani et al., 2019).

Two-First Aider Protocol

When two trained first aiders are present at the onset of a cardiac arrest, the resuscitation process can be executed more efficiently and effectively. The presence of two responders allows simultaneous execution of critical tasks, thereby minimizing delays and enhancing patient outcomes (Bahanshel et al., 2021).

Phase 1: Scene assessment and task delegation: Upon encountering an emergency, one first aider should immediately assume a leadership role to facilitate coordinated task allocation. While one first aider evaluates the environment to ensure safety for both patient and responders, the second first aider is responsible for activating emergency medical services via the regional emergency number (e.g., 112 in Europe) and retrieving an Automated External Defibrillator (AED) if one is available on-site. Effective communication during this phase is essential to establish a structured and time-efficient approach (Wagenplast et al., 2022).

Phase 2: Patient assessment: Patient assessment follows the same principles outlined in the one-first aider protocol. The first aider s must rapidly assess the patient's level of responsiveness and breathing status. If the patient is unresponsive and not breathing normally, CPR must be initiated immediately. In the ERC 2021 guidelines, agonal gasps are not considered normal breathing and should be treated as a sign of cardiac arrest. Pulse assessment may be attempted if feasible but should not delay the initiation of chest compressions if there is uncertainty (Allan et al., 2024).

Phase 3: Initiation of cardiopulmonary resuscitation: If the patient is unresponsive and exhibits no signs of normal breathing and circulation, one first aider should begin chest compressions immediately while the other provides rescue breaths. Compressions are delivered at a depth of 5–6 cm and a rate of 100–120 per minute. The standard compression-to-ventilation ratio is 30:2, consistent across single- and two-first aider scenarios. Rescue breaths should be delivered for approximately one second each, ensuring visible chest rise (Mathew et al., 2023).

Use of AED and role rotation: One first aider should prepare and apply the adhesive pads while the other continues compressions. The AED should be allowed to analyze the cardiac rhythm as soon as the pads are in place. Both of first aiders must stand clear of the patient during rhythm analysis to avoid artifact interference. If a shock is advised, the first aider operating the AED must loudly announce "clear" before administering the shock and ensure that no one is in contact with the patient. Immediately after the shock is delivered, chest compressions must be resumed without delay (Kim et al., 2023).

Team Coordination and Role Rotation

Continuous chest compressions are physically demanding and may lead to first aider fatigue, which in turn compromises compression quality. To prevent this, first aiders are advised to switch roles approximately every two minutes or after five cycles of 30:2. The transition should be completed within five seconds, ideally during the AED's rhythm analysis phase, when compressions are momentarily paused. The AED will typically prompt rhythm reassessment every two minutes, providing a natural interval for role exchange (Sandhu et al., 2022).

Throughout the CPR process, effective communication is vital. The first aider performing compressions should count out loud to allow timely delivery of ventilations. Clear verbal cues must also be used during AED operation, especially when instructing others to stay clear of the patient during analysis or defibrillation. This structured, coordinated approach continues until the return of spontaneous circulation (ROSC) is achieved or care is transferred to advanced life support providers (Sandhu et al., 2022).

2.2.5. ERC's BLS Protocol for Infants and Children

According to the European Resuscitation Council (ERC), individuals under one year of age are classified as infants, while those aged between one and eight years are categorized as children. This age-based classification is crucial for guiding appropriate resuscitation strategies, as anatomical and physiological differences significantly influence both the causes and management of cardiac arrest in pediatric patients. Unlike adults, pediatric cardiac arrests are typically secondary to respiratory failure or circulatory collapse, rather than primary cardiac events. This distinction highlights the importance of early recognition and timely intervention to prevent progression to cardiac arrest (Schnaubelt et al., 2024).

As a result, pediatric Basic Life Support (BLS) places particular emphasis on securing the airway, ensuring adequate ventilation, and preventing hypoxia—all of which are vital in reducing morbidity and mortality among children. Prompt and effective support of breathing and circulation through high-quality cardiopulmonary resuscitation (CPR) is critical in improving outcomes. Furthermore, early identification of clinical deterioration and immediate action can prevent irreversible organ damage and increase the chances of full recovery (Kolawole et al., 2024). Given that children are especially vulnerable in emergency and disaster settings, the ability of caregivers, educators, and community members to perform pediatric BLS is a key component of pediatric emergency preparedness and a powerful tool for saving young lives.

Chain of Survival in Pediatric Patients

In pediatric patients, preventing arrest through early identification and management of respiratory compromise is especially critical. The pediatric chain of survival includes the following key elements (Schnaubelt et al., 2024; Kolawole et al., 2024).

- Prevention of cardiac arrest
- Early and effective recognition of cardiopulmonary arrest and activation of emergency response
- High-quality CPR with adequate ventilation
- Rapid defibrillation when indicated
- Integrated post-resuscitation care

Single-First Aider Protocol for Infants and Children

Phase 1: Scene and victim assessment: As in adult protocols, the first step is to assess the scene's safety. The first aider must ensure that the environment poses no risk to themselves or the victim. The first aider should then check for responsiveness by gently tapping the child's shoulder and calling their name. For infants, tapping the sole may be more appropriate. If there is no response, call for help immediately and activate emergency medical services (EMS). If alone and a mobile phone is available, the first aider should use speaker mode to call 112 without leaving the patient (Vandamme et al., 2024).

Phase 2: Assessment of breathing and circulation: Breathing is assessed visually by observing chest movement and listening or feeling for airflow. Agonal respirations (gasping) are not considered normal breathing. Pulse assessment is also recommended, but differs by age (Anders et al., 2025):

- In infants, palpate the brachial pulse by placing two fingers inside the upper arm between the biceps and triceps.
- In children, the femoral pulse may be palpated in the inguinal crease or the carotid pulse if accessible.
- The first aider should spend no more than 10 seconds assessing breathing and circulation. If there is any doubt, CPR should be initiated immediately.

Phase 3: Initiation of resuscitation: This phase includes following steps (Skříšovská et al., 2024).

- If the patient has a pulse and is breathing normally, monitor the child's breathing and circulation until EMS arrives.
- If a pulse is present but the child is not breathing normally, begin rescue breathing. Deliver one breath every 2–3 seconds (20–30 breaths per minute), each delivered over approxi-

mately 1 second, producing a visible chest rise.

- Monitor the pulse every 2 minutes. If the heart rate drops below 60 beats per minute—even if a pulse is present—and there are signs of poor perfusion such as pallor, weak central pulses, or mottled skin, chest compressions must be initiated without delay.
- Before initiating chest compressions in infants and children, it is recommended to deliver five initial rescue breaths. This reflects the high prevalence of hypoxic causes in pediatric cardiac arrests, where early oxygenation is critical to prevent progression to full cardiopulmonary arrest.
- If there is no breathing and no detectable pulse, or if the heart rate is below 60 bpm with signs of poor perfusion, begin CPR immediately. Remove the child's clothing to allow proper hand placement and preparation for defibrillation.
- Chest compressions are performed using the appropriate technique (Obara et al., 2024).
  - For infants, use a two-finger or two-thumb encircling technique.
  - For children, one- or two-handed technique, depending on the child's size.
  - Deliver compressions at a rate of 100–120 per minute, at a depth of 4 cm for infants and 5 cm for children, approximating one-third of the chest's anteroposterior diameter.
  - Use a compression-to-ventilation ratio of 30:2 when only one first aider is present.
  - Continue CPR for approximately 1 minute or five cycles, then leave to activate EMS and retrieve an AED if this has not yet been done. This guidance is specific to pediatric cardiac arrest and is based on the understanding that such arrests are often hypoxic in origin. Providing early ventilation through CPR before leaving to call for help may significantly improve the chances of survival.

Use of AED and role rotation: Allow the AED to analyze the rhythm, and if a shock is advised, ensure that no one is touching the patient before delivering it. Immediately resume CPR after the shock, continuing in 30:2 cycles. Reassess the rhythm every 2 minutes, following AED prompts. Continue CPR until signs of life return, advanced life support arrives, or the first aider is physically unable to continue (Liang et al., 2022).

Two-First Aider Protocol in Pediatric BLS

The presence of two trained first aiders significantly enhances the effectiveness of pediatric resuscitation by allowing simultaneous execution of critical tasks. Children and infants often experience cardiac arrest secondary to hypoxia or circulatory shock, making timely and well-coordinated intervention essential (Anders et al., 2025).

Phase 1: Scene assessment and task delegation: One first aider assumes responsibility for assessing the scene and determining whether the proceeding is safe. The second first aider activates emergency medical services by calling the appropriate emergency number and retrieves an AED, if available (Keselica et al., 2024).

Phase 2: Patient assessment: This phase mirrors the approach used in the single-first aider protocol. The first aiders assess responsiveness, breathing, and circulation. For infants, the brachial pulse should be palpated; for children, the femoral or carotid pulse may be used. If the patient is unresponsive and not breathing normally, resuscitation should be initiated without delay (Noh et al., 2022),

Phase 3: Intervention based on clinical status: This phase includes following steps (Skříšovská et al., 2024).

- *If the patient is breathing and a palpable pulse is present,* the child or infant should be continuously monitored. Both first aiders should reassess pulse and respiration regularly until advanced life support arrives.
- *If the patient has a pulse but is not breathing adequately,* one first aider begins rescue breathing, delivering one breath every 2–3 seconds (20–30 breaths per minute), with a visible chest rise and each breath lasting approximately one second. The second first aider continuously evaluates the patient's pulse and signs of perfusion. Chest compressions should be initiated immediately if the pulse falls below 60 beats per minute or signs of inadequate perfusion (e.g., pallor, cyanosis, cold extremities, or weak pulses). If compressions are not required, rescue breathing should be continued with a reassessment of the pulse every two minutes
- *If both respiration and pulse are absent,* the first aider begins chest compressions using the two-thumb encircling hands technique for infants or the one- or two-handed technique for children, depending on the patient's size. The second first aider delivers rescue breaths as soon as possible.

In pediatric patient, the compression-to-ventilation ratio is 15:2, allowing more frequent ventilation than in adult protocols. This adjustment reflects the typical etiology of pediatric cardiac arrest, which often originates from hypoxia or respiratory failure. In such cases, oxygen levels in the bloodstream are already depleted at the time of arrest, making adequate ventilation a critical priority alongside compressions (Noh et al., 2022; Santos-Folgar et al., 2023).

Use of AED and role rotation: The AED must be powered on as soon as it becomes available, and the pediatric pads must be applied according to the manufacturer's instructions. Pads should be placed in the anterolateral position for children and the anteroposterior position for infants. The AED will analyze the cardiac rhythm and advise shock delivery if indicated. During rhythm analysis, both first aiders must ensure no contact with the patient. If a shock is advised, it should be administered immediately. Regardless of whether a shock is delivered, CPR must be resumed immediately following the AED prompt. First aiders should switch roles approximately every two minutes, preferably during rhythm analysis or other natural pauses in CPR, to reduce fatigue and maintain high-quality compressions. Rhythm analysis is repeated every two minutes, with ongoing reassessment of the patient's condition (McCartney et al., 2022; Elhussain et al., 2024).

This resuscitation cycle—comprised of 15:2 compressions and ventilations, rhythm checks, and AED interventions—must be maintained continuously until signs of return of spontaneous circulation (ROSC) are observed, advanced life support providers arrive and assume care, or the patient becomes responsive (Hoehn et al., 2020).

2.3. Airway Obstruction and Drowning

Airway obstruction refers to a potentially life-threatening condition in which a person is unable to breathe adequately due to a physical blockage in the upper respiratory tract, most commonly at the level of the laryngeal inlet. This situation rapidly compromises oxygen delivery to vital organs and, if not promptly addressed, can lead to unconsciousness, brain damage, or death within minutes. In adults, the most frequent cause of obstruction is a piece of improperly chewed food becoming lodged in the throat. In contrast, children, due to their natural curiosity and tendency to explore objects orally, are more likely to experience airway blockage from non-food items such as coins, small toy parts, or beads (Cramer et al., 2020; Yiannakis & Hilmi 2024). This type of emergency requires immediate and appropriate intervention. Recognizing the signs of airway obstruction—such as clutching the throat, inability to speak or cough, cyanosis, and respiratory distress—is critical. Without swift first aid, complete airway obstruction can quickly escalate to cardiac arrest. Basic Life Support (BLS) training plays a vital role in equipping individuals with the skills necessary to respond to these emergencies. Techniques such as back blows, abdominal thrusts (Heimlich maneuver), and chest compressions—when applied correctly and promptly—can restore airflow and prevent tragic outcomes (Cramer et al., 2020; Yiannakis & Hilmi 2024).

The importance of airway obstruction management is even greater in disaster settings, where environmental chaos, panic, and limited access to immediate professional care can delay life-saving treatment. In such situations, having trained bystanders who can identify and respond effectively to choking incidents can make the difference between life and death. Therefore, integrating airway obstruction recognition and relief techniques into public health education and disaster preparedness training is an essential component of building safer, more responsive communities (Yiannakis & Hilmi 2024).

2.3.1. Recognition of An Airway Obstruction Victim

A choking victim may not be immediately apparent to an untrained observer. However, prompt recognition will ensure prompt management, which increases the chances of a successful outcome. Therefore, it is important for all individuals training in BLS to familiarize themselves with the signs of choking (Pairi and Imran, 2024)

Signs of mild choking: Patients with mild choking usually have partial airway obstruction, so while breathing may be difficult, air exchange occurs at the lungs' level. Some signs of mild choking are below.

- Continuous cough in an attempt to expel the object
- A prominent wheeze between coughs

Signs of severe choking: In severe choking, there is complete airway obstruction, and as a result, air exchange is minimal or completely absent. This results in the following signs and symptoms.

- The patient is unable to speak at all or cry.
- There is a weak cough, or a cough is absent.

- High-pitched noise may be produced while attempting to inhale.
- There is cyanosis due to insufficient oxygen exchange.

The universal choking sign: It is an instinctive reaction and is considered the classical choking sign. The patient holds or clutches their throat with the thumb and fingers of one or both hands. If immediate relief from choking is not obtained, the lack of air exchange depletes the oxygen in the patient's blood. This causes the oxygen-deprived brain to shut down, and the patient may eventually lose consciousness (Figure 2.3-1).

Figure 2.3-1. Universal choking sign

2.3.2. Management of the Choking for Adult and Child Patient

Adoption of appropriate techniques can relieve choking in 70 to 80% of all cases. Appropriate management of the choking patient depends on two main factors (Suga et al., 2024).

- Whether the patient is an adult, child or infant
- Whether the patient is responsive (conscious) or unresponsive (unconscious)

Heimlich Maneuver

The heimlich maneuver (named after the physician who originally proposed the technique) is a series of controlled, upward abdominal thrusts. These thrusts put pressure on the diaphragm, forcing it upwards into the chest cavity. This, in turn, pushes air out of the patient's lungs, forcing them to cough and, eventually, expel the object. The heimlich maneuver can only be used in a conscious person capable of standing or sitting upright. It is not intended for use on infants (Basile et al., 2023).

Steps in performing the heimlich maneuver are below (Suga et al., 2024; Basile et al., 2023) (Figure 2.3-2).

- The patient should be positioned upright, either standing or sitting.
- The first aider is positioned behind the patient, ensuring they are close enough to encircle the patient's waist with both arms.
- A fist is formed with the dominant hand and placed with the thumb side inward, against the patient's abdomen—specifically in the midline, below the sternum, and just above the umbilicus.

- The non-dominant hand is used to grasp the fist, and quick, inward, and upward thrusts are administered.
- Each thrust should be forceful and directed upward toward the diaphragm to expel the obstructing object.
- Repeat the thrusts until: The foreign object is expelled, the choking is relieved, or the patient loses consciousness, and an alternate management method must be adopted.

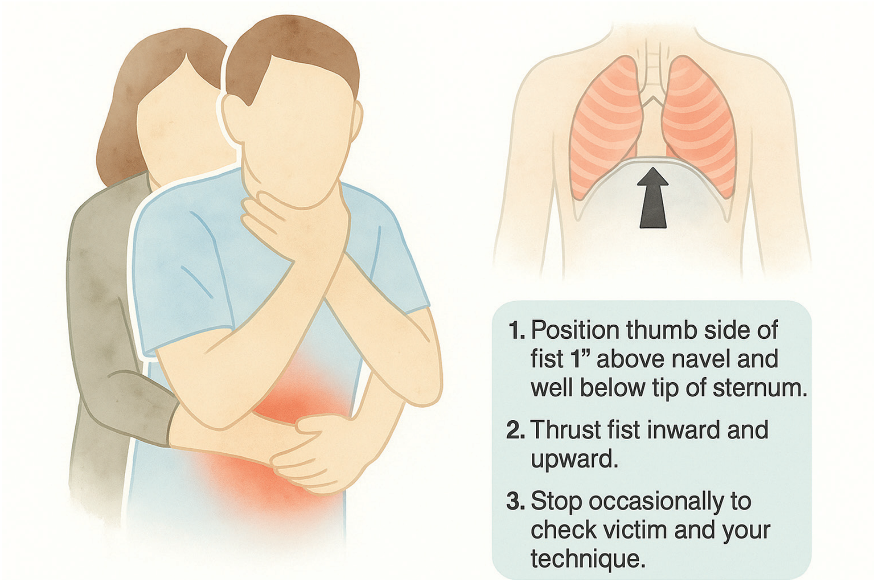


Figure 2.3-2. Heimlich maneuver

Modifications of the Heimlich Maneuver

Performing the maneuver on a pregnant and obese person: Chest thrust should be preferred for pregnant and obese people. Abdominal thrusts are contraindicated in pregnant individuals due to the upward displacement of the diaphragm by the enlarging uterus. In such cases, chest thrusts should be performed as an alternative. For optimal effectiveness, the first aider 's hands should be positioned at the lower end of the sternum during the maneuver (Suga et al., 2024; Djarv et al., 2025).

Combining abdominal thrusts with back blows: If back blows are ineffective, 5 abdominal thrusts should be applied. In this method, the first aider stands behind the patient to administer back blows in a manner similar to the Heimlich maneuver. The patient is bent forward at the waist while the first aider stabilizes the chest using the non-dominant arm. Subsequently, a sharp blow is delivered between the shoulder blades using the heel of the dominant hand. Abdominal thrusts follow this. The sequence of five back blows followed by five abdominal thrusts is repeated until the obstructing object is expelled or the patient becomes unresponsive (Basile et al., 2023) (Figure 2.3-3).

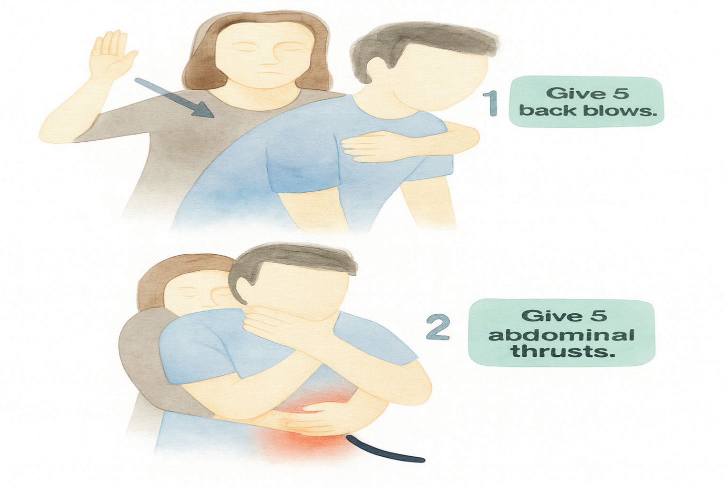


Figure 2.3-3. Five and five approach

Unresponsive Adult or Child: CPR

When a patient loses consciousness, it indicates oxygen deprivation to the brain. Immediate steps must be taken to maintain circulation and restore oxygen supply to the body's vital organs. The focus here is, therefore, on CPR. The following steps must be followed when the first aider is sure that unconsciousness is the result of choking (Thapa et al., 2024).

- Immediately call for help and ask any available people to activate the emergency response services.
- Gently lower the victim to the ground or any available firm surface.
- Start performing CPR. As per the most recent guidelines, looking for a pulse is unnecessary– this may delay the resuscitation process. Perform 30 chest compressions, followed by two rescue breaths.

Modification of Rescue Breathing

Prior to each cycle of rescue breathing, the patient's mouth should be opened fully and inspected for any visible foreign object. If the object is visible and can be removed easily, an attempt may be made to extract it using a safe and controlled technique. In cases where the object is not visible or cannot be easily accessed, two rescue breaths should still be delivered. It is critically important to avoid blind finger sweeps, as such attempts may inadvertently force the object deeper into the airway. CPR should be continued for five cycles of 30 compressions followed by two ventilations. If emergency medical services have not yet been contacted, they must be notified immediately after the completion of these five cycles (Costable et al., 2024).

Continuing CPR after Choking Relief

Chest compressions may function similarly to abdominal thrusts and aid in dislodging the foreign object. With periodic inspection before rescue breathing, removing the foreign object and clearing the airway may be possible. However, the patient may not regain consciousness immediately. The CPR must continue until the pulse and respiration recover completely or till the patient is shifted to the hospital (Raghuprasad, 2021)

2.3.3. Relief of Choking in an Infant

Abdominal thrusts are contraindicated in infants. Instead, chest thrusts are recommended. ERC recommended the "five-and-five" technique for responsive infants, though the procedure involves specific adaptations (Dunne et al., 2024). The first aider should be seated or kneeling, securely holding the infant on their lap. If feasible and time permits, removing the infant's clothing is advised, as direct access to the chest may enhance the effectiveness of chest thrusts. "Five-and-five" technique includes following steps (Igarashi et al., 2024).

- For back blows, the infant should be positioned prone on the first aider's forearm, with the forearm supported on the first aider's lap or thigh. The infant's head must be lower than the chest, and the first aider should use their hand to support the infant's head and jaw without applying pressure to the neck's soft tissues, which may exacerbate airway obstruction.
- Using the heel of the opposite hand, five firm back blows should be administered between the infant's two scapulas (Figure 2.3-4).
- To proceed with chest thrusts, the infant should be turned face-up in a controlled motion, resting on the opposite forearm, which remains supported by the thigh. Again, the head should remain positioned lower than the chest (Figure 2.3-5).
- Five chest thrusts should then be delivered by placing two fingers in the middle of their chest just below the nipples.
- The sequence of five back blows and five chest thrusts should be alternated continuously until the obstructing object is expelled or the infant becomes unresponsive.

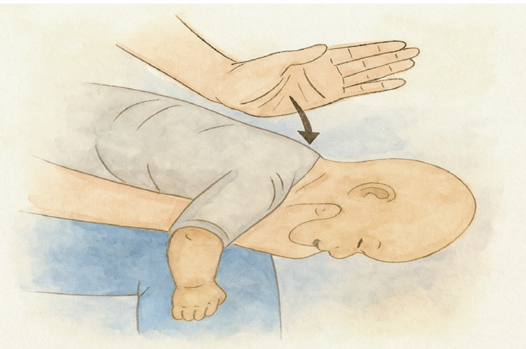


Figure 2.3-4. Supporting a choking infant

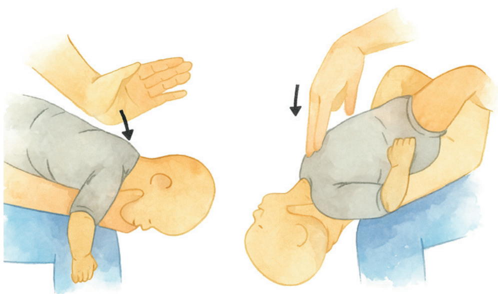


Figure 2.3-5. Choking relief for infants

Relief of Choking in an Unresponsive Infant

If the infant becomes unresponsive, the first aider must shift over to CPR. As for adults, one must not waste time looking for a pulse. The belowing steps must be followed (Machado et al., 2025).

- Call for help and ask any bystanders to activate emergency services.
- Place the patient on a firm surface and start chest thrusts. Alternate between chest thrusts and rescue breathing.
- As for adults, before beginning each rescue breath, visually inspect the airway for the foreign object and attempt to retrieve it if it can be easily done.
- Call for emergency services at the end of two minutes if it has not already been done.

2.4. Bleeding

Disasters are complex environments where physical traumas are common, time is a race, and resources are limited. Situations such as earthquakes, explosions, structural collapses, fires, floods, and armed conflicts often result in large numbers of individuals being simultaneously exposed to severe and sometimes life-threatening injuries. Among these, bleeding is one of the most frequent and immediate causes of death (Charlton et al., 2020). Hemorrhage, defined as the leakage of blood due to the disruption of vascular integrity, can lead to hypovolemic shock and death within minutes if not managed effectively. In such critical situations, timely and appropriate bleeding control becomes a life-saving priority.

In life-threatening bleeding scenarios, proper intervention within the first few minutes such as applying direct pressure, using a tourniquet, or performing wound packing, can significantly increase survival rates. Given that access to professional medical services is often delayed or disrupted in disaster settings, the ability of both disaster response personnel and ordinary citizens to recognize and manage bleeding is of paramount importance. Early intervention not only saves lives but also reduces the severity of long-term complications and lightens the burden on overwhelmed healthcare systems (Bobko et al., 2020).

Therefore, widespread dissemination of basic first aid knowledge, especially bleeding control techniques, should be considered an essential component of disaster preparedness. Public training programs, school-based education, and community drills can empower individuals to act decisively in emergencies, turning bystanders into immediate responders capable of making a crucial difference between life and death.

2.4.1. Classification of Bleeding

Bleeding can be classified according to various criteria. These classifications are important in determining the type of intervention.

Bleeding According to Source

Arterial bleeding: It originates from high-pressure arteries originating from the heart. It is bright red and gushes out in synchrony with the heartbeat. It causes rapid blood loss and is life-threatening (Sharifi et al., 2020).

Venous bleeding: It originates from low-pressure veins. It is dark red and flows more slowly but continuously (Sharifi et al., 2020).

Capillary bleeding: It is superficial bleeding coming from capillaries. It usually stops independently, but it is important for wound infection (Charlton et al., 2020).

Bleeding According to Visibility

External bleeding: It is bleeding in which blood flows outside the body and is visible. It is often seen in the extremities or head area due to trauma (Franjić, 2022).

Internal bleeding: It is the flow of blood into body cavities (abdomen, chest, brain). It is invisible to the eye but is life-threatening. It should be recognized with signs and symptoms (e.g., abdominal stiffness, signs of shock) (Holmgren and Beer, 2024).

Occult bleeding: Conditions where there is no obvious bleeding sign reflected externally despite the development of hemorrhagic shock (e.g., bleeding may leak into the tissue in cases such as femur fracture) (Lemeschewskij et al., 2023).

Bleeding According to Severity (Amount of Blood Loss)

1st Degree (blood loss of up to 15%): It does not show symptoms or is mild.

2nd Degree (blood loss of 15–30%): Pulse accelerates, and mild tachycardia develops.

3rd Degree (blood loss of 30–40%): Hypotension, confusion, sweating, and rapid and weak pulse are observed.

4th Degree (blood loss of more than 40%): Shock develops, and if emergency intervention is not performed, it is fatal (Lemeschewskij et al., 2023).

2.4.2. Hemostatic Mechanism and Pathophysiology of Hemorrhage

The human body has a complex but highly coordinated mechanism to prevent and control bleeding, known as hemostasis. Hemostasis functions through three main phases including *vascular spasm, platelet plug formation and the coagulation cascade*. These physiological responses aim to control bleeding and restore vascular integrity rapidly. However, in disasters, the importance of timely intervention cannot be overstated. Factors such as severe tissue injury, hypothermia, acidosis and delayed intervention may impair these natural mechanisms and increase the risk of uncontrolled hemorrhage (Lemeschewskij et al., 2023).

Vascular Spasm (Vasoconstriction)

Immediately after vascular injury, the body's response is remarkably adaptable. Smooth muscle in the vessel wall contracts to reduce blood flow, a reflex that is more pronounced in arterioles and is mediated by local myogenic responses, endothelin release, and neurogenic signals. However, in major traumas such as crush injuries or blast wounds, frequent disasters, vessel wall destruction may limit vasoconstriction, challenge the body's adaptability and accelerating blood loss (Thurman, 2021).

Primary Hemostasis: Platelet Plug Formation

In this phase, circulating platelets adhere to the exposed subendothelial collagen via the von Willebrand factor. They become activated, change shape, and release granules that recruit more platelets, forming a temporary plug. In patients with hypovolemia and hypothermia (common in disaster victims due to prolonged exposure and delayed rescue), platelet function may be severely impaired, diminishing the effectiveness of primary hemostasis (Thurman, 2021).

Secondary Hemostasis: Coagulation Cascade

This cascade involves a complex enzymatic activation of clotting factors, ultimately converting fibrinogen into fibrin strands that stabilize the platelet plug. Massive bleeding, acidosis (pH <7.2), and hypothermia (<35°C) create a condition known as the "lethal triad," which disrupts clotting enzyme activity and leads to coagulopathy. In this state, bleeding becomes uncontrollable despite ongoing interventions such as blood transfusions, fluid resuscitation and temperature management (Xiao and Wu, 2022).

Fibrinolysis and Clot Stability

After hemostasis is done, fibrinolytic pathways become active to dissolve the clot gradually. These pathways involve the activation of enzymes that break down the fibrin strands, thereby dissolving the clot. However, in trauma patients with systemic inflammatory response, often triggered by polytrauma in disasters, this balance can shift toward hyperfibrinolysis, causing the formed clots to break down prematurely, leading to recurrent bleeding (Thurman, 2021).

2.4.3. First Aid for External Bleeding

In a life-threatening injury, the patient person must be transported to a health institution immediately. This immediate action is crucial, as the time between the injury and bleeding control must be as short as possible (Charlton et al., 2020). Controlling bleeding is a first aid application that requires skill, but the urgency of getting the patient to a health institution cannot be overstated (Franjić, 2022).

The generally accepted first aid intervention method for bleeding control is applying direct pressure to the bleeding site (Lemeschewskij et al., 2023). The first aider's role in this is vital. Direct pressure helps the body's natural clotting mechanisms work by compressing the edges of the torn vein. This method is sufficient for most patients to control bleeding. Pressure bandages, tourniquets, local cold applications, and hemostatic dressings are other recommended methods for bleeding control. However, since elevating the bleeding limb is not beneficial, it is not recommended as a first aid method (Franjić, 2022).

Interventions performed for external bleeding may not be sufficient to stop the bleeding completely. However, these interventions applied by a first aider will help to preserve vital functions by slowing down the bleeding as much as possible until the 112-emergency team arrives and the patient reaches a health institution method (Charlton et al., 2020).

First Aid Application Steps in External Bleeding

First aid application includes following steps (Charlton et al., 2020).

- Before intervening with the patient, assessing whether the scene and the surroundings are safe is essential. Intervention should not be started before safety is ensured.
- Before starting the intervention, the first aider should identify himself/herself and then calm the patient.
- The patient should preferably be laid on his/her back on a flat surface. This position helps prevent additional trauma in case of possible loss of consciousness and contributes to the blood pooling in the lower body regions, entering the central circulation.
- If the injury is mild and the patient is more comfortable sitting, he/she should be allowed to sit.
- The patient's basic vital signs, such as breathing and circulation, should be assessed.
- If there is life-threatening external bleeding that cannot be controlled with direct intervention and there is only one first aider at the scene, the 112- emergency helpline should be called immediately. If a second person is at the scene, this task should be transferred to the second person.

- The patient should be kept as still as possible. Unnecessary movements should be prevented.
- Jewelry that may affect circulation, such as watches, bracelets, and rings, should be carefully removed from the wound area.
- If the bleeding area is not visible, clothing should be gently removed or cut to reveal the wound area so that the source of bleeding can be determined.
- A clean gauze, handkerchief, towel, piece of cloth, or the patient's clothing should be placed directly on the wound, and continuous direct pressure should be applied.

Direct Pressure Application and Support with Pressure Bandage

Direct pressure application includes following steps (Charlton et al., 2020; Lemeschewskij et al., 2023)

- When applying direct pressure, it's crucial to select the appropriate technique based on the size of the wound. For small-scale injuries, the aider must use fingertips, and for larger wounds, use palm. The key here is to maintain the applied pressure on the wound area for a full five minutes without interruption. This continuous and intense pressure ensures that the bleeding is under control, giving you the confidence that you're effectively managing the situation (Figure 2.4-1).
- It's important to remember that if the first dressing becomes wet with blood, it should not be removed. Doing so could cause the existing clot to break down and the bleeding to start again. Instead, add a new and clean material on top and continue the pressure. This caution can help you avoid potential risks and ensure the best outcome for the patient.
- If the bleeding persists after ten minutes, it's important to adapt the technique. Add additional layers on the existing material and treat a wider area with increased pressure. This adaptability is key in effectively managing the bleeding.
- A pressure bandage plays a crucial role in first aid. It ensures that the applied direct pressure remains constant, maintaining the effect of the intervention when it's necessary to leave the patient for a short time. To use it, place a sterile gauze or clean cloth on the wound, then wrap the limb tightly with a bandage, cheesecloth, tie, or similar non-stretchy cloth.
- A pressure bandage can save the first aider time for additional responsibilities, such as calling the 112-emergency helpline or tending to other injured people. It also contributes to maintaining the hemostatic effect during the patient's transfer to the health institution.

Figure 2.4-1. Direct pressure application

Controlling Bleeding with Pressure Bandages and Tourniquet Applications

When applying a pressure bandage, care should be taken to ensure it is not so tight that it blocks circulation. Symptoms that may occur when the bandage is too tight include increased pain, numbness or tingling, skin color changes, and loss of function in the relevant extremity. Such findings should be carefully monitored, and the bandage pressure should be adjusted if necessary (Charlton et al., 2020; Lautenschläger et al., 2021).

In cases of severe life-threatening extremity bleeding that cannot be controlled with direct pressure and pressure bandage applications, especially in limbs such as arms or legs, or in cases of limb amputation, tourniquet application should be considered. Similarly, if there is more than one patient and only one first aider at the scene, a tourniquet application may be necessary to save time and to attend to other injured people (Rodgers et al., 2024).

Since tourniquet application completely stops circulation, it should only be performed by experienced first aiders in necessary cases. Although it is an effective method of bleeding control, long-term and inappropriate applications can cause severe tissue damage and limb loss. Therefore, the tourniquet decision should be made carefully, and alternative methods (e.g., hemostatic pressure) should be tried first if possible (Charlton et al., 2020).

If the bleeding area is unsuitable for tourniquet application, bleeding control should be continued with direct pressure. In addition, if wound dressings have hemorrhage stopping properties in the area, direct pressure should be applied with these materials. Such special dressings can give effective results, mainly when used in areas where tourniquets cannot be applied, such as the abdomen, chest, and back (Charlton et al., 2020). Ready-made first aid tourniquets should be preferred in tourniquet application. However, if such a tool is unavailable, an improvised tourniquet should be prepared with the materials at hand. The material to be used for this purpose should be at least 5–10 cm wide, non-stretchable, and of a quality that will not cut the skin. Rope, wire or materials with cutting properties should not be used, because such materials can cause subcutaneous tissue damage and infection (Bedri et al., 2021).

To facilitate tightening and loosening of the tourniquet and to gradually restart blood flow, when necessary, hard materials such as a piece of wood or a pencil can be used at the point of the knot. A tourniquet should only be applied to areas with a single bone; for example, the arm and thigh suit this application. A tourniquet should not be applied to areas such as the forearm and lower leg, considering that hand and foot circulation may be impaired. However, a tourniquet can be applied to these areas with caution if there is a severed limb (Bedri et al., 2021; Schroll et al., 2022).

The tourniquet should be placed approximately 5–7 cm above the bleeding area and, if possible, not over a joint. It should be tightened until the bleeding stops and should not be tightened further after it stops. The applied tourniquet should never be covered and left open so that healthcare teams can easily see it. If the first aider has to transfer the patient to another person, he/she should verbally report that the tourniquet has been applied (Charlton et al., 2020; Lemeschewskij et al., 2023).

In cases of multiple injuries, the letter “Tourniquet” or “T” should be written on the forehead or on the person to whom the tourniquet is applied, thus accelerating the intervention of healthcare teams. In addition, the time of tourniquet application should be written and noted in a visible place, and the time of application should be clearly marked on the tourniquet. If an emergency call has not yet been made, 112 should be called immediately at this stage, or ensured that it is called. It is recommended that tourniquet application be kept under one hour, as durations longer than two hours significantly increase the risk of ischemia, tissue necrosis, nerve damage, and compartment syndrome. After tourniquet application, no intervention should be made to the tourniquet until the healthcare team arrives; it should not be loosened, opened, or readjusted (Charlton et al., 2018) (Figure 2.4-2) (Figure 2.4-3).

Figure 2.4-2. Tourniquet application

Figure 2.4-3. Fixing the tourniquet

Local Cold Application

Local cold application can also be considered an auxiliary method for controlling bleeding. This technique is especially effective in light tissue bleeding in superficial hematomas, ecchymoses, or scalp areas. However, caution should be exercised when applying cold, especially in pediatric patients, considering the risk of systemic hypothermia. Environmental conditions should also be considered in disaster environments, and body temperature should be maintained (Peng et al., 2020).

Application of Hemostatic Wound Dressings

Hemostatic wound dressings can be used in severe and life-threatening bleeding where standard direct pressure methods are inadequate or in anatomical areas where tourniquets cannot be applied (e.g., abdomen, back, chest). These materials should only be applied by trained and experienced first aiders This dressing application includes following steps (Raafat et al., 2024). When applying a hemostatic wound dressing, the entire wound surface, including profound tissue areas, should be covered entirely.

- If the first layer of the dressing is soaked with blood, a second layer should be placed on top of it without removing it.
- If the wound contains deep structures, a voluminous dressing should be added to the hemostatic dressing, and increasing pressure should control bleeding.
- If bleeding cannot be stopped, direct pressure, pressure bandage, and hemostatic dressings should be applied together.

Patient Information and Follow-up Practices

All applications (tourniquet, pressure bandage, wound dressing, etc.) should be clearly marked on the patient's body or written in a visible place. The patient should not be given food or drink. This may pose a risk of aspiration, especially if their level of consciousness has changed or if there is a risk of vomiting. The patient's state of consciousness, respiratory and circulatory findings (pulse, skin color, capillary refill) should be assessed regularly every 2–3 minutes (Xiao and Wu, 2022).

Shock Position Application

Individuals who are conscious, able to breathe normally, and show signs of shock should be laid on their back on a flat surface and given the shock position.

For the shock position (Orpet et al., 2024),

- The patient should be placed on their back on a flat surface.
- If there is no suspicion of traumatic injury or spinal damage, both legs should be raised approximately 30–60 degrees.
- For support, materials such as blankets, pillows, and rolled clothing should be placed under the raised legs.
- If the change in position causes pain, the legs should not be raised.
- The patient should be covered to maintain body temperature, and the risk of hypothermia should be reduced.

2.4.4. First Aid and Management of Internal Bleeding

Internal bleeding is a serious medical emergency that cannot be observed from the outside due to the preservation of skin integrity, but it can be life-threatening. Vascular damage to internal organs resulting from traumatic events, high-energy impacts, penetrating-cutting injuries, and some diseases can cause blood to leak into body cavities or tissue spaces (Tran et al., 2020). This condition can be noticed late due to the absence of external bleeding signs despite the blood leaving the vascular system. It can usually result in rapidly progressing hypovolemic shock. In disaster environments, such bleeding should be observed and recognized early, in the presence of limited time and healthcare personnel (Fatoni et al., 2022).

Some signs and symptoms may lead to suspicion of internal bleeding. These include bleeding from the mouth, nose, ear, genital area and anus; increased respiratory rate; coldness, paleness and moisture on the skin; tachycardia; restlessness and anxiety; abdominal or chest pain; swelling in these areas; changes in consciousness and excessive sleepiness (Bobko et al., 2020; Josse et al., 2020). In addition, "bleeding from natural openings" signs, such as bleeding from the nose and ears in skull injuries, coughing in chest bleeding, vomiting or defecation in digestive system bleeding, and blood in the urine in urinary tract bleeding, can also be observed. These signs are among the most important clues reflecting internal bleeding to the outside. It should not be forgotten that in some cases, the patient may have both internal and external bleeding simultaneously. Therefore, the bleeding type and general body responses should be evaluated correctly. Monitoring the signs of shock is of great importance in recognizing internal bleeding (Bobko et al., 2020; Josse et al., 2020).

First Aid Application Steps for Internal Bleeding

First aid for internal bleeding includes following steps (Charlton et al., 2020; Zideman et al., 2021).

- Before starting the intervention, it must be confirmed that the environment is safe. Intervention should not be made in unsafe situations before environmental risks are eliminated.
- The patient's consciousness should be checked, and if not already done, the 112-emergency helpline should be called or ensured.
- The patient should be laid on their back and kept in the most comfortable position possible. However, if there is a suspicion of spinal injury, they should not be moved.
- Airway patency, respiratory rate, quality, and circulation parameters should be assessed.
- The patient should not be moved as much as possible and should be kept stable.
- Direct pressure or a pressure bandage should be applied to the area if there is external bleeding simultaneously.
- It should be loosened to ensure proper circulation if the individual is wearing tight clothing. Wet garments or clothing that may contribute to heat loss should be carefully removed or incised along the seams, as appropriate, to prevent further reduction in body temperature.
- The patient should be placed flat on the right side to prevent secretions from entering the respiratory tract if bleeding from the mouth or vomiting.

- The patient should be supported in a sitting or semi-sitting position if a bloody cough and spinal injury are not suspected.
- The patient should be placed in the shock position if signs of shock are observed and there is no injury to the hips and legs.
- The patient should be covered to maintain body temperature, but excessive heating should not be applied.
- Immobilization (restraint) should be applied to the relevant area if internal bleeding originates from the arm or leg.
- The patient should not be given food or drink.
- The state of consciousness and vital signs should be rechecked every 2–3 minutes.
- The patient should not be left alone until the 112 emergency medical teams arrive, and should be kept under constant observation.
- Samples containing blood, such as vomit, sputum, or stool, should not be thrown away, but should be preserved to be delivered to the medical teams.

2.4.5. First Aid in Amputation

In disasters, amputations may occur due to high-energy traumas such as being buried under debris, explosions, and cutting-piercing traumas. This situation requires a two-way intervention process, as it both causes severe external bleeding and requires the amputated limb to be protected and delivered to a health institution. Early intervention in amputations is the key to the patient's life and saving the amputated limb. First aid for amputation includes following steps (Charlton et al., 2020; Lemeschewskij et al., 2023; Kumar et al., 2024; Djarv et al., 2025).

- Direct pressure or a bandage should be applied to the amputated area.
- If bleeding is severe and cannot be controlled with pressure, a tourniquet should be applied to the relevant limb.
- The amputated limb should never be washed or wetted with water or any other liquid.
- The piece should be wrapped in sterile gauze or a clean cloth if possible.
- The wrapped limb should be in a clean, waterproof, sealed plastic bag.
- After this bag is sealed, it should be placed in a second bag or bucket with one measure of water and two measures of ice in it. In this way, a transport that is protected in a cold environment without direct contact with ice is provided.
- The bag should be carried in the exact vehicle as the injured person, the injured person's name and surname should be written on it, and it should be delivered to the health institution within six hours at the latest.
- The 112-emergency helpline should be called or requested to be called.
- If the limb is not entirely severed, the tissues that are not severed should not be intervened in at all; the part should be brought to its natural position, wrapped with a dry (sterile if available) cloth, and an ice pack should be placed on it.

2.4.6. First Aid for Foreign Object Penetration

In disaster environments, foreign object penetration into the body due to debris, broken glass, metal pieces, or sharp-pointed objects is common. The most important priority in such injuries is not to touch the object and not to try to remove it, as this can both increase bleeding and cause irreversible damage to the tissues. First aid for foreign object penetration includes following steps (Wang et al., 2023).

- The penetrating object should never be removed or moved.
- The anatomical areas where the object passes should be carefully evaluated, and signs of nerve, vein, or organ injuries should be observed.
- In order to fix the object, a roll of bandage, gauze, or a clean cloth should be placed around it. This way, the object is fixed without further damaging the surrounding tissues (Figure 2.4-4).
- No direct pressure should be applied to the object; only the support material wrapped around the object should be fixed with a bandage or elastic bandage.
- If there are special bagel bandages, they should be preferred. Otherwise, a similar structure should be created with fabric materials shaped in a round shape.
- It should be ensured that the bandage applied does not entirely block blood circulation; symptoms such as skin color change, tingling, coldness, and numbness should be monitored.
- The 112-emergency helpline should be called or ensured to be called as soon as possible.

Figure 2.4-4. First aid for foreign object penetration

2.4.7. First Aid for Nose Bleeding

Although nose bleedings are frequently seen due to trauma in disasters, they can also occur in some individuals due to reasons such as existing hypertension, mucosal dryness, infection or medication use. Although not usually life-threatening, prolonged or severe nose bleedings can have serious consequences. First aid for nose bleeding includes following steps (Alzahrani et al., 2024).

- The patient should be calmed down and seated upright.
- If there is no suspicion of neck trauma, the head should be tilted slightly forward, thus preventing blood from being swallowed and entering the airway.
- Breathing through the mouth should be requested, and breathing through the nose should be prevented.

- The patient should be asked to squeeze the wings of the nose with their index finger and thumb and starting from the level of the nasal bone. If they cannot do this, this procedure should be performed by a first aider (Figure 2.4-5).
- The wings of the nose should be squeezed continuously for approximately 10–15 minutes, during which time the patient should refrain from talking, coughing, spitting, swallowing or sniffling as much as possible.
- If bleeding continues after 15 minutes or general symptoms such as dizziness develop, the 112-emergency helpline should be called.
- Emergency help should also be called if the patient is taking blood thinners, has bleeding disorders such as hemophilia, or if other head/face injuries accompany the trauma.

Figure 2.4-5. First aid for nose bleeding

2.4.8. First Aid for Ear Bleeding

Ear bleeding can occur due to reasons such as direct trauma, exposure to foreign objects or intracranial injuries. Bloody fluid coming out of the ear is of vital importance, especially in cases of skull base fractures. First aid for ear bleeding includes following steps (Mummidivarapu et al., 2023).

- The patient should be calmed down, and panic should be reduced.
- If bleeding is mild, the outer ear area should be wiped with a clean cloth, but the inside of the ear should not be cleaned.
- If severe bleeding occurs, clean gauze should cover the ear without blocking or applying pressure.
- The patient who is conscious should be laid on their back without being moved.
- People who are unconscious and have no suspicion of spinal injury should be placed on their side with the bleeding ear; thus, the blood should be drained out, and the risk of increased brain pressure should be reduced (Figure 2.4-6).
- The 112-emergency helpline should be called immediately, and if possible, medical support should be awaited without leaving the patient's observation.

Figure 2.4-6. First aid for ear bleeding

2.4.9. General Principles to Consider in Bleeding Patients

In disaster environments, when treating a bleeding patient, a comprehensive first aid approach should be implemented in terms of bleeding control and the individual's general safety, risk of infection, state of consciousness and development of shock. In disaster areas with limited resources and unfavorable environmental conditions, acting by these general principles directly affects the patient's chance of survival. General principles to be applied in first aid are below (Fatoni et al., 2022; Charlton et al., 2020).

- Contact with blood with bare hands should be avoided; gloves should be used or indirect contact should be provided with materials such as gauze and clean sheets.
- Protective equipment such as examination gloves, extra clothes and clean sheets should be used; otherwise, the risk of contamination should be reduced with improvised methods.
- If the patient is conscious and in good condition, direct pressure should be applied by the patient himself/herself.
- If direct contact with blood is unavoidable during the intervention, hands should be washed with soap and water before and after the procedure, and if possible, antiseptic should be applied.
- In serious and life-threatening external bleeding, direct pressure should be the first choice; external compression devices or pressure bandages should only be considered as supportive.
- In bleeding that can be controlled with direct pressure and pressure bandages, a tourniquet should not be applied, because tourniquets can cause severe tissue damage and limb loss when misused.
- Tourniquet application should only be considered in life-threatening bleeding in limbs, such as arms and legs, that cannot be stopped with other methods.
- The traditional approach that elevating the bleeding limb will control bleeding by reducing circulation has lost its validity today; therefore, limb elevation should not be recommended as a first aid practice.
- Absolutely nothing should be given to the patient by mouth. Giving fluids or food may create a risk of aspiration in individuals with altered consciousness; it may also lead to pre-anesthetic complications when emergency surgery is required.
- Materials contaminated with blood (vomit, feces, sputum, etc.) should not be thrown away, but should be preserved for delivery to healthcare professionals as an example.

2.5. Injuries

A wound is a pathological condition characterized by the disruption of the integrity of the skin or mucosal surfaces. While wounds may appear superficial, they often extend deeper to affect blood vessels, nerves, muscle tissues, and even internal organs. The skin, serving as both a physical barrier and a key component of the body's immunological defense, plays a vital role in protecting against external pathogens and maintaining physiological homeostasis. Therefore, when this barrier is compromised, it leads to increased vulnerability to infections, impaired regulation of body temperature and fluid balance, and delayed or complicated wound healing (Gopireddy et al., 2023).

These risks are significantly amplified in disaster environments, where hygiene conditions are poor, environmental contamination is high, and timely access to professional healthcare is often limited or delayed. In such settings, even minor wounds can rapidly become life-threatening due to infection or progression to more severe tissue damage. Proper identification and management of wounds at the first aid level become crucial to preventing further complications.

Wounds are generally classified into two main groups: open wounds (such as cuts, lacerations, punctures) and closed wounds (such as contusions or internal bleeding). This classification is not merely descriptive—it is essential in guiding the first aid approach. For example, open wounds may require bleeding control and protection from contamination, while closed wounds might demand cold application, immobilization, or urgent referral if internal bleeding is suspected (Kong et al., 2022).

In disaster preparedness and emergency response, training individuals to correctly recognize and manage different types of wounds is a vital skill that enhances survival chances, reduces the risk of infection, and supports the recovery process. Empowering communities with this knowledge strengthens public health resilience in the face of large-scale emergencies.

Open Wounds

Open wounds usually develop due to penetrating trauma and are situations in which the integrity of the skin or mucosa is disrupted. These wounds (e.g., incision wounds, stab wound, gunshot wound, bite wound, laceration, abrasion) carry a high risk of both bleeding and infection (Tawil et al., 2024).

Incision Wounds

They are linear and smooth-edged wounds usually caused by sharp objects such as knives, glass, or metal pieces. During home accidents and disasters, falling glass pieces and sharp materials can cause such injuries. They most often occur in exposed areas such as the hands, face and scalp. When subcutaneous vessels are damaged, wounds, especially in the facial area, can cause profuse bleeding. In deep incisions, nerve, muscle, tendon, and bone structures can also be damaged (Tawil et al., 2024).

Stab Wounds

These wounds, caused by sharp-tipped objects such as needles, nails, screwdrivers and knives, usually have small entry holes, but the risk of reaching deep tissues is high. Since they can lead to complications such as internal organ injury, nerve and vascular damage, especially those targeting the abdomen and chest area, can be life-threatening (Gopireddy et al., 2023).

Gunshot Wounds

Gunshots usually cause high-energy, stab wounds with entry and exit holes. Injury requires consideration of the bullet path and the damage caused by the kinetic energy it creates to the surrounding tissues. The risk of internal bleeding, organ perforation, and sepsis is high. It may occur in post-disaster security incidents (e.g., internal conflicts, looting, etc.) (Feliciano, 2020).

Bite Wounds

Animal or human bites are frequently seen in children. As a result of the injury, mechanical damage occurs, and microorganisms belonging to the oral flora pass directly into the tissue. This accelerates the development of infection. Cat bites, in particular, are deeper and more prone to infection. Tetanus and rabies prophylaxis should not be ignored in such injuries (Descamps et al., 2021).

Laceration (Rupture)

They are tissue splits with irregular, jagged edges that result from blunt trauma. The wound usually has non-living tissue (devitalized tissue), increasing the risk of infection. They are especially associated with traumas such as punches, sticks, and falls, and are frequently seen in individuals trapped under debris after a disaster. Lacerations on the face and scalp may bleed excessively due to intense vascularization (Gopireddy et al., 2023).

Abrasion (Scraping)

A superficial wound type characterized by epidermis peeling off from the surface. It is frequently seen in the knee, elbow, wrist and leg areas. It is more common and painful, especially in children. It becomes vulnerable to infection because it is in direct contact with the external environment (Perwira et al., 2024).

Closed Wounds

Closed wounds are types of injuries that cannot be seen from the outside, but in which the internal tissues are exposed to trauma. Since the skin integrity is preserved, it can be recognized late (Fernandez and Smith, 2023).

Contusion (Crush - Bruise)

It occurs when small vessels under the skin are damaged due to tissue trauma. A change in skin color (first red, then purple-blue, then green and yellow) is observed. Widespread contusions can cause pain and swelling. It can develop due to compression, falling and hitting hard surfaces in disasters (Dimitriou, 2021).

Crush Injuries

A type of injury frequently encountered in disasters, especially in situations such as being under debris. In tissues exposed to prolonged compression by a large force, intense bleeding and edema occur between the muscle planes. This condition causes severe circulatory disorders called compartment syndrome. This condition, which carries the risk of muscle ischemia, nerve damage, and infection, may require fasciotomy, which is a surgical emergency. In crush injuries in the chest area, ruptures or contusions may occur in vital organs such as the lungs, heart, liver, and spleen (Dimitriou, 2021).

2.5.1. Chest Injuries in Disasters

Disasters such as earthquakes, explosions, and building collapses often result in high-energy blunt or penetrating trauma to the thoracic region. The chest houses vital organs including the lungs, heart, and major vessels, making thoracic injuries a leading cause of mortality in multi-trauma patients, particularly in resource-constrained disaster settings. Both the structural integrity of the thoracic cage and the negative pressure system necessary for ventilation can be disrupted, resulting in respiratory compromise and rapid physiological deterioration (Griffard and Kodadek, 2023; Özyurt and Zirek, 2024). Chest injuries may be classified as blunt (closed) or penetrating (open). Blunt trauma typically occurs in crush injuries (e.g., being trapped under debris), while penetrating trauma results from sharp objects such as rebar, glass, or projectiles. Regardless of the type, the physiological consequences are often severe (Shevchenko et al., 2023).

- Rib fractures may impair respiratory mechanics and lead to splinting of breath due to pain.
- Hemothorax (accumulation of blood in the pleural space) and pneumothorax (accumulation of air) may both impair lung expansion.
- Tension pneumothorax, a rapidly fatal condition, occurs when air accumulates under pressure, shifting mediastinal structures and compromising venous return.
- Cardiac tamponade due to penetrating trauma may result in obstructive shock.
- In disaster scenarios, such injuries are often compounded by delayed evacuation and limited medical resources, increasing the risk of mortality.

Common signs and symptoms of chest trauma include below (Shevchenko et al., 2023).

- Respiratory distress (dyspnea, tachypnea)
- Chest pain, especially during inspiration
- Cyanosis or hypoxia
- Subcutaneous emphysema (crepitus)
- Diminished breath sounds on auscultation
- Visible wounds, protruding objects, or paradoxical chest wall motion
- Hemoptysis (blood in sputum)
- Signs of shock including tachycardia, hypotension, altered mental status
- In penetrating trauma, "sucking chest wounds" may be observed, where air is heard moving through the open wound during inspiration and expiration.

First Aid for Chest Injuries

In disaster settings with multiple casualties, where professional medical intervention is limited, early recognition and appropriate first aid measures are essential for reducing mortality. First responders and trained laypersons should follow a structured and evidence-based approach to the initial management of thoracic injuries in disaster zones (Zideman et al., 2021). The following first aid principles apply to both open and closed chest injuries (Steenhoff et al., 2019;

Zideman et al., 2021).

- Scene safety must be established before approaching any victim. Hazards such as debris, structural instability, fire, or toxic gas exposure must be eliminated or mitigated. Once safety is ensured, the patient's level of consciousness and respiratory function should be assessed immediately. If the patient is conscious, they should be reassured to reduce anxiety-induced respiratory distress.
- Emergency medical services should be activated without delay—ideally through a bystander if the first aider is alone. In the context of a disaster where formal EMS response may be delayed, the patient's vital signs (e.g., airway patency, breathing rate, pulse quality, skin color) must be monitored continuously.
- Positioning plays a critical role in minimizing physiological compromise. If tolerated and if spinal trauma is not suspected, the patient should be supported in a semi-upright (semi-fowler's) position and encouraged to lean toward the injured side. This facilitates more effective ventilation by reducing paradoxical chest wall movement and optimizing lung expansion on the healthy side. If the patient loses consciousness but continues to breathe spontaneously, the recovery position should be implemented, preferably with the injured side down to preserve oxygenation and drainage from the affected lung.
- In the event of respiratory arrest, BLS should be initiated without hesitation, following the ERC guidelines. Immediate initiation of high-quality chest compressions and rescue breathing (if trained and able) can be life-saving, particularly in hypoxia-induced cardiac arrest resulting from thoracic injury.

First Aid for Open (Penetrating) Chest Injuries

Penetrating chest injuries are commonly seen in disasters involving shrapnel, projectiles or structural fragments. These injuries often create an open communication between the atmosphere and the pleural space, leading to a "sucking chest wound" or open pneumothorax, where ambient air enters the chest cavity and impairs lung expansion (Shevchenko et al., 2023; Noor and Baseer, 2025). Initial management of these injuries requires precision and caution. First, the responder must secure the environment and approach the patient calmly. Visual inspection should be conducted to identify signs of impaled objects or open chest wounds. If an object is embedded in the chest wall, it must not be removed, as this could exacerbate bleeding or provoke further collapse of the lung. Instead, the object should be stabilized in place using bulky dressings such as rolled gauze or clean cloth (Krammel et al., 2023).

If there is visible bleeding, direct pressure should be applied around the wound, avoiding pressure on the object itself. An open chest wound should be left exposed to the external environment. The wound should not be dressed or covered. If necessary, local bleeding should be controlled by applying direct pressure. If a first aider is trained and the equipment is available, a special, non-occlusive or ventilated dressing should be applied, allowing air to flow freely during exhalation. Obstruction of airflow due to the wound, bleeding, or clotted blood should be checked (Djarv et al., 2025).

One of the critical complications following sealing of an open chest wound is the development of a tension pneumothorax, which occurs when air continues to accumulate in the pleural space without escape. This may manifest as increasing respiratory distress, cyanosis, distended neck veins, and hypotension. If such signs occur after application of a seal, the dressing should be immediately loosened or removed to allow trapped air to escape (Cakmak et al., 2022).

Throughout all interventions, the patient should be supported in a semi-upright position to ease breathing. If oxygen is available (e.g., in organized disaster relief zones or ambulance support), it should be administered continuously. The patient must be protected from environmental exposure by being covered with a thermal blanket to prevent hypothermia, especially in open-air disaster sites (Millán et al., 2021). Regular reassessment of airway, breathing, and circulation is mandatory until professional medical help arrives. Early identification and stabilization of thoracic injuries in disaster settings significantly improve the chances of survival and reduce the risk of irreversible complications.

2.5.2. Abdominal Injuries in Disasters

In disaster scenarios such as earthquakes, explosions, building collapses, vehicular accidents, or armed conflict, abdominal trauma represents a critical injury pattern due to its potential to cause concealed, life-threatening internal bleeding and multisystem damage. The abdomen houses multiple vital organs, including components of the gastrointestinal, genitourinary and vascular systems, all of which are vulnerable to both blunt and penetrating forces (Sajadi-Ernazarova et al., 2019). As professional medical access may be significantly delayed during mass-casualty incidents, early recognition and stabilization at the scene are essential to reducing morbidity and mortality (Lyng et al., 2024).

Abdominal injuries are primarily categorized into blunt (closed) and penetrating (open) traumas, both of which may lead to organ rupture, hemorrhage, peritonitis or shock. Even in the absence of visible bleeding, these injuries can result in rapid clinical deterioration due to intra-abdominal hemorrhage or hollow organ perforation. Therefore, responders operating in disaster zones must be trained to identify subtle signs, avoid exacerbating internal damage and prioritize rapid transport (Sajadi-Ernazarova et al., 2019).

Blunt Abdominal Trauma

Blunt abdominal trauma is frequently caused by mechanisms such as crush injuries (e.g., being trapped under debris), high-impact falls, vehicular collisions or pressure waves from explosions. The resulting injuries often affect solid organs such as the liver, spleen and kidneys, and may lead to massive intra-abdominal hemorrhage (Choi et al., 2022).

When subjected to blunt force, abdominal organs may rupture, shear at fixed points, or hemorrhage into the peritoneal cavity. The lack of external wounds can delay diagnosis, making clinical vigilance critical. The accumulation of blood in the abdominal cavity (hemoperitoneum) can compress vital structures, cause diaphragmatic elevation (impairing breathing), and ultimately lead to hypovolemic shock (Partama and Sueta, 2019).

Common clinical signs and symptoms include below (Partama and Sueta, 2019; Harjanti et al., 2023).

- Generalized or localized abdominal pain and tenderness
- Bruising, ecchymosis, or abrasions on the abdominal wall
- Abdominal distension or rigidity (“board-like abdomen”)
- Nausea, vomiting or loss of appetite
- Pale, cold and clammy skin (sign of shock)
- Tachycardia and hypotension
- Dizziness, anxiety, confusion or loss of consciousness

First Aid Principles for Blunt Abdominal Injuries

Blunt abdominal injuries include following first aid principles (Tsai et al., 2023)

- Scene safety should be ensured before approaching the victim.
- The patient’s level of consciousness and airway, breathing, and circulation (ABC) should be rapidly assessed.
- Emergency services (e.g., 112) must be activated as early as possible.
- The patient should be laid supine on a firm surface, and movement should be minimized.
- Clothing should be loosened, but the abdomen should not be palpated forcefully or compressed.
- No oral intake should be allowed, even water, as surgery may be required.
- The patient must be covered with a blanket to prevent hypothermia but should not be overheated.
- If signs of shock are present and there is no contraindication (e.g., lower limb trauma), the legs may be elevated to enhance circulation (shock position).
- If the patient becomes unresponsive but continues breathing, the recovery position should be used with the injured side down.
- In the event of respiratory arrest, BLS must be initiated promptly.

Penetrating Abdominal Trauma

Penetrating abdominal trauma occurs due to sharp objects (e.g., knives, shrapnel, glass), gunshot wounds or impalement. These injuries often involve direct damage to organs and blood vessels, with a high risk of contamination, infection and hemorrhagic shock.

Penetrating objects may perforate multiple abdominal structures, including the bowel (causing peritonitis), major vessels (causing hemorrhage) or solid organs. In cases where internal organs eviscerate (protrude outside the body), exposure to air, bacteria, and further trauma compounds the injury severity (Partama and Sueta, 2019; Choi et al., 2022).

Common clinical signs and symptoms include below (Abdallah et al., 2024).:

- Visible penetrating wound
- Pain, rigidity or swelling in the abdomen
- Bleeding (internal and/or external)
- Nausea, vomiting or vomiting of blood
- Protruding abdominal contents (evisceration)

- Gunshot or stab wound with possible exit wound
- Symptoms of hemorrhagic shock (as above)

First Aid Principles for Penetrating Abdominal Injuries

Penetrating abdominal injuries include following first aid principles (Obadiel et al., 2024).

- Ensure the scene is safe before initiating care.
- Activate emergency medical services immediately.
- Conduct rapid assessment of airway, breathing, and circulation.
- Lay the patient flat, limiting movement.
- If evisceration is present, do not attempt to push organs back in. Instead, cover them with a moist, sterile dressing (or clean cloth dampened with sterile saline) and then cover with a plastic wrap or foil to retain moisture and reduce contamination.
- For bleeding wounds, apply gentle direct pressure around the wound. If a foreign object is embedded, do not remove it; instead, stabilize it in place with bulky dressings (e.g., rolled gauze or simit bandage).
- Monitor for signs of deteriorating consciousness, increased abdominal distension or cyanosis.
- Do not allow oral intake, even water.
- Maintain patient warmth with a blanket.
- If signs of respiratory arrest appear, initiate BLS as per ERC guidelines.
- Reassess ABCs every 2–3 minutes until the patient is transferred to advanced care.

2.5.3. Head and Spine Injuries in Disasters

Head and spine injuries are serious traumatic conditions and are usually considered under the same heading. These injuries are frequently encountered in disaster scenarios such as earthquakes, building collapses, explosions, traffic accidents and fires and can result in life-threatening conditions (Abdul-Jabbar et al., 2019). Since all two areas are related to vital organs, delay or incorrect application of first aid can have irreversible consequences. Therefore, first aiders and the public working in disaster environments should be aware of recognizing and managing such injuries (Eng and Makovitch, 2019).

Signs and symptoms vary depending on each area. However, even injuries that generally appear minor can worsen over time and cause secondary complications, especially in disaster areas where access to health services is limited. Therefore, if there is even suspicion of head-neck-spine injuries, the person should not be moved, and their vital signs should be monitored until medical help arrives (Abdul-Jabbar et al., 2019).

Head Injuries

Head injuries include the scalp, skull and facial areas. Especially in disaster environments, traumas to the head region due to reasons such as falling, objects falling on them, hitting them, or being trapped under debris can cause serious injuries to both the brain and neck vertebrae. Therefore, the possibility of neck and spine injuries should also be considered in every individual with a head trauma (Kulnik et al., 2019).

Scalp: The scalp, located on the surface of the skull, is important in traumas due to some anatomical features. The scalp can easily shift on the surface of the skull and can easily separate as a result of trauma. In addition, due to its dense vascular structure, even a minor injury can cause serious bleeding and even shock. In disaster areas, interventions to control bleeding (direct pressure, bandage) should be performed quickly (Nurhidayah et al., 2025).

Skull: Skull injuries usually result in fractures. However, the most important result of trauma is not skull fracture, but damage to the brain tissue. Therefore, every patient with a head trauma should be evaluated for brain damage. It should not be forgotten that individuals removed from debris in disasters may have latent head trauma even if there are no visible symptoms (Fatimah and Heriani, 2019).

Face: Facial injuries, especially in the mouth and nose areas, can cause airway obstruction. Permanent impairments in sensory functions such as vision, hearing, and speech can also occur. People with facial injuries in disaster settings should be evaluated first for airway patency and bleeding (Halter et al., 2019).

Signs and Symptoms of Head Injuries (Kc et al., 2024):

- Scalp or facial injuries, swelling, and bleeding
- Headache and dizziness
- Altered consciousness (drowsiness, confusion, loss of consciousness)
- Impaired perception of space and time
- Memory loss
- Nausea and vomiting
- Bleeding from the nose or ear (especially if accompanied by cerebrospinal fluid leakage, an indicator of serious trauma)
- Deformity or tenderness in the skull
- Bruising behind the ear and around the eyes (e.g. battle sign and raccoon eye)
- Inequal pupils
- Coma

First Aid for Head Injuries

First aid interventions to be applied in head injuries should be performed carefully and systematically. Especially in individuals who have suffered head trauma in disaster environments, all applications should be performed without disrupting the alignment of the head, neck and spine, as spinal injuries may accompany them. Therefore, a passive approach should be adopted during interventions and unnecessary movements should not be applied to the patient (Thapa et al., 2024).

- The state of consciousness should be assessed; if the person is unconscious and still breathing, the person should be placed in the recovery position without disrupting the head-neck-spine line.
- The emergency service (112) should be called, or it should be ensured that it is called by people around.

- Vital signs should be monitored at regular intervals.
- The airway should be open. During this time, direct pressure should not be applied if there is a suspicion of fracture in the facial bones.
- The person should be laid on their back and the head and shoulders should be slightly elevated if there is no suspicion of spinal injury.
- Maintaining the head-neck-spine alignment, and the vomit should be prevented from entering the airway if the injured person is vomiting, the person should be carefully turned to the side position.
- The head and neck should be supported and the alignment maintained, and the person should be turned to the side position if the person is unconscious and breathing.
- Direct pressure should be applied to the bleeding area if there is external bleeding.
- In cases of bleeding from the scalp, direct pressure should be applied, but excessive pressure should be avoided due to the suspicion of a possible skull fracture.
- In cases of bleeding or fluid coming from the ear, a sterile or clean cloth should be gently placed over the ear and, if possible, the injured person should be turned towards the side of the fluid coming from.

First Aid for Spine Injuries

The spine (spinal column) is a structure consisting of 33 vertebrae extending from the base of the skull to the coccyx. Each vertebra protects the spinal cord by surrounding it. Spinal traumas are significant because they can affect the skeletal system and the spinal cord, a part of the central nervous system. Such injuries are frequently seen during disasters, especially in building collapses, falls from heights, explosions and crushes (Xue et al., 2017).

The damage that occurs in spinal trauma is evaluated in two stages. In the first stage, a fracture or dislocation develops in the spine as a result of the traumatic event, and the spinal cord is directly compressed or damaged. In the second stage, bleeding, edema and inflammatory response that develop in the process after the event cause additional damage to the spinal cord (Thapa et al., 2024). This condition is defined as secondary spinal cord damage, and even initially mild neurological deficits can turn into permanent paralysis over time. For this reason, appropriate first aid interventions in the early stages of spinal injuries directly affect the patient's prognosis (Saputro et al., 2024).

Spinal injuries can be seen in different parts of the body:

Cervical spine (neck): This is the most frequently injured area. The weak anatomical structure of the neck makes this area particularly vulnerable. In every traumatized patient, the possibility of cervical injury should be considered in all injuries at the head-neck level (Alghamdi et al., 2024).

Thoracic spine (back): It is relatively less affected because the ribs protect it; however, in severe traumas, fractures and spinal cord damage may occur in this area (Spota et al., 2023).

Lumbar spine (waist): It is frequently affected in vertical traumas such as falling from a height. It is also the region where the nerves going to the legs originate so that it may be associated with lower extremity paralysis (Saputro et al., 2024).

In disaster conditions, the risk of spinal injury is high, especially for injured people trapped under debris. Therefore, every unconscious or consciousness-altered disaster victim should be treated as if they have spinal damage (Cuthbertson and Weinstein, 2020; Saputro et al., 2024).

Intervention Priorities in Spinal Injuries

In a case where spinal trauma is suspected, the intervention priorities are as follows (Tawakul et al., 2024).

- Emergency medical assistance should be sought (e.g. 112 should be called).
- Airway, breathing and circulation should be controlled.
- Spine immobilization should be provided, and spinal alignment should be maintained.

These three basic steps are the basis for preventing secondary damage until professional health assistance arrives, especially in disaster areas.

First aid to the Conscious Victim

In disaster environments, individuals who are conscious and suspected of spinal trauma should be verbally informed to remain immobile. If the person is awake and alert, neck movement should be minimized and the person should be encouraged to maintain a comfortable, stable neck position. An uncooperative person should never be forced into any position, as this can exacerbate the injury (Djarv et al., 2025). If the individual is uncooperative, physical restraint should not be applied. Patients with severe spinal pain usually develop protective muscle spasms, which naturally immobilize the spine (Azharuddin, 2020).

If the casualty can remain in place and the environment is safe, they should be immobilized in their current position. However, if mandatory evacuation is required due to dangerous situations (fire, flood, risk of collapse, etc.), they should be moved carefully to minimize spinal movement. Such evacuations should be performed by individuals trained in spinal stabilization, if possible, and with the help of appropriate equipment (Saputro et al., 2024).

First aid to the Unconscious Victim

In an unconscious patient, the priority is always to keep the airway open. Even if there is a suspicion of spinal injury, it is an acceptable practice to slightly bring the head to a neutral position to ensure airway patency (Eli et al., 2021). Additionally, for unresponsive individuals lying supine, kneel behind their head and immobilize their head and neck using a head or trapezius compression technique. The need to open the person's airway is assessed using a "chin thrust" technique. If the person is unresponsive and lying prone, the airway is checked for patency and the neck is held in a stable position. If airway opening is necessary, seek assistance from others. Carefully place them on their back, keeping their neck aligned with their body and as still as possible. Then, the head or trapezius muscles are compressed. First aiders with specialized training (e.g., ski patrol, lifeguard) may consider selective use of spinal motion restriction using existing protocols (Djarv et al., 2025).

2.5.4. Fracture Injuries in Disasters

A fracture is the disruption of the integrity of bone tissue as a result of a traumatic effect. The structural strength of the bone depends on internal factors such as the density and flexibility of the bone, as well as the magnitude and direction of the external force it is exposed to. In the event of a sudden trauma, the bone becomes unable to carry the load on it and breaks. This situation may also be related to the accumulation of microtraumas that usually occur in the bone tissue. During a fracture, not only the bone but also the surrounding vessels, nerves, muscles and ligaments may be damaged. Bleeding at the fracture site may lead to hematoma development, and nerve injuries may lead to loss of sensory and motor functions (Kulakoğlu et al., 2023).

Since high-energy blunt traumas are common in disasters (such as earthquakes, building collapses, explosions, avalanches), fractures may be seen in more than one region. In such cases, fractures are mostly in the form of crushing and may be complicated in a way that disrupts circulation (Telefon et al., 2024).

Fracture Types

Closed (Simple) Fracture: Skin integrity is not disrupted. The fracture is limited only to the bone tissue (Munjal et al., 2023).

Open (Compound) Fracture: The fracture ends are exposed to the external environment by piercing the skin. It requires urgent and special intervention as the risk of infection is high (Chan et al., 2020).

Complete Fracture: Bone integrity is completely disrupted (Lv et al., 2022).

Incomplete (Green Branch) Fracture: It is usually seen in children. The bone bends but does not break completely (Rai et al., 2023).

Multiple Fracture: There is more than one fracture line in more than one bone or in the same bone (Asan et al., 2023).

Crush Fracture: It occurs due to the crushing of the bone and surrounding tissues with great force; it is frequently seen in disasters (Pazarci et al., 2024).

Fracture Signs and Symptoms (Nam et al., 2023)

- Severe pain
- Pain that increases with movement
- Swelling and bruising (ecchymosis)
- Deformity
- Abnormal movement or crepitation (crackling sound) at the fracture site
- Shortening of limb length or rotational deformity
- External exposure of bone ends in open fractures
- Limited movement or loss of function
- Loss of sensation or weakness due to nerve damage

First Aid for Fractures

The fact that many individuals are exposed to trauma in disaster conditions makes the prioritization and rapid decision-making skills of first aiders even more critical. Since fractures can often be seen together with other soft tissue, vascular, nerve or internal organ damage, the possibility of multiple injuries should always be considered. First aid interventions to be applied correctly under limited resources and time pressure in a disaster environment play a fundamental role in preventing fracture complications and sequelae. First aid practices should include the following steps (Xiong et al., 2023) (Figure 2.5-1):

- Security of the scene must be ensured. This step aims to protect not only the injured person but also the first aider and other individuals in the vicinity. In cases where safety cannot be ensured, intervention should be delayed, and professional help should be sought.
- Emergency Health Services (112) should be contacted. If there is only one first aider, a voice calls for help should be made; if there is someone else in the vicinity, the emergency help line should be called, and it should be ensured that the call is made.
- Hygienic conditions should be provided. Hands should be cleaned with soap and water if appropriate; if not, with alcohol-based disinfectants; and gloves should be worn for personal protection. If gloves are not available, alternative protective devices such as clean plastic bags should be preferred.
- The injured person should be reassured and calmed down. This both increases psychological stability and reduces panic behaviors.
- The area suspected of being fractured should not be moved. However, if transportation is necessary due to another life-threatening condition, movement should be kept to a minimum and, if possible, help should be sought from the environment.
- The position of the injured person should be supported. If the injured person can support the fractured area themselves, this should be encouraged; if not, manual support should be provided to include the upper and lower adjacent joints, and the area should be immobilized with a suitable splint or bandage.
- Peripheral circulation should be evaluated after the splint is applied. Signs of circulatory disorders (coldness, paleness, tingling, pulselessness) should be monitored.
- The injured person should be observed regularly until the healthcare team arrives. Respiration, consciousness and extremity circulation should be checked at intervals.
- The casualty should not be given water or food. This intervention should never be performed due to possible surgical need, change in consciousness or risk of aspiration.
- Hemorrhagic control should be provided with direct pressure or pressure bandaging if there is serious accompanying bleeding.
- Airway security should be ensured with appropriate positioning and the patient should be placed in the recovery position if the casualty is unconscious but breathing.
- If breathing stops, BLS should be started without delay. During this process, head-neck-spine integrity should be protected, and spinal immobilization principles should be observed.

Figure 2.5-1. First aid for fractures

2.5.5. Burn Injuries in Disasters

Burns are traumatic injuries resulting from thermal (heat), chemical, electrical, or radiation exposure that damages the skin and, in many cases, deeper tissues. These injuries are not only painful and debilitating but also potentially life-threatening, especially when left untreated or inadequately managed. Burn cases are frequently encountered in disaster scenarios—particularly following events such as fires, explosions, chemical spills, or electrical malfunctions. In such chaotic environments, burn injuries often occur alongside other traumas and tend to affect multiple individuals simultaneously, placing an enormous burden on emergency response systems (Gete et al., 2022).

Beyond causing local tissue destruction, burns can trigger serious systemic complications. Large-area or deep burns can disrupt the body's fluid balance, immune response, and thermal regulation. As a result, victims are at high risk for dehydration, infection, hypothermia, respiratory distress, and hypovolemic shock. These complications can rapidly become fatal if not recognized and managed appropriately. The skin, which serves as a protective barrier, loses its integrity in burn injuries, making the body vulnerable to microbial invasion and fluid loss—two of the most common causes of post-burn mortality.

In disaster settings, where time is limited, medical help may be delayed, and environmental conditions are unfavorable, it becomes critically important for first aid providers to recognize the severity of burn injuries and act swiftly. Proper initial response—such as removing the victim from the source, cooling the burn, covering the wound with a clean cloth, and preventing hypothermia—can dramatically influence the patient's prognosis. In severe burns, early intervention aimed at minimizing shock, preserving airway function, and preventing infection can make the difference between survival and death (Al-Mutairi et al., 2023).

Therefore, educating both disaster responders and the public on burn first aid, along with ensuring access to basic burn care supplies in emergency kits, should be considered a priority in disaster preparedness and community health resilience efforts.

Classification of Burns

Burns are classified according to various criteria (Haghighi et al., 2024):

Types of burns according to the cause

Thermal burns: Occur due to contact with flames, hot objects, steam or boiling liquids. It is the most common type of burn encountered in disasters.

Chemical burns: Occur from exposure to corrosive substances such as acids or bases. Chemical leaks and laboratory accidents in industrial areas can cause such burns.

Electrical burns: High voltage electric current damages the tissue as it passes through the body. Although there is minimal damage in appearance, it can cause severe damage to internal tissues.

Radiation burns: Develop after sunburns or radiation accidents. Although rare, it can occur in nuclear disasters.

Degrees of burns according to depth

First degree burns: Affect only the epidermis. Redness, pain, and mild edema are seen on the skin. It usually heals spontaneously.

Second degree burns: Affects the epidermis and dermis. Severe pain, redness, edema and blister formation are present. It is divided into two subgroups including superficial and deep.

Third degree burns: All skin layers are affected. The skin has a white, leathery appearance. The sensation of pain may be reduced because the nerve endings are damaged.

Fourth degree burns: These severe burns have progressed to the skin, muscle and bone tissue. They can usually result in loss of limbs.

First Aid Interventions for Thermal Burns

Thermal burns, which are frequently encountered in disaster situations, occur due to contact with hot surfaces, flames, steam or boiling liquids. Early and appropriate first aid can limit the spread of damage to tissues, reduce the risk of complications, and contribute positively to the healing process.

The interventions that should be implemented in this direction are listed below (Atique et al., 2023):

- The security of the scene must be ensured. Before starting the intervention, it must be ensured that the scene is safe for the injured individual and the person who will perform the intervention. Secondary risks such as fire, gas leakage or electrical hazards caused by the disaster must be eliminated.
- The cause of the burn must be eliminated. If the burn is caused by an ongoing heat source (e.g., flame, hot liquid, electric current), continued contact with this factor must be prevented. Additional safety measures, such as turning off fuses, must be taken without delay in electrical burns. Flaming clothing must be extinguished. Panic must be prevented in a burning individual. The person should be prevented from running and should be rolled on the ground or covered with a blanket to prevent oxygen contact with the flame.
- If necessary, the person should be evacuated to a safe area. In environments where there

is a risk of fire or collapse, the casualty should be transported to a safe area with appropriate transportation techniques.

- Vital signs should be assessed. Respiratory functions, airway patency, and circulation status should be reviewed quickly. In closed-area fires, in particular, the risk of inhalation burns should be considered, and respiratory distress should be assessed.
- The burned area should be cooled. The burned area should be kept under cold (but not ice-cold) water for 20 minutes. If the burning surface is vast and this application may cause hypothermia, a clean, cold, water-soaked gauze or towel should be laid on the burned area, and local cooling should be applied for 15–30 minutes.
- The casualty should be covered to prevent heat loss. Especially in disaster conditions, if the ambient temperature is low or intervention is being performed in an open area, the casualty should be covered with a blanket to maintain body temperature. If the burn surface is more than 10%, this is even more important in order to avoid hypothermia.
- The clothes on the burnt area should be removed in a controlled manner. After the cooling process is completed, the clothes should be removed by cutting them from the seams; fabrics that are stuck to the burnt area should be cut around them without tearing them off and released.
- Foreign substances and contamination should be removed. Burnt areas contaminated with substances such as tar, soil, and asphalt should be carefully cleaned with only soap and water, and abrasive substances should not be used.
- The burnt surface should be covered with sterile material. After removing the clothes, if possible, the burnt surface should be covered with a lint-free, sterile, and dry material (e.g., sterile gauze, stretch film). This both reduces the risk of infection and creates a barrier against external contact.
- Jewelry and tight accessories should be removed. Considering the possible development of edema, objects that may impede circulation, such as rings, bracelets, and watches, should be removed.
- Extremities at risk of swelling should be elevated. In burns, especially on the arms and legs, it is recommended to keep these areas above the level of the heart to control edema. This practice should be continued for 24–48 hours.
- Necrotic (dead) tissues should be cleaned. Dead tissues formed on the surface should be cleaned under sterile conditions as they may increase the risk of infection. However, this procedure may require professional intervention.
- Accompanying injuries should not be ignored. Combined injuries are usually seen in disasters. It should not be forgotten that conditions such as fractures, trauma, and inhalation injuries may also accompany burns.
- The call for emergency help should not be neglected. While all these interventions are being carried out, the 112-emergency helpline should be reached simultaneously, and professional health support should be requested without delay.

Points to be noted (Atique et al., 2023):

- Water-filled blisters should not be burst.
- Substances such as toothpaste, yogurt, ice, powder, and ointment should not be applied to the burn surface.
- Bandages or gauze should not be applied to the burn areas. If an application must be made, non-adhesive wound dressings that will not disrupt blood circulation should be used.

Chemical Burns

Chemical burns are severe tissue damage from contact with household cleaning products or various laboratory substances, especially in industrial environments. The areas where burns are most frequently observed include the skin, eyes, hands, arms, and legs. Acidic (e.g., sulfuric acid, hydrochloric acid) or basic (e.g., sodium hydroxide, potassium hydroxide) substances can rapidly progress in the tissue they contact, causing necrosis (Masoumi et al., 2021; Kim et al., 2022).

Unlike thermal burns, damage in chemical burns continues for as long as the chemical remains in the tissue. Therefore, tissue damage deepens when the chemical is removed from the environment. In addition, additional complications such as systemic toxicity and vision loss may develop if chemical vapors are inhaled or come into contact with the eyes. The risk of exposure increases even more after hazardous substances are spilled in disaster areas or explosions (Kim et al., 2022).

Clinical Symptoms and Signs in Chemical Burns

The following clinical symptoms and signs may be observed in the area in contact with the chemical substance (Shen et al., 2024).

- Severe stinging pain (starts at the moment of first contact and increases over time)
- Skin irritation, redness or pale color change
- Edema and blister formation
- Skin peeling and moist-wet appearance
- Local or systemic poisoning symptoms due to exposure
- Difficulty in breathing, nausea, dizziness (in case of chemical vapor inhalation)
- Pain, blurred vision, or complete loss of vision upon eye contact

First Aid Interventions in Chemical Burns

When applied correctly, early intervention plays a critical role in limiting tissue damage and accelerating the healing process. The following first aid steps should be followed carefully (Levine et al., 2024):

- The safety of the scene should be ensured as a priority. If there is a chemical leak or vapor, entry to the scene should be controlled, and the respiratory tract and eyes should be protected. The person performing the intervention should use personal protective equipment (PPE); if this is not possible, temporary protectors such as clean plastic bags should be preferred instead of gloves.

- Direct contact with the chemical substance should be prevented. Gloves should be worn, and the chemical should not be touched with clothing or bare hands.
- The 112-emergency helpline should be notified without delay. Professional support should be requested in cases such as a large surface area of the burn, a change in consciousness, or respiratory distress.
- The chemical substance should be removed:
    - If the chemical substance is in powder form, the dry chemical substance should first be brushed away, and then the area in contact should be washed with low-pressure running water for 10–15 minutes.
    - In case of contact with liquid chemicals, the skin should be held under running water for 15–30 minutes.
    - Since alkali substances (e.g., sodium hydroxide) cause deeper tissue damage, the washing time should be extended.
    - After contact with hydrochloric acid (hydroxide), the affected area should be washed with water for 15–20 minutes and then kept in ice water for a short time.
    - In cement burns, the clothes and shoes that have touched the skin should be removed, the skin should be washed with plenty of water, and, if necessary, antibiotic ointment should be applied.
    - In case of contact with sulfuric acid and similar substances, prolonged washing with plenty of water is also recommended.
- Clothing and jewelry exposed to the chemical should be removed. This process should be done carefully; if the clothing sticks to the affected area, it should be cut around it without tearing it off.
- The contact area should be loosely covered with sterile material. Stretch film or clean lint-free cloth can be used. This both reduces the risk of infection and protects the injured person from external effects.
- The washing process should be repeated if the injured person develops a second burning sensation. If pain and burning continue despite the first intervention, the washing should be repeated for 3–5 minutes.
- If there is loss of consciousness but breathing continues:
    - The injured person should be placed in the recovery position if there is no suspicion of spinal injury.
    - Respiration and consciousness should be continuously monitored.
    - If breathing stops, intervention should be started with the BLS protocol.

Electrical Burns

Electrical burns are tissue damage caused by contact with electrical energy, ranging from low-voltage household currents to high-voltage industrial sources and lightning strikes. Electrical energy can cause serious damage to internal tissues as it passes through entry and exit points into the body. These burns show different clinical characteristics than thermal burns because they are of-

ten deeper and more dangerous than they appear. While they are more common in adults due to work accidents, children may experience contact with cables or sockets at home.
The severity of electrical burns varies depending on the voltage of the electrical current exposed, the strength of the current, the duration of exposure, the path the current follows within the body, and the person's body resistance. Although burn marks can be seen at the entry and exit points, tissue damage can also occur along the path the current follows within the body. Current passing through the heart muscle in particular can be life-threatening due to the risk of cardiac arrest (Zemaitis et al., 2025).

Clinical Symptoms and Signs in Electrical Burns

The main symptoms and signs that can be observed due to electric shock are as follows (Zemaitis et al., 2025):

- Loss of consciousness
- Shortness of breath or respiratory arrest
- Cardiac arrest or cardiac arrhythmia
- Local burn wounds at entry and exit points
- Muscle spasms and sudden contractions
- Invisible internal organ and vascular damage
- Secondary injuries due to traumatic falls
- In addition to these symptoms in lightning strikes, typical burn patterns such as Lichtenberg patterns on the skin, temporary paralysis, sensory loss and hearing impairments can also be seen.

First Aid Interventions in Electrical Burns

The main priority in responding to electrical burns is to ensure the safety of the scene. The responder must take the following precautions to avoid direct exposure to electric current (AlQhtani et al., 2024; Zemaitis et al., 2025):

- It should be checked whether the injured person is still connected to the electrical source; direct contact should not be made.
- The electric current should be cut off from its source as soon as possible and disabled.
- In high voltage currents (≥1000 Volts), it can be dangerous to approach the injured person directly; a distance of at least 18 meters should be kept considering the risk of current splash, but intervention should not be made without ensuring that the electrical source is completely disabled.
- If there is a household type low voltage (220 volts) current and the electricity cannot be cut off, the electrical source should be removed from the injured person and the person performing the intervention by means of non-conductive objects (wood, plastic, cardboard).
- In disasters such as lightning strikes, a closed area should be entered or a suitable protective position should be taken; high objects such as trees and electric poles should be avoided.
- The 112-emergency helpline should be called immediately or ensured to be called.

- First aid interventions should be started after safety is ensured.
- If there is no danger in the location of the injured person, they should not be moved.
- Burnt areas caused by electric shock should be cooled with running water for 10–15 minutes. However, this procedure should only be done after ensuring that the current is completely cut off.
- Extremely cold water should not be used, as this can increase the risk of hypothermia. During the cooling process, the injured person should be covered with a blanket to prevent heat loss.
- Before the intervention, hands should be washed with soap and water, or alcohol-based disinfectants should be used.
- If possible, gloves should be used, if gloves are not available, hygiene should be provided with alternative methods such as a clean plastic bag.
- The burn area should be loosely covered with a clean, lint-free and dry cloth.
- Blisters should not be burst, and they should not be directly treated.
- Clothes and jewelry that do not stick to the skin should be removed carefully; those that do should not be forced.
- Objects such as jewelry, belts, and shoes that may cause swelling should be removed; limbs should be kept above the level of the heart.
- The injured person should be kept warm without overheating, and should be protected from hypothermia, especially in open air conditions.
- Individuals who have lost consciousness but continue to breathe should be placed in the recovery position and kept under observation. In the event of respiratory arrest, Basic life support should be applied.

2.6. Freezing and Heat Stroke

2.6.1. Freezing (Frostbite)

Freezing injuries, commonly referred to as frostbite, happen when the skin and underlying tissues freeze due to exposure to extreme cold. This condition most often affects areas farthest from the heart (e.g., the fingers, toes, ears, cheeks and nose) and can lead to permanent tissue damage if not treated quickly. Frostbite, also known as freezing cold injury (FCI) develops when skin and tissues freeze at temperatures below 32°F (0°C). Any portion of exposed skin is prone to the damaging effects of frostbite (Imray & Oakley, 2005).

Body parts most prone to frostbite include the feet, hand, ears, lips, and nose. Most cases of frostbite occur in the winter; homeless people and those who perform outdoors activity are most susceptible to the injury (Basit et al., 2025). However, with the increase in technology and accessibility, recreational sports have become a significant repository for frostbite cases. Homeless populations, children and the older people are especially vulnerable to frostbite. Risk factors include behavioral (lack of clothing, alcohol/drug consumption, access to shelter), physiological (dehydration, high altitudes, hypoxia), and other comorbidities with a predilection for tissue hypoxia (diabetes, peripheral vascular disease, Raynaud phenomenon) (Imray & Oakley, 2005).

Pathophysiology of Frostbite

Frostbite progresses through four overlapping pathological stages: pre-freeze, freeze-thaw, vascular stasis, and late ischemic phases. The pre-freeze stage involves tissue cooling with vasoconstriction and reduced blood flow, causing ischemia without ice crystal formation. During this phase, sensory changes like hyperesthesia or paresthesia may occur, but permanent damage is avoidable if exposure ends here. In the freeze-thaw stage, ice crystals develop, either intracellularly during rapid freezing or extracellularly during slower freezing, resulting in cell membrane disruption, electrolyte imbalance and eventual cell death (Rintamäki, 2000). Thawing can trigger ischemia, reperfusion injury and inflammation. The vascular stasis phase is marked by unstable vessel dilation and constriction, leading to leakage or clotting within blood vessels. In the late ischemic phase, progressive tissue damage occurs due to inflammatory mediators like thromboxane A2, prostaglandin F2α, bradykinin, and histamine. These contribute to vasoconstriction, continued reperfusion injury, micro emboli and thrombosis in larger vessels. Ultimately, microcirculatory damage becomes the key driver of cell death. Repeated freezing after initial thawing significantly worsens tissue injury (McIntosh et al., 2024).

Normal skin blood flow is about 250 ml/min but during frostbite, the flow drops to less than 20-50 ml/min. As the temperature drops to below 0 degrees Centigrade, blood flow ceases. The slower venous system freezes before the arterial system. In most cases, recovery from frostbite can take 5-30 days, depending on the severity of injury. Frostbite causes injury in the following ways (McIntosh et al., 2024).

- Direct damage of the cold to the tissues
- Indirect damage caused by dehydration
- Formation of ice crystals that leads to alteration in electrolytes and lipid layers
- Stasis of the micro-vessels leading to thrombus formation and ischemia
- Reperfusion injury

Frostbite injury is classified into three zones which include:

1. Zone of coagulation which is the most distal and often the most severely injured and the injury is irreversible.
2. Zone of stasis is the middle zone where the injury can be moderate to severe but it reversible.
3. Zone of hyperemia is the proximal zone, which is the least injured.

Classification of Frostbite

Frostnip is a superficial nonfreezing cold injury associated with intense vasoconstriction on exposed skin. Ice crystals, appearing as frost, form on the skin's surface. Frostnip is distinct from and may precede frostbite. With frostnip, ice crystals do not form within the tissue, and tissue loss does not occur. Numbness and pallor resolve quickly after warming the skin with appropriate clothing, direct contact, breathing with cupped hands over the nose, or gaining shelter. No long-term damage occurs. Frostnip signals conditions favorable for frostbite; appropriate action should be undertaken immediately to prevent injury.

Frostbite has historically been divided into 4 tiers or "degrees" of injury following the classification scheme of severity for thermal burn injury. These classifications are based on acute physical findings and advanced imaging after rewarming. The classifications can be difficult to assess in the field before rewarming because the still-frozen tissue is hard, pale, and anesthetic. A classification more appropriate for field use (after rewarming but before imaging) is suggested after the following 4-tier classification (Cauchy et al., 2001) (Figure 2.6-1).

First-degree frostbite causes numbness and erythema. A white or yellow, firm, and slightly raised plaque develops in the area of injury. No gross tissue infarction occurs; there may be slight epidermal sloughing. Mild edema is common.

Second-degree frostbite injury causes superficial skin vesiculation. A clear or milky fluid is present in the blisters, surrounded by erythema and edema.

Third-degree frostbite causes deeper hemorrhagic blisters, indicating that the injury has extended into the reticular dermis and beneath the dermal vascular plexus.

Fourth-degree frostbite extends completely through the dermis and involves the comparatively avascular subcutaneous tissues, with necrosis extending into muscle and bone.

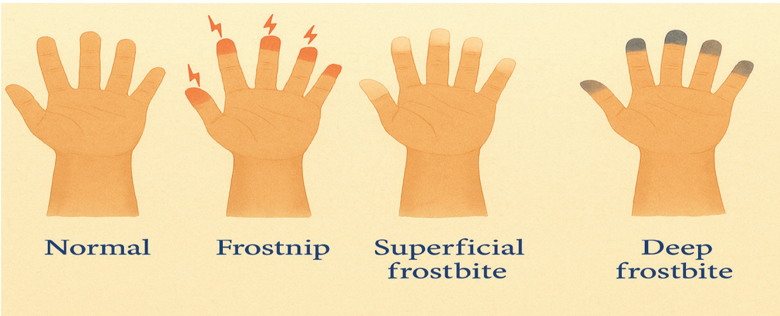


Figure 2.6-1. Classification of frostbite

First Aid and Secondary Prevention

Patients are at high risk for ischemic tissue injury and necrosis. Patients that survive cold tissue injury are prone to secondary infection and dehydration from loss of the skin barrier. The goal of treatment is to salvage as much tissue as possible so that maximal function remains (Basit et al., 2025).

Patients should have protection from further injury by covering exposed areas. The care of patients with frostbite begins with rewarming in the field if there is no anticipation of refreezing, as thaw-refreezing may worsen injuries (Roche-Nagle et al., 2008). Remove patients from the wind. Remove wet clothing and replace with dry clothing. Avoid vigorous rubbing as this can cause further damage (Handford et al., 2014).

Refreezing injury: Before thawing frostbitten tissue, assess environmental conditions. If there is a risk of the tissue refreezing, it is safer to keep it frozen until a stable, thawed state can be maintained. The freeze-thaw cycle triggers the release of prostaglandins and thromboxane, which promote vasoconstriction, platelet clumping and thrombosis, ultimately causing further cellular damage. Refreezing increases these harmful effects and can lead to serious complications. If thawing occurs in the field, refreezing must be strictly avoided.

Spontaneous or passive thawing: If rapid rewarming is not immediately possible, frostbite may thaw gradually and should be allowed to do so. Body heat, such as placing the affected area under an arm, can be used as an alternative warming method. Avoid intentionally keeping tissue frozen, as this prolongs exposure and may worsen the injury. When feasible, allow slow or spontaneous thawing to occur (McIntosh et al., 2024).

First Aid and Secondary Prevention in the Field can be Change Based on The Situation

The frozen part has the potential for refreezing and is not actively thawed, or the frozen part is thawed and kept warm without refreezing until evacuation is completed (McIntosh et al., 2024; ANZCOR, 2025; CDC, 2022).

When the frozen part has the potential for refreezing and is not actively thawed

- NEVER thaw a part if there is any likelihood of it being refrozen. Thawing and refreezing results in far more tissue damage than leaving the tissue frozen for even several hours.

When the frozen part is thawed and kept warm without refreezing until evacuation is completed

Rapid field rewarming of frostbite: Remove constrictive or damp clothing if dry replacement clothing is available. Wrap in warm blankets and give warm fluids by mouth. Field rewarming should only be done if the affected part can remain thawed route to definitive care. Use a water bath (37–39°C) if available and definitive care is over 2 hours away. Avoid dry heat sources (e.g., fire, space heater, oven, heated rocks) due to burn risk. Circulate the water to maintain temperature and replace it as it cools. Use a thermometer if available; if not, a caregiver's uninjured hand can test water safety (hand in the water for at least 30 s to confirm that the water temperature is tolerable and will not cause burn injury). Avoid heating containers directly with tissue inside. Rewarming is complete when the tissue becomes red or purple and soft—usually within 30 minutes. Gently air or blot dry the area.

Antiseptic solution: While infections are rare, adding antiseptics (e.g., povidone-iodine, chlorhexidine) to the rewarming bath may reduce skin bacteria. Adding an antiseptic solution to the water while rewarming is unlikely to be harmful and might reduce the risk of cellulitis if severe edema is present in the affected extremity.

Pain control: Administer non-steroidal anti-inflammatory drugs or opioids as needed to manage pain during rewarming.

Spontaneous or passive thawing: If field rewarming is not possible, spontaneous or slow thawing should be allowed. Slow rewarming is accomplished by moving to a warmer location (e.g., tent or hut) and warming with adjacent body heat from the patient (e.g., frozen hands/fingers in the axillae) or a caregiver.

Debridement of blisters: Do not break blisters in the field. If clear blisters are tense and may rupture during evacuation, aspiration followed by a dry gauze dressing is appropriate. Hemorrhagic blisters should not be disturbed.

Dressings: Apply bulky, dry gauze dressings to protect thawed tissue. Dress loosely to accommodate swelling and avoid pressure injury.

Ambulation and protection: Using a thawed limb for evacuation must be carefully weighed against the potential for added injury. While limited evidence exists, ideally, avoid walking or climbing on recently thawed extremities. If passive thawing has occurred, boots may be left on to manage swelling.

Elevation of extremity: If possible, the thawed extremity should be elevated above the level of the heart, which might decrease the formation of dependent edema.

A summary of the suggested approach to the field treatment of frostbite, are shown in Table 2.6-1.

Table 2.6-1. Summary of first aid of frostbite (>2 h from definitive care)

Treat hypothermia or serious trauma
1. Remove jewelry or other extraneous material from the body part
2. Do not rub or apply ice or snow to the affected area
3. Rapidly rewarm in water heated and maintained between 37 and 39 °C (98.6 and 102.2°F) until area becomes soft and pliable to the touch (approximately 30 min); allow spontaneous or passive thawing if rapid rewarming is not possible
4. Ibuprofen (12 mg kg−1 per day divided twice daily) if available
5. Pain medication (e.g., opiate) as needed
6. Air dry (do not rub at any point)
7. Protect from refreezing and direct trauma
8. Apply topical aloe vera cream or gel, if available
9. Dry, bulky dressings
10. Elevate the affected body part if possible
11. Systemic hydration (oral veya intravenously)
12. Avoid ambulation on thawed lower extremity (unless only distal toes are affected)

2.6.2. Heat Stroke

Heat stroke is a severe heat illness characterized by a core temperature >40°C (104°F) and central nervous system abnormalities such as altered mental status (encephalopathy), seizure, or coma resulting from passive exposure to environmental heat (classic heat stroke) or strenuous exercise (exertional heat stroke). A temperature above 40.5°C (or 105°F) is generally considered to be consistent with severe hyperthermia. As global warming proceeds, the incidence and severity of heat-related illness continue to increase (Gallo et al., 2024; Wilderness Medical Society, 2019; Zideman et al., 2021). There are following two types of heat stroke (Danzi & Grayzel, 2025; Zideman et al., 2021).

Non-exertional (classic) heat stroke: Non-exertional heat stroke typically affects individuals with impaired thermoregulation due to physiological or anatomical factors, chronic medical conditions, or limited access to cooling or hydration. Risk factors include cardiovascular, neurologic or psychiatric disorders; obesity; anhidrosis; physical disability; extreme age; use of substances such as alcohol, cocaine, or medications like beta-blockers, diuretics, and anticholinergics. Older people (especially those over 70) are most at risk, but young children left in hot vehicles are also vulnerable. Lack of air conditioning, inadequate shelter, and outdoor labor increase risk.

Exertional heat stroke: Exertional heat stroke affects healthy individuals. Some may have an underlying susceptibility to malignant hyperthermia, as shown by in vitro muscle testing.

Pathophysiology of Heat Stroke

Thermoregulation is typically efficient, with only a 1°C rise in core temperature for every 25–30°C increase in ambient temperature. In acclimatized individuals, heat-shock proteins help repair hyperthermia-induced cellular damage. The body dissipates heat primarily through increased cardiac output, splanchnic vasoconstriction, and sweating. However, evaporative cooling becomes ineffective when humidity exceeds 75%, and other heat loss mechanisms—radiation, conduction, and convection—are limited when ambient temperature surpasses skin temperature.

Inadequate fluid replacement can result in dehydration, often with normo-natremia or hypernatremia, potentially leading to cerebral edema, hemorrhage, or permanent brain injury. Overhydration with hypotonic fluids, seen in endurance athletes, may rarely cause hyponatremia. Heat stroke is also associated with hyperkalemia, typically due to muscle breakdown or acidosis, which shifts potassium extracellularly. This, alongside hypocalcemia, can cause cardiovascular instability, rhabdomyolysis, and cardiac conduction abnormalities, including QT prolongation and fatal arrhythmias. Coagulopathies in heat stroke range from mild clotting abnormalities to disseminated intravascular coagulation (DIC). Heat-induced endothelial injury promotes platelet aggregation and microvascular thrombosis, potentially resulting in consumptive coagulopathy and bleeding (Morris & Patel, 2025).

First Aid for Heat Stroke

It is important to differentiate where the patient is on the heat illness continuum. Heat exhaustion typically presents with symptoms such as muscle cramps, fatigue, dizziness, nausea, vomiting, and headache. When signs of end-organ damage develop, the condition progresses to heat injury. The presence of neurologic impairment differentiates heat stroke from heat injury.

Patients with heat stroke often exhibit abnormal vital signs, including elevated core temperature, sinus tachycardia, tachypnea, widened pulse pressure, and hypotension in approximately 25% of cases. Additional signs may include weakness, lethargy, nausea, vomiting, dizziness, flushing, pulmonary crackles, oliguria, bleeding, and neurologic dysfunction. In classic heat stroke, patients frequently present with hot, dry skin due to anhidrosis. In contrast, anhidrosis is uncommon in exertional heat stroke; these patients often continue sweating after physical activity ends (Adams et al., 2012; Zideman et al., 2021; Morris & Patel, 2025).

The strategies for treatment /management of heat stroke as follow (Djarv et all., 2025) (Figure 2.6-2):

- Consider symptoms of heat stroke with high ambient temperature, like elevated core body temperature, confusion, agitation, disorientation, seizures or unresponsiveness.
- Prevent exertional heat stroke (i.e. during long-distance sport events in a hot climate) by adequate preparation and provide tools to support recognition (e.g. rectal temperature probes) and cooling (e.g. immersion ice-water baths).
- With suspected heat stroke remove the person from the heat source and commence passive cooling by removing excess clothing and placing the person in a cooler/shaded location
- Use any technique immediately available to provide active cooling, if core temperature >40°C.
- Use whole body (neck down) cold water (1 to 26°C) immersion until the core temperature falls below 39°C. Alternatives are: tarp-assisted cooling oscillation (TACO) (Fig. 13) ice sheets, commercial ice packs, fan alone, cold shower, hand cooling devices, cooling vests and jackets or evaporative cooling (mist and fan).
- Where possible monitor core temperature (rectal thermometer).
- If a core temperature cannot be obtained, continue cooling for 15 min or until neurological symptoms resolve, whichever is first.
- Remember: cool first, transfer second.
- Continue cooling as needed during transportation to a medical facility for further evaluation.

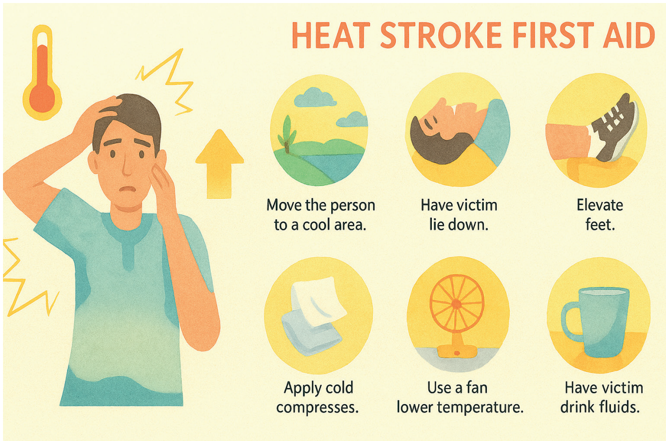


Figure 2.6-2. First aid for heat stroke

2.7. Poisoning

A poison is a substance (other than an infectious substance) that is harmful to human health if ingested, inhaled, injected or absorbed through the skin. Substances that are benign or therapeutic at low levels (for example, pharmaceuticals and herbal remedies) may be poisonous at higher concentrations. During disasters, poisoning may occur due to environmental, chemical (e.g., chlorine, ammonia, nerve agents), biological exposures, or inhalation of toxic gases such as carbon monoxide and ingestion of unsecured drugs, especially after earthquakes. These cases require rapid identification and prompt medical intervention (Wang, 2024). Poisons can exert harmful effects through various mechanisms, leading to a broad spectrum of symptoms such as unconsciousness, nausea, vomiting, burning sensations in the mouth or throat, headache, visual disturbances, seizures, respiratory distress, and in severe cases, respiratory or cardiac arrest (Wang, 2024). While poisoning may be apparent from the context of exposure, it is not always immediately recognized. Individuals may present with nonspecific physical symptoms or altered behavior that could be mistaken for alcohol intoxication or psychiatric illness. Prompt medical evaluation is essential following any significant exposure, regardless of the initial severity of symptoms (Severin and Jacobson, 2020; Ghannoum and Roberts, 2023; ANZCOR Guideline, 2025).

First Aid for Poisoning

Effective poisoning management involves the following principles (Severin and Jacobson, 2020; Erdil et. al., 2020; Ghannoum and Roberts, 2023; ANZCOR Guideline, 2025; Djarv et al., 2025).

Rescuer safety: Preventing further exposure is the first priority. The rescuer must identify the suspected poison and handle the patient safely to avoid contamination—particularly if the substance is transferable via skin contact, clothing or the environment.

- Use personal protective equipment (PPE) when appropriate.
- Be especially cautious in industrial, agricultural, or laboratory settings where hazardous agents may be involved.
- If multiple individuals are affected, assume environmental contamination.
- Rescue may be unsafe without proper equipment.

Decontamination: Separate the patient from the source of poisoning based on the route of exposure.

- **Swallowed poison**: In cases of swallowed poison, gastrointestinal decontamination methods may be considered, depending on the substance, time of ingestion, and patient condition.
    - Give a small sip of water to rinse the mouth.
    - Do *not* induce vomiting or use Ipecac syrup.
- **Inhaled poison**: Prompt decontamination in cases of inhaled poison is critically important, as rapid removal from the toxic environment can significantly reduce pulmonary damage and prevent systemic complications.
    - Move the patient to fresh air promptly, avoiding exposure yourself.
    - Specialized breathing apparatus may be required (e.g., cyanide, agricultural toxins).
- **Eye exposure**: Immediate ocular decontamination is essential in cases of toxic eye exposure, as prompt and thorough irrigation can prevent serious complications such as corneal injury, vision loss, or chemical burns.
    - Irrigate the eye with running water or saline for at least 15 minutes, keeping eyelids open
- **Skin contact**: Rapid skin decontamination is crucial following toxic exposure through skin contact, as decontamination can significantly reduce dermal absorption and prevent systemic toxicity or local tissue damage.
    - Remove contaminated clothing carefully.
    - Rinse affected skin with cold running water, then wash gently with soap and rinse thoroughly.

Resuscitation and supportive care: In the management of poisoning, prompt resuscitation and supportive care are fundamental, as they address life-threatening complications such as airway compromise, respiratory failure, and circulatory instability, regardless of the specific toxin involved.

- If the patient is unconscious or not breathing normally, initiate resuscitation following the current BSL flowchart.
- Wipe visible contaminants from the mouth before starting ventilation.
- Call for an ambulance immediately.
- Use a bag-valve-mask for ventilation if available; avoid mouth-to-mouth ventilation if cyanide or organophosphate poisoning is suspected.
- Inhaled poisons usually pose minimal risk unless there is direct contact with the liquid form.

Specific poison management: Poisons with known antidotes including cyanide, organophosphates, iron, paracetamol, methanol, ethylene glycol (antifreeze), some antidepressants, digoxin, warfarin. While many antidotes are used only in hospital settings, early identification improves outcomes. If medical advice is delayed, continue to monitor airway, breathing, and circulation, and follow the BLS flowchart.

- Determine the substance, amount, and time of exposure if possible.
- Seek medical advice urgently through.
- According to the ERC 2025 Guidelines**,** administration of naloxone is recommended in cases of suspected opioid overdose. The responder should assess whether the person is conscious and breathing normally. If the person is unresponsive or has no or abnormal breathing, an emergency call should be made immediately, and CPR should be initiated. If naloxone is available and the responder is trained in its use**,** it should be administered without delay**.**
- If containers or packaging are available, send them with the patient to the hospital.

2.8. Animal Bites

Animal bites pose a heightened public health risk in disaster settings, where disrupted infrastructure, displacement, and increased human-animal interactions create ideal conditions for such injuries to occur. In the aftermath of natural disasters—such as earthquakes, floods, or hurricanes—domesticated animals may become frightened, aggressive, or feral, while wild animals may encroach on human settlements in search of food or shelter. These bites not only result in physical trauma but also carry a high risk of secondary infections and zoonotic diseases, including rabies and tetanus (Maniscalco & Edens, 2025; Wang, 2024). Animal bites account for approximately 1% of all emergency department visits in the United States yearly and range from superficial injuries to disfiguring and even fatal wounds. Relatively minor wounds can become infected; therefore, all bites should be evaluated carefully and thoroughly regarding potential complications (Basit et al., 2025).

2.8.1. Snakebite

Snakebite envenomation is one of the most neglected tropical diseases according to WHO, and the harm caused by snakebite envenomation is immense (Imray & Oakley, 2005). Snakes produce venom in modified salivary glands, and the venom is forced out under pressure through paired fangs in the upper jaw. Snake venoms are complex mixtures of many toxic substances which can cause a range of effects in humans. The greatest threat to life and cause of over half of deaths is early cardiovascular collapse. Other significant effects include major bleeding due to inability to clot blood; nerve paralysis leading to respiratory muscle paralysis; muscle damage; and kidney failure due to microscopic blood clots. A snakebite may be painless and lack visible marks. When present, signs can include paired fang marks; however, a single puncture or scratch is more common. Local redness and bruising are uncommon in Australian snakebites (Rintamäki, 2000).

Systemic signs and symptoms occurred after snakebites may include:

- Headache
- Nausea and vomiting
- Abdominal pain
- Blurred or double vision, ptosis (drooping eyelids)
- Difficulty speaking, swallowing or breathing
- Swollen, tender lymph nodes in the groin or axilla of the affected limb
- Limb weakness or paralysis
- Respiratory muscle weakness or arrest

The leading cause of death from snakebite is sudden collapse with cardiac arrest, typically occurring within 10–60 minutes of envenomation. Most fatalities occur before hospital arrival and require immediate CPR. Notably, brown snake envenomation may present with early collapse or confusion, followed by partial or complete apparent recovery. This may be the only clinical sign and should be communicated clearly to receiving medical staff when antivenom (It is a biological preparation containing antibodies produced by the immune system against the venom of a specific animal) administration is being considered (Rintamäki, 2000).

First Aid for Snake Bites

First aid is the primary intervention for snakebite envenomation, with proper on-site management playing a critical role in delaying venom spread. Key measures include keeping the patient calm, applying pressure at the bite site, and immobilizing the entire body, especially the affected limb. As initial care is often provided by the victim or bystanders, public education is essential to discourage the use of harmful traditional remedies, particularly in regions where snakebites are common. Given the life-threatening nature of envenomation, management should be integrated into a coordinated regional pre-hospital rescue system. Improving accessibility to pre-hospital care is vital. Drawing on trauma system models, continuity of care must be ensured across all phases—from time of bite to first medical contact, arrival at the emergency department and prompt administration of antivenom (Imray & Oakley, 2005).

Key steps in the management of suspected snakebite include (ANZCOR, 2025; Erdil et al., 2020; Djarv et al., 2025) (Figure 2.9-1).

- Immediately move away from the area where the bite occurred. If the snake is still biting and holding on, use a stick or another object to gently remove it without using your hands. Sea snake victims need to be moved to dry land to avoid drowning.
- Immediately call for an ambulance.
- Remove anything tight from around the bitten part of the body (e.g., rings, anklets, bracelets, clock) as these can cause harm if swelling occurs.
- Reassure the victim. Many snake bites are caused by non-venomous snakes. And even after most venomous snake bites the risk of death is not immediate.
- Immobilize the person completely. Splint the limb to keep it still. Use a makeshift stretcher to carry the person to a place where transport is available to take them to a health facility.
- Keep the patient still, calm, and under continuous observation.
- Avoid traditional first aid methods, herbal medicines and other unproven or unsafe forms of first aid.
- Transport the person to a health facility as soon as possible.
- Paracetamol may be given for local pain (which can be severe).
- Vomiting may occur, so place the person on their left side in the recovery position.
- Closely monitor airway and breathing and be ready to resuscitate if necessary.
- If the patient becomes unresponsive and is not breathing normally, begin CPR following the current guideline. There is no risk of venom transmission to the rescuer when performing CPR.

Important precautions:

- Do not apply a pressure dressing.
- Do not apply ice and heat.
- Do not cut or incise the bite site.
- Do not apply an arterial tourniquet.
- Do not wash or suck the bite area.

Figure 2.8-1. First aid for snake bites

2.8.2. Bee Sting

Bee stings are a common cause of minor injuries, typically resulting in localized pain, redness, and swelling. While most reactions are mild and self-limiting, some individuals may experience severe allergic reactions, including anaphylaxis, which requires immediate medical attention.

First Aid for Bee Sting

Prompt first aid for a bee sting is crucial, as it can alleviate pain, reduce local reactions, and prevent serious allergic complications such as anaphylaxis in sensitive individuals. First aid interventions for bee sting include the following (AADA, 2023; CDC, 2022; Lee et al., 2020) (Figure 2.8-2):

- Move the individual away from the area to prevent additional stings, especially near a disturbed hive.
- If the stinger remains embedded, remove it as quickly as possible by scraping it with a blunt-edged object (e.g., a credit card). Avoid using tweezers or fingers to pinch the stinger, as this may inject more venom.
- Wash the affected area with soap and water to prevent secondary infection.
- Use a cold pack or cloth-wrapped ice for 10–15 minutes to reduce pain and swelling.
- Administer oral antihistamines (e.g., diphenhydramine) or apply topical corticosteroids or calamine lotion to relieve itching and inflammation.
- Observe the person closely for signs of systemic or anaphylactic reactions, particularly within the first 30 minutes. Warning signs include:

- Difficulty breathing
- Swelling of the face, lips or throat
- Rapid heartbeat
- Dizziness or fainting
- Widespread hives or rash

- If any of these symptoms develop, immediately call emergency services and, if available, administer epinephrine via autoinjector (e.g., EpiPen).

Special considerations: Individuals with known bee sting allergies should carry an epinephrine autoinjector at all times. Children and elderly individuals may be more susceptible to complications and should be monitored closely. Multiple stings, especially in small children, may lead to venom toxicity and warrant urgent medical evaluation.

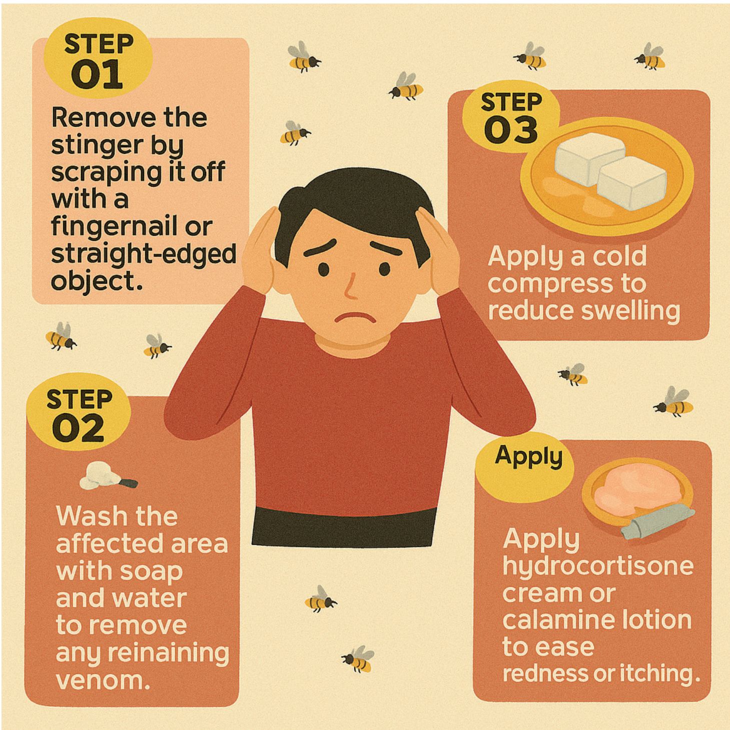


Figure 2.8-2. First aid for bee sting

2.8.2. Tick Bite

Ticks are parasites that feed on warm-blooded hosts by biting them. A tick bite can infect humans and animals with bacteria, viruses and protozoans (organisms made up of one cell) that can cause diseases. Tick bites are often painless and may go unnoticed. While some bites cause mild local irritation or itching, others may produce no immediate symptoms. Not all tick bites result in disease transmission, and prompt removal may prevent infection. In cases where transmission occurs, symptoms typically arise from the infection itself rather than the bite and may develop after an initial localized skin reaction such as a rash or small indurated lesion (CDC, 2023; WHO, 2023)

First Aid for Tick Bite

Prompt and proper first aid for tick bites is essential to minimize local reactions and reduce the risk of tick-borne disease transmission, including Lyme disease and other infections. The first aid strategies for tick bites as follows (CDC, 2023; WHO, 2023).

- The tick should be removed as soon as possible using fine-tipped forceps or tick-removal tools. Grasp the tick close to the skin surface and apply steady, even pressure to pull upward. Avoid twisting or crushing the tick, as this can lead to incomplete removal or increased risk of pathogen transmission. Do not use methods such as burning, applying petroleum jelly, or other chemical irritants, as these may cause the tick to regurgitate its contents, increasing the chance of infection.
- After removal, cleanse the bite site with soap and water or an antiseptic solution such as iodine or alcohol. Wash hands thoroughly after tick handling.
- The site should be observed for signs of local infection or allergic reaction. In the weeks following the bite, the individual should monitor for systemic symptoms such as fever, headache, fatigue, or rash, which may indicate a tick-borne illness. A circular rash (erythema migrans) may suggest Lyme disease and warrants prompt medical evaluation.
- If possible, the tick can be saved in a sealed container with the date of the bite, as identification may assist in diagnosis if symptoms develop.
- Medical assessment is advised if:
  - The tick cannot be fully removed.
  - Symptoms develop following the bite.
  - The individual is in an area known for tick-borne diseases.

2.9. Foreign Object Insertion (Eye, Ear and Nose)

In disaster settings, the risk of foreign object insertion into the eyes, ears, and nose increases significantly, particularly among children and displaced individuals who are forced to live in crowded, chaotic, or unsanitary environments. During evacuation, sheltering, or structural collapses, individuals may be exposed to large amounts of dust, debris, and physical trauma, all of which can contribute to the accidental entry of foreign bodies into sensitive anatomical areas. Children are especially vulnerable due to their natural curiosity and lack of awareness about danger, while adults may be affected due to environmental exposure or accidents occurring in unstable shelters (Patel et al., 2012; Bourke et al., 2021).

If not identified and managed promptly, these types of injuries can lead to a wide range of serious complications. Foreign bodies in the **ears** may cause pain, infection, or even hearing loss if they perforate the tympanic membrane. Objects inserted into the **nose** may obstruct breathing and result in mucosal damage or chronic infection. When foreign materials enter the **eyes**, they can cause corneal abrasions, infections, or long-term vision impairment. In rare but critical cases, especially in small children, foreign objects in the nasal passages or throat can contribute to airway obstruction, posing a direct threat to life (Patel et al., 2012; Bourke et al., 2021).

In disaster situations where access to medical professionals may be delayed or nonexistent, the ability of caregivers, volunteers, and first responders to recognize signs of foreign body injury and provide appropriate first aid becomes essential. Safe and gentle techniques—such as avoiding attempts to remove deeply embedded objects or flushing the eye in case of superficial exposure—can prevent further harm until professional care is available.

Therefore, raising awareness about these risks and including basic training in foreign body management as part of disaster preparedness education can significantly reduce the incidence of preventable complications. Empowering communities with knowledge and practical skills in such scenarios not only helps protect vulnerable populations, especially children, but also supports a more resilient and health-aware disaster response.

2.9.1. Foreign Objects in Eye

Intraocular foreign bodies (IOFBs) are a significant cause of ocular morbidity, particularly in younger individuals. IOFB-related trauma is distinct and requires prompt, skilled evaluation and early intervention. Most IOFBs are metallic in nature, commonly resulting from high-velocity activities such as chisel hammering, drilling, gunfire or explosions. Manual laborers are especially at risk (Patel et al., 2012; Bourke et al., 2021). IOFBs can become lodged in any part of the eye but are most often found in the posterior segment due to their sharpness and speed. Prognosis is influenced by several factors, including the foreign body's size, location, composition, the extent of tissue damage, time to treatment, inflammatory response, and the presence of complications such as endophthalmitis or retinal detachment (Azad et al., 2004; Gupta & Tripathy, 2023).

First Aid for Foreign Object in Eye

Early first aid plays a crucial role in minimizing harm by preventing further injury, reducing the risk of infection, and ensuring timely referral to healthcare providers when advanced care is needed. First aid interventions are follows (Cauchy et al., 2001):

- Do not rub the eye, rubbing can cause abrasions or drive the object deeper into ocular tissues.
- Encourage the person to blink several times to dislodge the object naturally. Examine the eye in a well-lit area. Gently pull down the lower eyelid or lift the upper eyelid to inspect the conjunctiva and cornea.
- If the object is not embedded, irrigate the eye with sterile saline or clean running water. Tilt the person's head so the affected eye is downward and to the side to prevent contamination of the unaffected eye. Continue flushing for 10–15 minutes if the foreign body is chemical in nature.
- If the object is embedded in the cornea or sclera, or if it cannot be removed with flushing, cover the eye with a sterile dressing or shield (avoid pressure) and seek immediate medical attention. Do not attempt to remove embedded objects.
- Contact lenses should not be worn until the object is removed and the eye has healed.
- Urgent ophthalmic referral is needed if there is persistent pain, vision change, excessive tearing, photophobia, or if an embedded object is suspected.
- Special considerations are follows:

- **Metallic foreign bodies**: These can rust rapidly and cause ocular toxicity; early removal and possible tetanus prophylaxis are recommended.
- **Organic matter**: Wood or plant material may increase the risk of fungal infection and should be managed promptly and cautiously.

2.9.2. Foreign Objects in Ear

Commonly retrieved foreign bodies include beads (the most frequent), pieces of paper or tissue, and popcorn kernels, which collectively account for more than half of the reported cases in one study. A slight predominance among males has been noted, though findings vary across studies. Certain objects, such as button batteries, necessitate urgent removal due to the risk of chemical injury. In contrast, most inorganic foreign bodies in the external auditory canal (EAC) do not require immediate extraction. However, delayed removal or significant swelling of the EAC can make extraction more difficult and uncomfortable).

First Aid for Foreign Object in Ear

Prompt and appropriate first aid is essential to minimize complications and prevent further injury caused by improper removal attempts. Early intervention not only reduces discomfort but also preserves auditory function and helps avoid the need for more invasive medical procedures. First aid interventions are follows (WHO, 2023; Lotterman et al., 2025;):

- Avoid using cotton swabs, tweezers, or other tools to remove the object, as this may push it deeper or cause injury to the ear canal or eardrum.
- Especially in children, keeping the individual calm can prevent sudden movements that could worsen the injury.
- If the object is at the outer edge of the ear canal and can be easily grasped with fingers or blunt tweezers without inserting anything into the canal, it may be gently removed. Avoid this if the object is not clearly visible or if resistance is felt.
- If a live insect is suspected in the ear, tilt the head to the affected side and pour a few drops of warm (not hot) vegetable oil, baby oil, or sterile saline into the ear to suffocate and immobilize the insect. Do not use water if there is a possibility of tympanic membrane perforation.
- Do not flush the ear with water or saline unless you are certain the object is not organic (e.g., seeds or beans), as these can swell with fluid and worsen the obstruction.
- Prompt referral to a healthcare provider is necessary if the object is not easily removable, is causing pain or bleeding, or if the individual experiences hearing loss, dizziness, or discharge.
- Special considerations are follows:
  - Organic materials, such as food or plant matter, may swell or decompose in the ear, increasing the risk of infection and should be removed by a healthcare professional.
  - Button batteries in the ear canal are a medical emergency due to their potential to cause rapid tissue damage and must be urgently removed.

2.9.2. Foreign Objects in Nose

Foreign bodies to the nose are most commonly seen in children, mentally challenged, and psychiatric patients. Although they may be located anywhere within the nasal cavity, they are most commonly located in or around the floor of the nose just below the inferior turbinate or immediately anterior to the middle turbinate (Wilderness Medical Society, 2019).

First Aid for Foreign Objects in Nose

Early and appropriate first aid is essential to prevent further complications and ensure safe removal. Delayed or improper intervention may worsen the condition and increase the risk of respiratory distress or localized tissue damage. First aid interventions are follows (Heim & Maughan, 2007; Grigg & Grigg, 2018):

- Keep both yourself and the child calm. Panic can make the situation worse.
- Encourage the child to breathe through their mouth to avoid inhaling the object further into the nasal passage.
- If the object is in one nostril, gently press the other nostril closed and have the child blow out through the affected nostril. This method, known as positive pressure, can help expel the object.
- Parent's kiss technique: For young children, place your mouth over the child's mouth to create a seal. Close the unaffected nostril with your finger and give a quick, gentle puff of air into the child's mouth. This can help dislodge the object from the nasal passage.
- If the object is clearly visible and easily graspable use the tweezer to remove the object. Be cautious, as improper use can push the object further in.
- Avoid using cotton swabs, fingers, or any tools to probe the nose, as this can push the object deeper and cause injury.
- Do not have the child blow their nose forcefully or repeatedly, as this can cause the object to move further into the nasal passage.
- Do not attempt to flush the object out with water, especially if it's a battery or other object that can react with moisture.
- Seek medical help;
    - If the object is a button battery or magnet, seek immediate medical attention, as these can cause serious tissue damage quickly.
    - If you cannot see or easily remove the object.
    - If the child experiences persistent pain, bleeding, or foul-smelling discharge.
    - If the child shows signs of breathing difficulty.

2.10. Medical Emergencies (Seizure, Diabetes Mellitus, Myocardial Infarction, Stroke and Infection Control)

Medical emergencies such as seizures, the need for strict infection control, diabetes mellitus, myocardial infarction and stroke become critically important due to limited healthcare access, overcrowding, and disrupted infrastructure in disaster settings. Prompt recognition and management of these diseases, along with effective infection prevention measures, are essential to reduce morbidity and prevent secondary outbreaks in vulnerable populations (Tomio & Sato, 2014).

2.10.1. Seizure

A seizure is defined as an episode of uncontrolled, abnormal electrical activity in the brain, which can lead to alterations in consciousness, behavior, memory or emotional state. When evaluating such an event, the differential diagnosis includes convulsive concussion, convulsive syncope, movement disorders, rigors, sleep-related phenomena and psychogenic non-epileptic episodes. Seizures are broadly categorized as either partial or generalized. Partial seizures, the most common type in adults, originate in a specific region of the cerebral cortex and may present with focal motor or sensory symptoms. In contrast, generalized seizures involve widespread cortical activation from the onset or represent the progression of focal seizure activity to a generalized state (Huff & Murr, 2023).

First aid for Seizure

Providing timely and appropriate first aid during a seizure is crucial to protect the individual from injury, support breathing, and ensure safety until medical help arrives. First aid interventions are follows (Rank, 2020; CDC, 2024; Epilepsy Foundation of Minnesota, 2025):

- Stay calm and ensure safety. Keep yourself composed to help the person effectively. Remove any nearby objects that could cause injury.
- If patient is falling or has fallen, gently guide the patient to the ground to prevent injury. Place something soft under their head, such as a folded jacket, to cushion it.
- Turn the person onto their side to help keep the airway clear and prevent choking, especially if they are salivating or vomiting.
- Avoid holding the person down or trying to stop their movements, as this can cause injuries.
- Do not insert any objects into the person’s mouth. This can lead to dental injuries or airway obstruction.
- Use a watch or phone to monitor the duration of the seizure. Most seizures last between 1 to 2 minutes.
- Once the seizure ends, help the person rest in a safe position. They may be confused or tired. Reassure them and stay with them until they are fully alert.
- While many seizures are not medical emergencies, call emergency or seek immediate medical assistance if:
    - The seizure lasts longer than 5 minutes.
    - Another seizure follows immediately without the person regaining consciousness.
    - The person has difficulty breathing or does not regain consciousness after the seizure.
    - The person is injured during the seizure.
    - The seizure occurs in water.
    - The person is pregnant, diabetic, or has no known history of seizures.
- Post-seizure care are follows:
    - Examine the person for any injuries sustained during the seizure, especially to the head or limbs.

- Offer reassurance as they regain awareness. They may be disoriented or embarrassed.
- Wait until the person is fully alert before offering anything to eat or drink, to prevent choking.
- Remain with the person until they are fully recovered and can safely resume their activities.

2.10.2. Diabetes Mellitus

Diabetes mellitus (DM) poses unique challenges during disasters, where disruption of medications, altered food intake, dehydration and stress can destabilize glycemic control. Both hyperglycemia and hypoglycemia are common and potentially life-threatening during emergencies, particularly in insulin-dependent patients (CDC, 2024; ADA, 2023). Disaster-related factors such as missed insulin doses, reduced access to food, and increased physical exertion can **precipitate** hypoglycemia**,** diabetic ketoacidosis (DKA)**, or** hyperosmolar hyperglycemic state (HHS)**—**conditions requiring immediate attention (IDF, 2022).

Hypoglycemia (Blood Glucose <70 mg/dL)

Common causes of hypoglycemia in disaster settings including missed meals, increased exertion, excess insulin or stress-related mismanagement. Signs and symptoms of hypoglycemia are shakiness, sweating, dizziness or lightheadedness, confusion or irritability, blurred vision, loss of consciousness (in severe cases) (CDC, 2024).

First aid for hypoglycemia

Immediate recognition and reversal of hypoglycemia is critical to prevent seizures, coma, or death (Djarv et al., 2025).

- Suspect hypoglycaemia in someone with diabetes or chronic malnutrition AND sudden impaired responsiveness or behavioural change.
- Give glucose or dextrose tablets (15–20 g), by mouth if the person is awake and able to swallow
- If feasible, measure capillary blood sugar using a blood glucose meter and treat if low (a value less than 4.0 mmol/L or 70 mg/dL) and repeat measurement after treatment.
- If glucose or dextrose tablets are not available give other dietary sugars, such as a handful of sugary sweets or 50–100 ml of fruit juice or sugar containing soda.
- If oral glucose is not available, give a glucose gel (partially held in the cheek, and partially swallowed).
- Repeat giving oral glucose if the symptoms are still present and not improving after 15 min.
- If the person has a prescribed glucagon autoinjector, this could be administered under the skin in the outer thigh (self-administered or by trained individuals). Some diabetics may have glucagon syringes for nasal use.
- For children, consider administering half a teaspoon of table sugar (2.5 g) under the child's tongue, if they are uncooperative with swallowing oral glucose.
- Call your emergency number (112) if the person is/or becomes unresponsive or the con-

dition does not improve. Following recovery from symptoms (5–10 min after sugar intake) encourage the person to eat a light snack.
- For unresponsive persons, do not give oral sugar due to the risk of aspiration, instead call your local emergency number (112).

In disaster situations, glucagon kits are a critical part of the diabetic emergency kit (IDF, 2022).

Hyperglycemia (Blood Glucose >180 mg/dL)

Signs and symptoms of hyperglycemia include increased thirst and urination, fatigue, nausea or vomiting, fruity breath odor (suggestive of DKA), dry mouth and dehydration. Prolonged hyperglycemia increases the risk of DKA, especially in type 1 diabetics. HHS may occur in type 2 diabetics under extreme stress (ADA, 2023).

First aid for hyperglycemia and suspected DKA

While hyperglycemia evolves more slowly than hypoglycemia, it can become life-threatening without intervention (Umpierrez et al., 2024).

Step 1: Identify symptom and signs

- Polyuria, polydipsia, abdominal pain, deep/labored breathing (kussmaul respiration) and fruity-smelling breath.

Step 2: Encourage hydration

- If alert and able to drink, encourage **sips** of water or electrolyte-containing fluids**.**
- Avoid sugar-sweetened beverages.

Step 3: Monitor

- Check blood glucose if glucometer is available.
- Test for ketones (urine strip or blood test) if patient has type 1 DM and glucose >250 mg/dL.

Step 4: Seek emergency medical help

- DKA and HHS require IV fluids, insulin therapy, and hospital-level electrolyte monitoring.
- Arrange for evacuation to a healthcare facility as quickly as possible.

Diabetic First Aid Kits in Disaster Settings

Field responders should prioritize hypoglycemia **as a** life-threatening emergency and manage hyperglycemia with fluid replacement and early evacuation. Healthcare responders and diabetic patients should maintain emergency kits including (CDC, 2024; ADA, 2023):

- Blood glucose meter and test strips
- Glucose tablets or gel
- Glucagon emergency kit (injectable or nasal)
- Rapid- and long-acting insulin, if applicable
- Ketone testing strips
- Hydration solution (e.g., oral rehydration salts)
- Medical identification (bracelet, card)
- Emergency contact and medication list

2.10.3. Myocardial Infarction

Myocardial infarction (MI), commonly known as a heart attack, occurs when blood flow to a part of the heart muscle is obstructed, leading to tissue damage. In disaster scenarios, where access to advanced medical care may be delayed, prompt recognition and immediate first aid is crucial (American Heart Association & American Red Cross, 2024; European Resuscitation Council, 2015). Prompt first aid and early medical intervention can significantly reduce the severity of myocardial damage and increase the chances of survival (WHO, 2022).

Recognizing the signs and symptoms of MI is critical for timely action. Common symptoms and signs include (CDC, 2022):

- Chest pain or discomfort, often described as pressure, squeezing, fullness, or pain in the center or left side of the chest
- Pain or discomfort in the jaw, neck, back, shoulders or arms
- Shortness of breath, which may occur with or without chest discomfort
- Cold sweat, nausea or lightheadedness

Symptoms and signs may vary between individuals and may be less pronounced in women, older adults, and people with diabetes (AHA, 2023).

First Aid Management for Myocardial Infarction

First aid management for myocardial infarction is critically important during disasters, as immediate and proper response can significantly reduce mortality when access to professional medical care may be delayed (AHA, 2023, Boehringer & Kissela, 2020, AHA, 2020; Djarv et., 2025).

Call for emergency help immediately: If a heart attack is suspected, call emergency medical services (EMS) immediately (e.g., 112). Do not delay—every minute counts.

Encourage the person to stay calm and rest: Placing the person in a semi-sitting position and rest in a comfortable position. Reassure them and try to keep them calm to reduce strain on the heart.

Administer aspirin (if appropriate): If the person is not allergic and has no contraindications, give them a standard dose of aspirin (300 mg) to chew slowly. Aspirin inhibits platelet aggregation, helping to reduce clot size.

Loosen tight clothing: Remove or loosen any tight clothing to help the person breathe more easily.

Monitor the person: Stay with the person until EMS arrives. Be prepared to start cardiopulmonary resuscitation (CPR) if they become unresponsive and stop breathing normally.

Initiate CPR if necessary: If the person becomes unconscious and is not breathing or only gasping, begin CPR immediately.

Important Considerations

- **Do not let the person eat or drink anything**, as they may require surgery upon arrival at the hospital.

- **Do not drive the person to the hospital yourself**, unless absolutely necessary. Ambulances can provide advanced care and route.

2.10.4. Stroke

Stroke is a medical emergency characterized by a sudden interruption of blood flow to the brain due to either a blocked artery (ischemic stroke) or a ruptured blood vessel (hemorrhagic stroke) (Goyal et al., 2016). Immediate medical intervention can save brain tissue and reduce the risk of long-term disability. Therefore, providing prompt and appropriate first aid is a vital part of the chain of survival. According to the World Stroke Organization (2022), stroke is the second leading cause of death and a leading cause of disability worldwide. Timely recognition and action can significantly improve outcomes. The FAST acronym is the most widely used and evidence-based tool for recognizing stroke symptoms quickly (CDC, 2023; Djarv et al., 2025):

F – Face: Ask the person to smile. Is there drooping on one side?

A – Arms: Ask the person to raise both arms. Does one drift downward?

S – Speech: Ask the person to repeat a simple sentence. Is speech slurred or strange?

T – Time: Time to call emergency services immediately

Studies support those FAST captures the majority of common stroke presentations and aids laypersons in identifying potential stroke victims effectively (Pickham et al., 2019). Other symptoms and signs may include sudden confusion, trouble seeing, dizziness, imbalance, or a severe headache with no known cause (Johnston et al., 2011).

First Aid Management for Stroke

First aid management for stroke plays a vital role during disasters, when timely medical intervention may be limited or delayed. Early recognition and immediate response can greatly reduce the risk of severe disability or death, making basic stroke first aid skills essential for communities affected by emergencies. First aid interventions for stroke are below (Jauch et al., 2013):

Activate emergency medical services (EMS) immediately: Call emergency services (e.g., 112) as soon as stroke is suspected. Early treatment, particularly within the first 4.5 hours, may allow the use of thrombolytic drugs like alteplase for ischemic stroke.

Keep the person safe and still: Help the individual lie down in a comfortable, side-lying position with their head slightly elevated (if conscious). This positioning helps maintain cerebral perfusion and reduces aspiration risk if vomiting occurs.

Do not give food, drink or medication: Stroke victims may have impaired swallowing (dysphagia), increasing the risk of choking. Avoid giving anything by mouth, including water, food, or medications like aspirin, unless directed by a healthcare professional.

Monitor vital signs: Observe the person's breathing and consciousness. If they become unresponsive and are not breathing normally, begin cardiopulmonary resuscitation (CPR) if trained.

Stay calm and reassure: Minimize stress by remaining calm and providing reassurance. Anxiety may worsen the condition through elevated blood pressure or hyperventilation.

Important Considerations

- Do not delay seeking help by waiting for symptoms to improve.
- Do not allow the person to walk or exert themselves, as this could worsen the stroke.
- Do not administer aspirin or other drugs, which may be harmful in hemorrhagic strokes.

2.10.5. Infection Control

Effective infection prevention and control (IPC) measures are essential in first aid settings to protect both the caregiver and the patient from the transmission of infectious agents. These interventions are grounded in evidence-based guidelines provided by leading health organizations such as the WHO and the Centers for Disease Control and Prevention (CDC) (CDC, 2024)

Basic Infection Control Measures for First Aid

These measures are follows (CDC, 2024):

- Hand hygiene is the cornerstone of infection prevention. It involves cleaning hands at critical moments to prevent the spread of pathogens. Perform hand hygiene:
  - Before and after any patient contact
  - After contact with potentially infectious materials
  - Before performing aseptic tasks
  - After removing gloves
- Hand hygiene can be performed using soap and water or alcohol-based hand rubs (ABHRs). ABHRs are preferred when hands are not visibly soiled, while soap and water are recommended when hands are visibly dirty or after contact with bodily fluids.
- Use of personal protective equipment (PPE). PPE serves as a barrier between the caregiver and infectious agents. The selection of appropriate PPE depends on the anticipated exposure. Types of PPE are follows:
  - Gloves: Protect hands from contamination
  - Gowns/aprons: Protect skin and clothing
  - Masks and respirators: Protect the respiratory tract
  - Eye protection: Protect mucous membranes of the eyes
- Proper donning and doffing techniques are crucial to prevent self-contamination.
- Implementing respiratory hygiene measures reduces the transmission of respiratory pathogens. These practices are essential, especially during outbreaks of respiratory illnesses. https://en.wikipedia.org/wiki/Transmission-based_precautions?utm_source=chatgpt.com
  - Cover mouth and nose with a tissue or elbow when coughing or sneezing.
  - Dispose of used tissues promptly.
  - Perform hand hygiene after contact with respiratory secretions.
  - Provide masks to individuals exhibiting respiratory symptoms.
- Improper handling of sharps can lead to injuries and transmission of bloodborne pathogens.
  - Do not recap used needles.
  - Dispose of sharps immediately in designated puncture-resistant containers.
  - Ensure sharps containers are not overfilled.

- Maintaining a clean environment reduces the risk of pathogen transmission.
    - Regularly clean and disinfect surfaces and equipment.
    - Use appropriate disinfectants effective against the targeted pathogens.
    - Follow manufacturer instructions for dilution and contact time.
- Proper segregation and disposal of waste prevent environmental contamination.
    - Infectious waste: Materials contaminated with blood or bodily fluids.
    - Sharps waste: Needles, scalpels, and other sharp instruments.
    - General waste: Non-hazardous waste.
- Implement the standard precautions. These are the minimum infection prevention measures applied to all patient care. Transmission-based precautions are additional measures used for patients known or suspected to be infected with specific pathogens.
- Types of transmission-based precautions are follows:
    - Contact precautions: For infections spread by direct or indirect contact.
    - Droplet precautions: For pathogens transmitted through respiratory droplets.
    - Airborne precautions: For pathogens transmitted via airborne particles.

2.11. Transporting the Injuried People/ Patients

In disaster situations, the safe and timely transport of injured individuals is critical to reduce mortality, prevent further harm, and ensure access to definitive medical care amidst chaotic and resource-limited conditions. In this content, the organization and delivery of Emergency Medical Services (EMS) differ across countries; however, all critically injured patients require prompt and safe transport from the injury site to a definitive care facility. When considering long-distance transfers, the potential benefits must be balanced against risks, costs, evacuation time, resource use, patient discomfort, and survival likelihood. Accurate assessment of injury severity, timely medical intervention, and selecting the appropriate destination are key factors influencing patient outcomes, including morbidity and mortality (Spoelder et al., 2022).

Principles of Safe Patient Transport

Before initiating transport, emergency personnel must perform a thorough assessment of the patient's condition to determine the most appropriate method of transfer. Improper handling during transport can exacerbate injuries, particularly spinal, orthopedic, or internal injuries. According to the WHO, the following principles should be observed (WHO, 2005; Erdil et al., 2020; Holleran, 2009):

- Maintain cervical spine immobilization if spinal injury is suspected.
- Ensure airway, breathing, and circulation (ABCs) are stable before transport.
- Use appropriate lifting and moving techniques to avoid further injury to the patient or rescuer.
- Select suitable transport equipment, such as stretchers, backboards, or scoop stretchers, based on the nature of injuries and the environment.
- After assessing the patient, they are classified based on priority as outlined below:

  - First priority for transport (critical emergencies): Individuals with chest, facial, or neck injuries; respiratory distress; loss of consciousness; severe bleeding; extensive burns; heatstroke; or those in shock.
  - Second priority for T\transport (urgent cases): Individuals who have had a tourniquet applied; those with head, abdominal, jaw, facial, or internal organ injuries; gunshot wounds; internal bleeding; moderate crush injuries; hypothermia; or exposure to low doses of radiation.
  - Third priority for transport (non-urgent cases): Individuals with minor injuries, fractures, sprains, small burns or those experiencing stress reactions.
  - Fourth priority for transport (Deceased or those with minimal chance of survival): Deceased individuals and those who are near death; those with extremely extensive burns; severe crush injuries with deep shock; or those exposed to excessive levels of radiation.
- General principles of transporting the patients are follows:
  - Evaluate the situation for potential safety hazards (e.g., utilities, gasoline, propane, fuel oil, water, sanitary systems, movement of vehicles, or release of high-pressure systems).
  - Secure the accident scene.
  - Wear personal protective equipment (PPE) appropriate to the hazards on the scene (e.g., gloves, goggles, or self-contained breathing apparatus).
  - Gain access to the patient.
  - Provide life-sustaining care to the patient.
  - Disentangle the patient from the vehicle.
  - Prepare the patient for removal from the accident scene (e.g., place cervical collar).
  - Remove the patient.
  - Prepare the patient for transport to the hospital.
  - Provide the patient with treatment and route.
  - When a rescue takes place in a wilderness or backcountry setting, the TOMAS mnemonic should be utilized to guide the response effectively.
    - T: Terrain (exposure, cliffs, water, forest, vegetation, hiking terrain, snow)
    - O: Obstacles (trees, loose rock, debris, wires, daylight, rotor wash, blade clearance)
    - M: Method (type of insertion and location, landing near or remote from patient, hover load)
    - A: Alternatives (wait for search and rescue, ferry search and rescue personnel, relocate patient, no go/ abort mission)
    - S: Safety (first, last, always)

Methods for Transport

Different methods and devices may be used depending on the injury type, number of patients, and environmental factors (Erdil et al., 2020; Hunt & American Academy of Orthopaedic Surgeons, 2021):

The following positions should be used when transporting a patient:

- Conscious patient with leg, hip or spinal fractures: Supine (lying on the back) and flat position.
- Unconscious or patient in shock, or when CPR and artificial respiration are being performed during transport: Supine with legs elevated.
- Comatose or unconscious patient: Lateral recumbent (recovery) position.
- Patients with breathing difficulties such as pulmonary edema or asthma: Semi-sitting (semi-fowler's) position.
- In pregnant women with umbilical cord prolapse or partial breech delivery: Supine with hips elevated.
- In cases of head trauma or stroke: Supine with the head elevated about ten degrees.
- Patients with chest pain or intrathoracic bleeding: Semi-sitting position.

As a general rule, the position of the patient or injured person should not be changed. However, in the event of an exceptional danger, emergency transport may be necessary despite the risks. Injured individuals should be moved to a safe location as quickly as possible.

Dragging Methods

Dragging is a transport method commonly used to evacuate heavy or large patients, especially from confined, low-clearance, or obstructed areas where standard carrying techniques are not feasible. When possible, a blanket should be used to reduce friction and provide additional support during dragging.

1. Dragging by the ankles

This method is appropriate for patients or injured individuals without trauma and when the surface is flat and free of obstacles, eliminating the risk of head injury from contact with the ground. The rescuer holds the patient's ankles and drags them backward, ensuring that the head, neck, and torso remain aligned during movement (Figure 2.11-1).

Figure 2.11-1. Dragging by the ankles

2. Dragging by the armpits

If the surface is unsuitable for ankle dragging (e.g., due to debris or uneven terrain), the armpit dragging method should be used. Follow these steps (Figure 2.11-2):

- Lay the patient/injured person flat on their back.
- Kneel at the head end of the patient.
- Slide your arms under the patient's armpits.
- Secure a firm grip under the armpits.
- Rest the patient's head against your forearms, turn slightly to one side, and walk backward to drag the individual safely.

Figure 2.11-2. Dragging by the armpits

3. Dragging with a blanket

Dragging a patient using a blanket is a safe and effective method, particularly for unconscious individuals, as it minimizes the risk of twisting or straining the spine, arms, or legs. This technique provides stable support and allows for smoother movement over various surfaces. To perform blanket dragging:

- The rescuer rolls one half of the blanket lengthwise and places the rolled portion alongside the patient.
- The patient is gently turned toward the rescuer to allow placement of the rolled blanket as close as possible to the body.
- The patient is then carefully returned to a supine (lying on the back) position, and the rolled section is pulled through from underneath.
- The other side of the blanket is then rolled toward the patient.
- The rescuer grasps the end of the blanket near the patient's head and drags them to safety.

This method ensures that the patient's body remains aligned and supported throughout the movement.

4. Dragging using clothing (carrying the patient by pulling the collar)

This method is used when no blanket or similar materials are available. It is crucial during dragging to prevent the head from dropping and to ensure the torso remains aligned and straight throughout the movement. This method is effective for quickly removing a patient from a hazardous area when resources are limited. Steps to perform collar dragging:

- The rescuer grasps the clothing at the patient's shoulder area.
- The patient is dragged along the long axis of the body to maintain proper alignment.
- The rescuer supports the patient's head with their arms during movement.
- Using leg and back muscles for support and stability, the rescuer pulls the patient to safety.

5. Over-the-neck dragging (neck-supported carry)

This method is particularly useful for removing a patient or injured person from narrow or confined spaces where standard carrying techniques are impractical. This technique enables controlled movement through tight spaces while maintaining support for the patient's upper body. Steps to perform over-the-neck dragging:

- The patie nt's hands are secured together using a tie, cloth, or similar material.
- The rescuer then passes their neck between the patient's bound hands, allowing the arms to rest securely over the rescuer's shoulders.
- In a straddling position over the patient, the rescuer crawls on hands and knees, dragging the patient to safety.

6. Vehicle extrication technique (rautek maneuver)

The Rautek maneuver is used to safely extract an injured person from a vehicle in life-threatening situations such as respiratory arrest, fire, or risk of explosion, with minimal risk of spinal injury. This technique is essential in emergencies where rapid evacuation is required while prioritizing spinal protection. Steps for performing the maneuver (Figure 2.12-3):

- Ensure that the patient's feet are not trapped between the pedals and remove the seatbelt if present.
- Approach the injured person from the side.
- Using one hand, grasp the patient's arm, and with the other hand, support the chin to stabilize the head and neck.
- Carefully pull the patient straight out of the vehicle, maintaining alignment of the head, neck, and torso as much as possible.
- Once clear of the vehicle, gently lower the patient to the ground or a stretcher.

Figure 2.12-3. The Rautek maneuver

Fast Carrying Techniques for Short Distances Fast Carrying

Fast carrying techniques for short distances are essential in emergency situations and can be performed by either one or two rescuers, depending on the condition of the injured person and the surrounding environment.

1. **Techniques with a single first aider**

Carrying in the arms: This method is used for conscious adults without trauma. It allows for safe and supportive transport over short distances. This technique is ideal for moving non-traumatized individuals from one place to another when other methods are not required or feasible. To perform this carry, the first aider should:

- Place one arm under the patient's knees to support the lower body.
- Use the other arm to support the patient's torso, holding securely from the back.
- Instruct the patient to wrap their arms around the rescuer's neck, which helps the patient feel secure and stable during the movement.
- Bend at the knees and use leg strength to lift the patient safely.

Piggyback carry (back carry): This method is used to transport conscious patients or injured individuals who are able to maintain some degree of stability and cooperation during movement. This technique is effective for short-distance transport in situations where stretchers or wheelchairs are unavailable. To perform this carry, the first aider should (Figure 2.11-4):

- Squat in front of the seated patient, positioning their back against the patient's chest.
- Ask the patient to cross their arms over the rescuer's chest, while the rescuer grasps the patient's arms and supports their legs from underneath.
- Using leg strength, the rescuer lifts the patient by rising from the squat, ensuring balance and stability.

Figure 2.11-4. Piggyback carry

Shoulder carry (firefighter's carry): The firefighter's carry is used to transport unconscious or non-ambulatory patients. It is particularly useful in emergency situations such as fire evacuations or when navigating stairs, as the rescuer retains one free arm for balance or support. This method allows for rapid and effective evacuation while maintaining control and minimizing strain on the rescuer. To perform this carry, the first aider should (Figure 2.11-5):

- Bring the patient to a seated position by supporting them under the left arm and shoulder.
- Squat down and pass their right arm between the patient's legs.
- Lift the patient's body onto the right shoulder, balancing their weight securely.
- With the left hand, grasp the patient's right wrist, and using leg strength, stand up carefully.
- Grasp the patient's free wrist in front and quickly evacuate the area.

Figure 2.11-5. Firefighter's carry

2. **Fast carrying techniques with two first aids**

Carrying by hands (golden cradle): The "Golden Cradle" technique is used when the patient or injured person has no serious injuries and can cooperate during transport. This method can be performed using two, three, or four hands, depending on the number of rescuers and the condition of the patient. This technique provides a secure and coordinated way to carry a conscious, lightly injured individual without specialized equipment. This method follows (Figure 2.11-6):

- Two first aiders face each other and interlock hands beneath the seated patient's legs, forming a stable base.
- One rescuer supports the patient from the back, while the other grips the waist or belt. Alternatively, both may hold the patient by the belt for stability.
- The rescuers then lift and carry the patient together.

Figure 2.11-6. Golden cradle technique

3. **Three-hand and four-hand techniques**

These manual carrying techniques are suitable for conscious patients without severe injuries, particularly when the patient is able to assist during the transfer. The three-hand method is ideal when one leg is injured or immobilized, while the four-hand method offers greater support and is used when two rescuers are available.

Three-hand carry (for a patient with one injured leg): This method is used when the patient has an injury to a single leg, such as one that is splinted, and requires support from underneath during transport (Figure 2.11-7):

- The first rescuer grasps the patient's left wrist with their right hand.
- The second rescuer, positioned on the side of the injured leg, keeps their inner hand free and uses their other hand to grasp the first rescuer's wrist.
- The patient is gently seated onto the rescuers' interlocked wrists, with the injured leg supported from beneath during transport.

2.11-7. Three-hand carry

Four-hand carry: This method provides a stable seat for carrying conscious patients over short distances. These techniques offer safe, coordinated, and equipment-free transport options in non-critical situations. This method includes following steps (Figure 2.11-8).

- Each rescuer first grasps their own left wrist with their right hand.
- Then, each rescuer grabs the other rescuer's right wrist, creating a square seat with four interlocked hands.
- Both rescuers kneel on one knee in front of the patient.
- The patient is seated on the formed hand seat and holds onto the rescuers' shoulders or necks for balance while being carried.

Figure 2.11-8. Four-hand carry

Techniques for Placing a Patient on a Stretcher

1. **Scoop technique**

The scoop technique is used when access to the patient is limited to one side and requires the assistance of three first aiders. This method ensures minimal movement of the patient and is particularly useful in suspected spinal or musculoskeletal injuries. This technique ensures safe and coordinated movement, minimizing the risk of further injury. To apply the scoop technique (Figure 2.11-9):

- All three first aiders kneel on one knee on the same side of the patient. The strongest rescuer is positioned in the middle, while the rescuer at the head assumes control and gives verbal commands throughout the procedure.
- The patient's arms are crossed over the chest, and if wearing a belt, the hands are placed inside the belt to stabilize the upper body. The patient should lie flat and aligned.
- The first rescuer supports the head and shoulders, the second supports the lower back and thighs, and the third supports under the knees and ankles.
- The rescuer at the head checks if everyone is ready, then gives a coordinated lift command after counting to three. All rescuers lift the patient simultaneously to rest on their knees.
- Once stabilized, they stand together in unison, and in a single, fluid motion, they rotate the patient toward their chests and gently place them onto the stretcher.

Figure 2.11-9. Scoop technique

2. **Opposite-facing lift technique**

The opposite-facing lift technique is employed particularly in cases of suspected spinal injuries and requires three first aiders to ensure the patient is moved without compromising spinal alignment. This technique ensures minimal spinal movement and is vital in trauma situations where spinal injury is suspected. To perform this technique:

- Two first aiders kneel on opposite sides of the patient at chest level, while the third kneels at knee level.
- The patient's arms are crossed over the chest. If a belt is present, the patient's hands are placed inside it to stabilize the upper body. The patient should be positioned flat and aligned.
- The two rescuers at the head and chest level place their hands under the back, carefully maintaining head-neck-spine alignment.
- The third rescuer supports the knees and ankles.
- On a coordinated command, the team lifts the patient as one unit while keeping the body straight and places them gently onto the stretcher.

3. **Bridge technique**

The bridge technique is used when the patient or casualty can be accessed from both sides, and it requires four first aiders for safe and coordinated lifting. This technique ensures a stable transfer with minimal body movement, making it ideal for trauma cases where spinal protection is critical. To perform this technique (Figure 2.11-10):

- All four first aiders position themselves by straddling the patient, squatting down slightly over the casualty to prepare for lifting.
- The first aider supports the head, neck, and shoulders, ensuring spinal alignment and head protection. The second aider holds the patient firmly at the hips. The third aider supports the legs just below the knees.
- On the command of the first aider, all three lift the patient simultaneously in a coordinated, level motion.
- The fourth aider slides the stretcher smoothly under the patient between the legs of the other rescuers.
- The patient is then gently lowered onto the stretcher.

Figure 2.11-10. Bridge technique

Transporting a Casualty with a Stretcher

As a general rule, transporting the patient or casualty with a stretcher is the preferred method. In the absence of a stretcher, alternative materials that can function as a stretcher may be used. For instance, a makeshift stretcher can be created by placing a sturdy sheet between two long poles, or by folding the edges of a blanket to provide support. However, it is crucial that these improvised materials are strong enough to avoid tearing or breaking during transport.

When using a stretcher, the following general principles should be observed:

- The patient should be wrapped in a blanket or sheet to maintain warmth and stability.
- The patient must be secured to the stretcher with straps or ties to prevent falling.
- The head should always be positioned in the direction of movement.
- The stretcher must be kept in a horizontal position at all times.
- If the patient's condition changes, they should be repositioned appropriately before continuing transport.
- The patient's condition must be monitored continuously during the transfer.
- The strongest first aider should support the head end of the stretcher.
- A designated team leader should be in charge of coordinating all stretcher movements and issuing commands. For example:
  - "Lift stretcher" should be used to raise the stretcher in unison.
  - "Move back" when a reverse movement is needed.
  - "Lower stretcher" when placing it down.

1. **Carrying a stretcher with two people**

This technique is used when two first aiders are available to carry a stretcher. The procedure is as follows:

- Both first aiders squat down, keeping their backs straight and knees bent, positioning themselves at the inner sides of each end of the stretcher.
- Upon the command, they lift the stretcher simultaneously, and begin to walk in synchronized, alternating steps following another command.
- The first aider walking at the front is responsible for alerting the team to any potential obstacles along the path.

2. **Carrying a stretcher with four people**

When the patient's condition is critical, or if the transport distance is long, difficult, or includes obstacles, four-person stretcher carrying is recommended. The procedure is as follows:

- Two first aiders position themselves at the head end, and the other two at the foot end of the stretcher. All four squat beside the stretcher with straight backs and bent knees, firmly grasping the handles. Upon the command "Lift the stretcher," they raise it simultaneously.
- At the command "Proceed," they begin walking using the inner leg first, maintaining synchronization. The "Inside–Outside" command helps coordinate the steps to prevent jostling the patient.
- When navigating through narrow spaces, first aiders position themselves with their backs toward the inside of the stretcher for better control and maneuverability.
- While ascending or descending stairs or slopes, the stretcher must be kept as horizontal as possible. During upward movements (e.g., stair climbing or transferring to an ambulance or bed), the head of the patient should lead.

ACKNOWLEDGES

Some of the figures in this book were developed or adapted with the assistance of AI-based illustration support through OpenAI's ChatGPT. We gratefully acknowledge this contribution in the visual representation of first aid practices in disaster settings.

REFERENCES

Abdul-Jabbar, A., Yilmaz, E., Fisahn, C., Drazin, D., Blecher, R., Uppal, M., Phernetton, B. L., Altafulla, J., Oskouian, R. J., & Chapman, J. R. (2019). Disaster scenarios in spine surgery: A survey analysis. *Spine*, *44*(14), 1018–1024. https://doi.org/10.1097/BRS.0000000000003040

Aciksari, K., Koçak, M., Solakoglu, G., & Bodas, M. (2024). The effect of multiple triage points on the outcomes (time and accuracy) of hospital triage during mass casualty incidents. *Injury*. Advance online publication. https://doi.org/10.1016/j.injury.2024.111318

Adams, T., Stacey, E., Stacey, S., & Martin, D. (2012). Exertional heat stroke. *British Journal of Hospital Medicine (London)*, *73*(2), 72–78.

Alesi, A., Bortolin, M., Ragazzoni, L., & Lamberti-Castronuovo, A. (2023). Primary health care and disasters: Applying a "whole-of-health system" approach through reverse triage in mass-casualty management. *Prehospital and Disaster Medicine*, *38*(5), 654–659. https://doi.org/10.1017/S1049023X23006246

Alghamdi, F. A., Alghamdi, G. A., Almatrafi, W. S., Alghamdi, R. F., Kelantan, S. R., Abdulsamad, F. F., Bawahab, N. S., Babateen, O., Albar, H. T., & Hariri, N. H. (2024). Public awareness levels regarding cervical spine injury and the suitable first aid response among adults in Makkah, Saudi Arabia. *International Journal of General Medicine*, *17*, 6253–6267. https://doi.org/10.2147/IJGM.S482337

Allan, K., McCulloch, H., Ruether, K., Zotzman, J., Blanchard, I., Janczyszyn, M., & Dhillon, S. (2024). Acceptability and effectiveness of a novel, video-based CPR and AED education program in Canadian schools. *Circulation*. Advance online publication.

AlQhtani, A. Z., Al-Swedan, N. H., Alkhunani, T. A., Basalem, A. A., Alotaibi, A. M., Alsaygh, K. W., AlSahabi, A. M., & Alabdulkarim, A. O. (2024). Knowledge, attitudes, and practices regarding electrical burns. *Journal of Burn Care & Research*, *45*(2), 478–486. https://doi.org/10.1093/jbcr/irad182

American Academy of Dermatology Association. (2023). *First aid for insect stings*. Retrieved June 17, 2025, from https://www.aad.org/public/everyday-care/injured-skin/bites/treat-bee-sting

American Diabetes Association. (2023). Standards of care in diabetes—2023: Emergency preparedness. *Diabetes Care*, *46*(Suppl 1), S259–S265. https://doi.org/10.2337/dc23-S020

American Heart Association, & American Red Cross. (2024). 2024 American Heart Association and American Red Cross guidelines for first aid. *Circulation*, *150*(24), e1000–e1024. https://doi.org/10.1161/CIR.0000000000001281

American Heart Association. (2020). *Highlights of the 2020 American Heart Association guidelines for CPR and ECC*. Retrieved June 17, 2025, from https://cpr.heart.org

American Heart Association. (2023). *Heart attack symptoms, risk, and recovery*. Retrieved June 17, 2025, from https://www.heart.org/en/health-topics/heart-attack

Anders, J. F., Anderson, C., Wright-Johnson, C., & O'Connell, K. J. (2025). Improving the quality of pediatric basic life support cardiopulmonary resuscitation with a novel method: The Maryland hiccup. *Cureus*, *17*, e000000.

Australian and New Zealand Committee on Resuscitation. (n.d.). *ANZCOR guideline 9.4.1: First aid man-*

agement of Australian snake bite. Retrieved June 17, 2025, from https://survive-student-resource.austererisk.com/environmental/anzcor_9_4_1_snake_bite/

Asan, C., Mursalov, E., Demirba, A., Soylu, E., Bilge, S., Topan, C., Kaba, Y., & Alkan, A. (2023). Evaluation of mandibular fracture patterns and treatment methods: A single center retrospective study. *Annals of Medical Research*, *30*(7), 656–662. https://doi.org/10.5455/annalsmedres.2023.05.120

Atique, H., Atique, H., Shamoon, S., Azeem, H., & Hussain, S. (2023). Knowledge of first aid treatment of burns: A comparative study of parents and non-parent adults. *Eplasty*, *23*, e31.

Azad, R. V., Kumar, N., Sharma, Y. R., & Vohra, R. (2004). Role of prophylactic scleral buckling in the management of retained intraocular foreign bodies. *Clinical and Experimental Ophthalmology*, *32*(1), 58–61.

Bartos, J., Agdamag, A. C., Kalra, R., Nutting, L., Frascone, R., et al. (2023). Supraglottic airway devices are associated with asphyxial physiology after prolonged CPR. *Resuscitation*. Advance online publication.

Basile, A., Spagnuolo, R., Cosco, V., Rodinò, S., Luzza, F., & Abenavoli, L. (2023). Esophageal rupture after Heimlich maneuver: A case report and literature review. *Minerva Gastroenterology*, *69*(2), 156–160.

Basit, H., Wallen, T. J., & Dudley, C. (2025). Frostbite. In StatPearls. *StatPearls Publishing*. Retrieved June 17, 2025, from https://www.ncbi.nlm.nih.gov/books/NBK536914/

Bayageldi, N., & Binici, D. (2024). Are nursing students ready to respond to disasters? A study on self-efficacy of nursing students to apply psychological first aid. *Nurse Education Today*, *143*, 106367. https://doi.org/10.1016/j.nedt.2024.106367

Bielski, K., Smereka, J., et al. (2021). Meta-analysis of chest compression–only versus standard CPR. *Resuscitation Plus*.

Bobko, J. P., Badin, D., Danishgar, L., Bayhan, K., Thompson, K., Harris, W. J., Baldridge, R., & Fortuna, G. R. (2020). How to stop the bleed: First care provider model for developing public trauma response beyond basic hemorrhage control. *Western Journal of Emergency Medicine*, *21*, 365–373. https://doi.org/10.5811/westjem.2020.1.44856

Boehringer, T. I., & Kissela, B. M. (2020). Aspirin in the prevention and treatment of cardiovascular disease. *The American Journal of Medicine*, *133*(1), 10–14. https://doi.org/10.1016/j.amjmed.2019.06.030

Bourke, L., Bourke, E., Cullinane, A., O'Connell, E., & Idrees, Z. (2021). Clinical outcomes and epidemiology of intraocular foreign body injuries in Cork University Hospital, Ireland: An 11-year review. *Irish Journal of Medical Science*, *190*(3), 1225–1230. https://doi.org/10.1007/s11845-020-02446-1

Cantu, M., & Kondis, J. (2021). Abusive burns. In L. K. Murray et al. (Eds.), *Handbook of interpersonal violence and abuse across the lifespan*. Springer. https://doi.org/10.1007/978-3-319-62122-7_249-1

Carlson, J., & Wang, H. E. (2020). Optimal airway management in cardiac arrest. *Critical Care Clinics*, *36*(4), 705–714. https://doi.org/10.1016/j.ccc.2020.06.001

Cauchy, E., Chetaille, E., Marchand, V., & Marsigny, B. (2001). Retrospective study of 70 cases of severe frostbite lesions: A proposed new classification scheme. *Wilderness & Environmental Medicine*, *12*(4), 248–255.

Centers for Disease Control and Prevention. (n.d.). *Insects and scorpions at work*. Retrieved June 17, 2025, from https://www.cdc.gov/niosh/outdoor-workers/about/insects-and-scorpions.html

Centers for Disease Control and Prevention. (2024). *First aid for seizures*. Retrieved June 17, 2025, from https://www.cdc.gov/epilepsy/first-aid-for-seizures/index.html

Centers for Disease Control and Prevention. (2022). Heart disease facts. Retrieved June 17, 2025, from https://www.cdc.gov/heartdisease/facts.htm

Centers for Disease Control and Prevention. (2023). Stroke signs and symptoms. Retrieved June 17, 2025, from https://www.cdc.gov/stroke/signs_symptoms.htm

Centers for Disease Control and Prevention. (2023). Tick removal and tickborne disease prevention. Retrieved June 17, 2025, from https://www.cdc.gov/ticks

Centers for Disease Control and Prevention. (2024). CDC's core infection prevention and control practices for safe healthcare delivery in all settings. Retrieved June 17, 2025, from https://www.cdc.gov/infection-control/hcp/core-practices/index.html

Centers for Disease Control and Prevention. (2024). Diabetes care during emergencies. Retrieved June 17, 2025, from https://www.cdc.gov/diabetes/articles/diabetes-care-emergencies.html

Chai, H., Chaudhari, N., Kornhaber, R., Cuttle, L., Fear, M., Wood, F., & Martin, L. (2022). Chemical burn to the skin: A systematic review of first aid impacts on clinical outcomes. Burns, 48(7), 1680–1688. https://doi.org/10.1016/j.burns.2022.05.006

Chan, Y., Selvaratnam, V., James, L., & Nayagam, S. (2020). Paediatric open tibial fractures: Do children require a modified approach to that advised by the British Orthopaedic Association and British Association of Plastic Reconstructive and Aesthetic Surgeons in the UK? Journal of Pediatric Orthopaedics B, 30(1), 19–24. https://doi.org/10.1097/BPB.0000000000000721

Charlton, N., Swain, J., Brożek, J., Ludwikowska, M., Singletary, E., Zideman, D., Epstein, J., Darzi, A., Bąk, A., Karam, S., Leś, Z., Carlson, J., Lang, E., & Nieuwlaat, R. (2020). Control of severe, life-threatening external bleeding in the out-of-hospital setting: A systematic review. Prehospital Emergency Care, 25(2), 235–267. https://doi.org/10.1080/10903127.2020.1743801

Chougule, U., Sharma, K., Kolekar, S. S., Nerlekar, H. V., & Gupta, S. (2025). Informed consent in surgery: Legal and ethical considerations. Journal of Neonatal Surgery.

Costable, N., Costable, J., & Rabin, G. (2024). The use of LifeVac, a novel airway clearance device, in the assistance of choking victims aged five and under: Results of a retrospective 10-year observational study. Journal of Pediatric Critical Care. https://doi.org/10.4103/jpcc.jpcc_3_24

Cuthbertson, J., & Weinstein, E. (2020). Spinal immobilization in disasters: A systematic review. Prehospital and Disaster Medicine, 35(4), 406–411. https://doi.org/10.1017/S1049023X20000680

Dadashzadeh, A., Khani, J., & Soleymani, M. (2019). Triage in the mass casualties in pre-hospital emergency. Journal of Injury and Violence Research, 11(4 Suppl 2), Article 146.

Djarv, T., Rogers, J., Semeraro F., Bra L. et all. (2025). *European Resuscitation Council Guidelines 2025: First Aid*. *Resuscitation*, 199, 110736. https://doi.org/10.1016/j.resuscitation.2025.110736

Elhussain, M. O., Ahmed, F. K., Mustafa, N., Mohammed, D. O., Berkiah, I., Alnaeim, N., … & Abdelrahman,

N. (2024). The role of automated external defibrillator use in the out-of-hospital cardiac arrest survival rate and outcome: A systematic review. *Circulation*. https://doi.org/10.1161/circ.150.suppl_1.4141290

Eli, I., Lerner, D., & Ghogawala, Z. (2021). Acute traumatic spinal cord injury. *Neurologic Clinics*, *39*(2), 471–488. https://doi.org/10.1016/j.ncl.2021.02.004

Erdil, F., Bayraktar, N., & Şenol Çelik, S. (2020). Hayvan ve insan ısırmaları. In *Temel ilk yardım* (Bölüm 10).

Erdil, F., Bayraktar, N., & Şenol Çelik, S. (2020). Yaralının kaza ortamından çıkarılması ve taşınması. In *Temel ilk yardım* (Bölüm 13).

Epilepsy Foundation of Minnesota. (2025). *Seizure first aid*. Retrieved June 17, 2025, from https://www.epilepsyfoundationmn.org/about-epilepsy/seizure-first-aid/

Erfanian, R., Jazinizadeh, S., Karimi, E., Varpaei, H. A., Yazdani, R., & Habibi, S. (2024). Effect of jaw thrust, chin lift, and other maneuvers on upper airway obstruction during sleep endoscopy. *Indian Journal of Otolaryngology and Head & Neck Surgery*, *76*(3), 2273–2281.

European Resuscitation Council. (2015). *European Resuscitation Council guidelines for resuscitation 2015: Section 9. First aid*. Retrieved June 17, 2025, from https://ercguidelines.elsevierresource.com/european-resuscitation-council-guidelines-resuscitation-2015-section-9-first-aid

Franjić, S. (2022). Stopping bleeding is a priority in any injury. *International Journal of Clinical and Medical Case Reports*. https://doi.org/10.31579/2834-8664/009

Gallo, E., Quijal-Zamorano, M., Méndez Turrubiates, R. F., Tonne, C., Basagaña, X., Achebak, H., & Ballester, J. (2024). Heat-related mortality in Europe during 2023 and the role of adaptation in protecting health. *Nature Medicine*, 1–5.

Gete, B., Demas, T., Asrat, B., & Endeshaw, A. (2022). Knowledge, attitude, and practice towards burn first aid and its associated factors among caregivers attending burn units in Addis Ababa, Ethiopia: A cross-sectional study. *Annals of Medicine and Surgery*, *81*, 104402. https://doi.org/10.1016/j.amsu.2022.104402

Giarratano, G., Bernard, M., & Orlando, S. (2019). Psychological first aid. *The Journal of Perinatal & Neonatal Nursing*, *33*(3), 219–228. https://doi.org/10.1097/JPN.0000000000000419

Gomes, A. O., Araujo, L. S., Sales, M., Rezende, A. A. B., Araújo, W. N., … & Takada, J. A. P. (2020). Basic life support: A literature review about its relevance and level of knowledge of health professionals. *International Journal of Advanced Engineering Research and Science*. https://doi.org/10.22161/ijaers.71.20

Goyal, M., Menon, B. K., van Zwam, W. H., Dippel, D. W. J., Mitchell, P. J., Demchuk, A. M., … & Hill, M. D. (2016). Endovascular thrombectomy after large-vessel ischaemic stroke: A meta-analysis of individual patient data from five randomised trials. *The Lancet*, *387*(10029), 1723–1731. https://doi.org/10.1016/S0140-6736(16)00163-X

Grabmayr, A. J., Dicker, B., Dassanayake, V., Bray, J., Vaillancourt, C., Dainty, K. N., Olasveengen, T., & Hansen, C. M. (2024). Optimising telecommunicator recognition of out-of-hospital cardiac arrest: A scoping review. *Resuscitation Plus*, *20*, 100754. https://doi.org/10.1016/j.resplu.2024.100754

Grigg, S., & Grigg, C. (2018). Removal of ear, nose and throat foreign bodies: A review. *Australian Journal* *of General Practice*, *47*(11), 682–685.

Gupta, A., & Tripathy, K. (2023). Intraocular foreign body. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK576415/

Haghighi, M., Latifi, A., Nourian, A., & Tamri, P. (2024). Comparison of the effects of cinnamic acid and silver sulfadiazine on deep second-degree burns in rabbits. *Journal of Skin and Stem Cell*. https://doi.org/10.5812/jssc-145290

Handford, C., Buxton, P., Russell, K., Imray, C. E., McIntosh, S. E., Freer, L., Cochran, A., & Imray, C. H. (2014). Frostbite: A practical approach to hospital management. *Extreme Physiology & Medicine*, *3*, 7.

Haider, A. H., Haut, E. R., & Velmahos, G. C. (2017). Converting bystanders to immediate responders: We need to start in high school or before. *JAMA Surgery*, *152*(10), 909–910. https://doi.org/10.1001/jamasurg.2017.2231

Halter, M., Kulnik, S., Hilton, A., Baron, A., Garner, S., & Jarman, H. (2019). PP24 Lay understanding of head injury and when an ambulance might be needed: a mixed methods study. Emergency Medicine Journal, 36, e11 - e11. https://doi.org/10.1136/emermed-2019-999abs.24.

Heim, S. W., & Maughan, K. L. (2007). Foreign bodies in the ear, nose, and throat. *American Family Physician, 76*(8), 1185–1189.

Heller, A. R., Neidel, T., Klotz, P. J., Solarek, A., Kowalzik, B., Juncken, K., & Kleber, C. (2023). Validation of secondary triage algorithms for mass casualty incidents. Die Anaesthesiologie, 72, 1–9.

Hunt, R. J., & American Academy of Orthopaedic Surgeons. (2021). AEMT: Advanced Emergency Care and Transportation of the Sick and Injured Advantage Package. Jones & Bartlett Learning.

Holleran, R. S. (Ed.). (2009). ASTNA Patient Transport-E-Book: Principles and Practice. Elsevier Health Sciences.

Huff JS, Murr NI. Seizure. [Updated 2023 Feb 7]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430765/

Imray CH, Oakley EH. Cold still kills: cold-related illnesses in military practice freezing and non-freezing cold injury. J R Army Med Corps. 2005 Dec;151(McIntosh et al., 2024):218-22.

International Diabetes Federation (IDF). (2022). *Diabetes and disasters: Western Pacific Region manual (2nd ed.)*. Retrieved from https://idf.org/news/new-edition-of-diabetes-care-and-disasters-idf-western-pacific-region-manual/

Jang, J. H., Cho, J. S., Lim, Y. S., Hyun, S. Y., Woo, J. H., Choi, W. S., Choi, J. Y., & Yang, H. J. (2022). Disaster Response to a Mass Casualty Incident in a Hospital Fire by Regional Disaster Medical Assistance Team: Characteristics of Hospital Fire. Disaster medicine and public health preparedness, 16(1), 8–11. https://doi.org/10.1017/dmp.2020.164

Jauch, E. C., Saver, J. L., Adams, H. P., Bruno, A., Connors, J. J., Demaerschalk, B. M., ... & Yonas, H. (2013). Guidelines for the early management of patients with acute ischemic stroke. *Stroke, 44*(Rintamäki, 2000), 870–947. https://doi.org/10.1161/STR.0b013e318284056a

Johnston, S. C., Mendis, S., & Mathers, C. D. (2011). Global variation in stroke burden and mortality: Estimates from monitoring, surveillance, and modelling. *The Lancet Neurology, 8*(McIntosh et al., 2024),

345–354. https://doi.org/10.1016/S1474-4422(09)70023-7
Kaye, D., Chongwe, G., & Sewankambo, N. (2019). Ethical tensions in the informed consent process. BMC Medical Ethics, 20.

Kim, D. H., Seo, Y. W., & Jang, T. C. (2023). CPR quality with rotation of every 1 versus 2 minutes as characteristics of rescuers: A randomized crossover simulation study. Medicine, 102.

Kim, M., Shin, H., Kim, H., Choi, S., Kim, J., Lee, H., & Moon, J. (2022). Analysis of Factors Contributing to the Occurrence of Systemic Toxicity in Patients with Hydrofluoric Acid Skin Exposure Injury: An Individual Participant Data Meta-Analysis of 125 Clinical Cases from 1979 to 2020.. Journal of burn care & research : official publication of the American Burn Association. https://doi.org/10.1093/jbcr/irac063.

Kowal, B., O'Reilly, M., Lee, T.-F., & Schmölzer, G. (2024). Hand position during chest compression in infantile piglets – Do you need to encircle the chest with the 2-thumb technique? Resuscitation Plus, 21, 100857. https://doi.org/10.1016/j.resplu.2024.100857

Kragh, A. R., Kjærholm, S., Flarup, L. C. H., Grabmayr, A. J., Borch-Johnsen, L., Folke, F., Tjørnhøj-Thomsen, T., Hassager, C., & Hansen, C. M. (2024). Barriers for responding to pediatric out-of-hospital cardiac arrest during emergency medical calls: A qualitative study. Journal of the American Heart Association. https://doi.org/10.1161/JAHA.124.035636

Krammel, M., Frimmel, N., Hamp, T., Grassmann, D., Widhalm, H., Verdonck, P., Reisinger, C., Sulzgruber, P., & Schnaubelt, S. (2023). Outcomes and potential for improvement in the prehospital treatment of penetrating chest injuries in a European metropolitan area: A retrospective analysis of 2009 - 2017.. Injury, 110971 . https://doi.org/10.1016/j.injury.2023.110971.
Kulakoğlu, B., Uzunay, Z., Pota, K., Varhan, N., & Fırat, M. (2023). Evaluation of musculoskeletal injuries after the 2023 Kahramanmaras earthquake: A local hospital experience. Joint Diseases and Related Surgery, 34, 509 - 515. https://doi.org/10.52312/jdrs.2023.1100.

Lafrance, M., Recher, M., Javaudin, F., Chouihed, T., Wiel, E., Helft, G., Hubert, H., & Canon, V. (2023). Bystander basic life support and survival after out-of-hospital cardiac arrest: A propensity score matching analysis. The American Journal of Emergency Medicine, 67, 135–143. https://doi.org/10.1016/j.ajem.2023.02.028

Lee, J. E., Lee, J., Oh, J., Park, C., Kang, H., Lim, T., & Yoo, K. (2019). Comparison of two-thumb encircling and two-finger technique during infant cardiopulmonary resuscitation with single rescuer in simulation studies. Medicine, 98(30), e17853. https://doi.org/10.1097/MD.0000000000017853

Lee, J. A., Singletary, E., Charlton, N., & Charlton, N. P. (2020). Methods of honey bee stinger removal: a systematic review of the literature. Cureus, 12(5).

Lemeschewskij, A., Lemeschewskaya, S., Bautsiuk, M., Klimuk, S., Hiniuk, V., Lemeschewskij, I., Charnenka, H., & Hiniuk, E. (2023). First aid in severe external bleeding: Updated recommendations and approaches to training. Medical Journal, 2023(2), 18–23. https://doi.org/10.51922/1818-426X.2023.2.18
Levine, J. M., Parekh, N. S., & Cooper, M. L. (2024). Contact with Wet Cement-A Preventable Cause of Chemical Burn: Case Report and Discussion. Advances in skin & wound care, 37(6), 292–296. https://doi.org/10.1097/ASW.0000000000000144

Liang, L. D., Leung, K. B. B., Chan, T. C. Y., Deakin, J., Heidet, M., Meckler, G., … & Grunau, B. (2022). Pediatric and Adult Out-of-Hospital Cardiac Arrest Incidence Within and Near Public Schools in British Columbia: Missed Opportunities for Systematic AED Deployment Strategies. Resuscitation.

Lotterman, S., Sutton, A. E., & Hohman, M. H. (2025). Ear foreign body removal. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK459136/

Lyng, J., Ward, C., Angelidis, M., Breyre, A., Donaldson, R., Inaba, K., Mandt, M., & Bosson, N. (2024). Prehospital Trauma Compendium: Traumatic Pneumothorax Care - a position statement and resource document of NAEMSP.. Prehospital emergency care, 1-35 . https://doi.org/10.1080/10903127.2024.2416978.

Machado, D. S., Vazquez-Colon, Z., Botelho, V., Garvan, C., Lopez-Colon, D., Rodriguez, D., ... & Cascio, E. (2025). Cardiopulmonary resuscitation training decreases anxiety levels in parents of infants with congenital heart disease. Cardiology in the Young, 1–6. https://doi.org/10.1017/S1047951124026441

Maniscalco K, Edens MA. Animal Bites. [Updated 2022 Sep 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430852/)

Masoumi, L., Daneshmand, S., & Roshanzamir, S. (2021). Investigating the Prevalence of Peripheral Neuropathy in Chemical Burns. , 8, 23-28. https://doi.org/10.32598/JROSJ.8.1.742.1.

Mathew, M. J., Kundra, P., & Vinayagam, S. (2023). Chest compression quality comparing 1-min vs 2-min rotation of rescuers wearing N95 masks. The American Journal of Emergency Medicine, 76, 75–81.

McAuley, C., Mullen, S., Corley, L., McDonald, R., & Quinn, N. (2023). Secondary survey in paediatric trauma. Archives of Disease in Childhood – Education & Practice Edition.

McIntosh, S. E., Freer, L., Grissom, C. K., Rodway, G. W., Giesbrecht, G. G., McDevitt, M., ... & Hackett, P. H. (2024). Wilderness Medical Society clinical practice guidelines for the prevention and treatment of frostbite: 2024 update. Wilderness & Environmental Medicine, 35(Basit et al., 2025), 183-197.

Millán, M., Ordoñez, C., Parra, M., Caicedo, Y., Padilla, N., Pino, L., Rodríguez-Holguín, F., Salcedo, A., García, A., Serna, J., Herrera, M., Quintero, L., Hernández, F., Serna, C., & Hadad, A. (2021). Hemodynamically unstable non-compressible penetrating torso trauma: a practical surgical approach. Colombia Médica : CM, 52. https://doi.org/10.25100/cm.v52i2.4592.

Missel, A. L., Gomez, A., Dowker, S. R., Rizk, D., Neumar, R. W., & Hunt, N. (2025). Accuracy of automated external defibrillator pad placement during out-of-hospital cardiac arrest resuscitation simulations. Prehospital Emergency Care, 1–4. https://doi.org/10.1080/10903127.2024.2438394

Mohamed, B. (2022). Airway management during cardiopulmonary resuscitation. Current Anesthesiology Reports, 12, 363–372.

Molnár, N., Nagy, F., Fritúz, G., Kovács, E., & Diószeghy, C. (2023). Out-of-hospital adult basic life support: New guidelines and the involvement of bystanders. Orvosi Hetilap, 164(12), 443–448. https://doi.org/10.1556/650.2023.32723

Morris A, Patel G. Heat Stroke. [Updated 2023 Feb 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK

Mtiraoui, A., Mahjoubi, H., Achour, A., Ghardallou, M., & Nakhli, J. (2025). The Impact of Psychological First Aid Training (RAPID-PFA) on Self-Efficacy, Perceived Competencies and Disaster Preparedness of

Nursing Students in Tunisian Public Institutions: A Randomized Controlled Trial. Journal of Contingencies and Crisis Management. https://doi.org/10.1111/1468-5973.70019.

Munjal, M., Kanotra, S., Munjal, S., Chopra, P., Saggar, V., Kaur, H., Sandhu, L., Binepal, T., Pillai, A., Chopra, H., & Uppal, S. (2023). Clinical manifestations of nasoethmoid-central midface and lateral mid midface trauma: an analytical study. International Journal of Otorhinolaryngology and Head and Neck Surgery. https://doi.org/10.18203/issn.2454-5929.ijohns20233213.

Nagao, K., Yonemoto, N., et al. (2021). The Impact of Cardiopulmonary Resuscitation Guidelines. Resuscitation.

Nam, Q., Thuan, N., Thang, N., & Cuong, N. (2023). 9. ASSESSMENT OF THE TREATMENT RESULTS OF NASAL BONE FRACTURES AT 103 MILITARY HOSPITAL. Tạp chí Y học Cộng đồng. https://doi.org/10.52163/yhc.v64i13.864.

Nonexertional (classic) heat stroke in adults, Section Editor: Daniel F Danzi, Deputy Editor: Jonathan S Grayzel, 2025

Noor, N., & Baseer, A. (2025). Impact of Imaging on Surgical Management of Penetrating Chest Trauma: Experience From a High-Volume Trauma Center in a Resource-Constrained Environment. Cureus, 17. https://doi.org/10.7759/cureus.77476.

Obara, T., & Naito, H. (2024). Spread of chest compression-only CPR during the COVID-19 pandemic. Resuscitation Plus.

Olasveengen, T. M., Semeraro, F., Ristagno, G., Castrén, M., Handley, A. J., Kuzovlev, A., … & Perkins, G. D. (2021). European Resuscitation Council Guidelines 2021: Basic Life Support. Resuscitation, 161, 98–114. https://doi.org/10.1016/j.resuscitation.2021.02.009

Olorunfemi, O., & Adesunloye, O. B. (2024). Disaster Preparedness and First Aid Response: The Role of Emergency Nurses. Archives of Medicine and Health Sciences.

Orpet, R. E., Barrett, W. J., Kaucher, K. A., Colwell, C., & Lyng, J. (2024). Prehospital Trauma Compendium: Vasopressors in Trauma - a Position Statement and Resource Document of NAEMSP. Prehospital Emergency Care, 1–7.

Owen, J. R., Kemp, D., van der Watt, P., Harris, J., Ang Li Ern, M., & Marais, L. (2024). Disaster scenes as a foundation for emergency response planning. International Journal of Disaster Risk Reduction

Pairi, A., & Imran, S. (2024). Effectiveness of Child and Infant Airway Management Training. West Science Interdisciplinary Studies, 2(7). https://doi.org/10.58812/wsis.v2i07.1141

Pareja, R. R., Delgado, R., Fuentes, F. T., Thissard-Vasallo, I. J., Rosa, D. S., & González, P. A. (2020). Prehospital triage for mass casualty incidents using the META method for early surgical assessment. European Journal of Trauma and Emergency Surgery, 46, 425–433.

Patel, S. N., Langer, P. D., Zarbin, M. A., & Bhagat, N. (2012). Diagnostic value of clinical examination and radiographic imaging in identification of intraocular foreign bodies in open globe injury. *European Journal of Ophthalmology, 22*(2), 259–268.

Pazarci, Ö., Talmaç, M., Sarı, B., & Sökücü, S. (2024). Review of the treatment options and results of earthquake-related pelvic injuries after the Türkiye earthquake on 6th February. Acta Orthopaedica et Traumatologica Turcica, 58, 229 - 234. https://doi.org/10.5152/j.aott.2024.23205.

Pek, J., Quah, L., Teng, K., Yeo, Y., & Lee, C. (2023). Developing the Disaster Medical Responder's Course in Singapore. Western Pacific Surveillance and Response Journal : WPSAR, 14, 1 - 6. https://doi.org/10.5365/wpsar.2023.14.6.1009.

Peng, M., Xiao, T., Carter, B., & Shearer, J. (2024). Evaluation of system based psychological first aid training on the mental health proficiency of emergency medical first responders to natural disasters in China: a cluster randomised controlled trial. BMJ Open, 14. https://doi.org/10.1136/bmjopen-2023-078750.

Penketh, J., & Nolan, J. (2023). Airway management during cardiac arrest. Current Opinion in Critical Care, 29, 175–180.

Pickham, D., Valdez, A., Demeestere, J., Lemmens, R., Diaz, L., Smith, B., & Ghaffari, A. (2019). Prognostic value of the FAST-ED score in predicting large vessel occlusion stroke. *Prehospital Emergency Care, 23*(Basit et al., 2025), 195–200. https://doi.org/10.1080/10903127.2018.1481448

Prescott, T., May, S., Horne, S., & Barnard, E. (2022). Prehospital emergency care in humanitarian settings: Ethical considerations. BMJ Military Health.

Raafat, A. I., El-Hag Ali, A., & Hassan, A. A. (2024). Radiation development and hemostatic performance of innovative hydroxypropyl methyl cellulose-based sponge dressings for controlling severe hemorrhagic wounds. International Journal of Biological Macromolecules, Article 139132.

Rahmania, A., & Dhomiri, H. R. (2020). Use of Full Outline of Unresponsiveness (FOUR) scale and Alert Verbal Pain Unresponsiveness (AVPU) scale to assess the level of consciousness in head injury patients: A systematic review. 4th International Conference on Nursing.

Rai, S., Bendale, M., Hanwate, M., Reddy, D., & Gandotra, A. (2023). Possibility of Avoiding Anesthesia in the Reduction of Greenstick and Angulated Forearm and Distal-End Radius Fractures in Children: A Comparative Study. Cureus, 15. https://doi.org/10.7759/cureus.38966.

Randolph, R., Morsch, G., & Chacko, S. (2019). Disaster Medicine: Disaster response and on-scene care. FP Essentials, 487, 27–33.

Rank, W. P. (2020). Seizure first aid for bystanders. Nursing2024, 50(Centers for Disease Control and Prevention [CDC], 2022), 11-12.

Rintamäki H. Predisposing factors and prevention of frostbite. Int J Circumpolar Health. 2000 Apr;59(Basit et al., 2025):114-21.

Roche-Nagle G, Murphy D, Collins A, Sheehan S. Frostbite: management options. Eur J Emerg Med. 2008 Jun;15(Rintamäki, 2000):173-5.

Sandhu, T., Szyld, E., Anderson, M. P., & Shah, B. (2022). Effect of rotating providers on chest compression performance during simulated neonatal cardiopulmonary resuscitation. PLoS ONE, 17.

Santos-Folgar, M., Otero-Agra, M., Fernández-Méndez, F., Hermo-Gonzalo, M. T., Barcala-Furelos, R., & Rodríguez-Núñez, A. (2018). Ventilación durante la reanimación cardiopulmonar en el lactante: ¿boca a boca y nariz o con bolsa autoinflable? Un estudio cuasiexperimental [Ventilation during cardiopulmonary resuscitation in the infant. Mouth to mouth and nose, or bag-valve-mask? A quasi-experimental study]. *Anales de pediatria*, *89*(5), 272–278. https://doi.org/10.1016/j.anpedi.2017.12.014

Saputro, M., Sudiro, S., Mahardini, F., & Shobirun, S. (2024). The Effectiveness of Role Play on Knowledge and Skills of Spinal Injury Indications Evacuation Improvement. JKG (Jurnal Keperawatan Global). https://doi.org/10.37341/jkg.v8i2.879.

Schwartz, R., & McNutt, R. (2020). The explosive mass casualty incident: Prehospital incident management and triage. In Disaster Medicine (pp. 189–206).

Shen, Y., Fu, L., Yue, Z., Shi, W., Li, C., & Zhang, C. (2024). First aid treatment and airway management for chemical burns combined with inhalation injury: A case report. Respirology case reports, 12(12), e70094. https://doi.org/10.1002/rcr2.70094

Shevchenko, O., Makarov, V., Shevchenko, R., Todoriko, L., Petrenko, V., Smolianyk, K., & Pohorielova, O. (2023). Penetrating combat-related thoracic trauma (review). Tuberculosis, Lung Diseases, HIV Infection. https://doi.org/10.30978/tb2023-2-68.

Skříšovská, D., & Djakow, J. (2024). Ventilation efficacy during paediatric cardiopulmonary resuscitation: A randomized manikin study. Children.

Spota, A., Giorgi, P., Cioffi, S., Altomare, M., Schirò, G., Legrenzi, S., Villa, F., Chiara, O., & Cimbanassi, S. (2023). Spinal injury in major trauma: Epidemiology of 1104 cases from an Italian first level trauma center.. Injury. https://doi.org/10.1016/j.injury.2023.02.039.

Spoelder, E. J., Slagt, C., Scheffer, G. J., & van Geffen, G. J. (2022). Transport of the patient with trauma: a narrative review. Anaesthesia, 77(Wilderness Medical Society, 2019), 1281-1287.

Stassen, W., Rambharose, S., Wallis, L. A., & Moodley, K. (2022). Acceptability of delayed consent for prehospital emergency care research. PLoS ONE, 17.

Suga, R., Igarashi, Y., Kitano, S., Suzuki, K., Yokobori, S., Ogawa, S., & Yokota, H. (2024). Effectiveness of the abdominal thrust maneuver for airway obstruction removal: Analysis of data from the National Emergency Medical Services Information System. Journal of Nippon Medical School, 91(3), 270–276.

Tang, S., & Chen, Z. (2021). Understanding Natural Disaster Scenes from Mobile Images Using Deep Learning. Applied Sciences, 11(9), 3952. https://doi.org/10.3390/app11093952

Tani, Akihiro & Nagao, Ken & Tahara, Yoshio & Nonogi, Hiroshi & Yonemoto, Naohiro & Gaieski, David & Ito, Noritoshi & Yagi, Tsukasa & Chiba, Nobutaka & Tachibana, Eizo & Sato, Naoki & Ikeda, Takanori. (2019). Abstract 141: Defibrillation Protocol Update Neurologically Intact Survival for Patients With Out-Of-Hospital Shockable Cardiac Arrest. Circulation. 140. 10.1161/circ.140.suppl_2.141.

Tawakul, A., Samkari, J., Babateen, O., Alzubaidi, B., Alhuzali, M., Alshinkity, M., Abeeri, N., Alshrif, A., Almalki, M., & Alnashri, A. (2024). Awareness of Spinal Cord Injury Among Medical Students at Umm Al-Qura University in Makkah City, Saudi Arabia: A CrossSectional Study. JOURNAL OF HEALTHCARE SCIENCES. https://doi.org/10.52533/johs.2024.40103.

Telefon, A., Çelik, Ü., Turgut, E., Gülmez, T., Çil, M., Sönmez, G., & Taner, S. (2024). 2023 catastrophic Turkey earthquake: clinical outcomes of pediatric patients rescued under the rubble. Postgraduate Medicine, 136, 430 - 437. https://doi.org/10.1080/00325481.2024.2354654.

Thapa, G., Sapkota, R., Thapa, A., Sharma, R., Lubetkin, D., Lubetkin, C., Nesemann, S., & Kharel, R. (2024). Pilot Training Program on Hands-Only CPR and Choking First Aid for Frontline Police Responders in Rural Nepal. Wilderness & Environmental Medicine, 35, 51 - 56. https://doi.org/10.1177/10806032241226691.

The Australian and New Zealand Committee on Resuscitation (ANZCOR), Guideline 9.3.6 - Cold Injury

Available at: https://survive-student-resource.austererisk.com/environmental/anzcor_9_3_6_cold_injuries/

Tomio, J., & Sato, H. (2014). Emergency and disaster preparedness for chronically ill patients: a review of recommendations. Open Access Emergency Medicine, 69-79.

Tran, T. T., Sleigh, A., Labond, C., & Banwell, C. (2024). Bystanders' Behaviour in Traffic Crashes: A Vietnamese Case of Confucian Morals, Social Relationships, and Good Samaritan Risks. Global Journal of Health Science.

Umpierrez, G. E., Davis, G. M., ElSayed, N. A., Fadini, G. P., Galindo, R. J., Hirsch, I. B., ... & Dhatariya, K. K. (2024). Hyperglycemic crises in adults with diabetes: a consensus report. Diabetes care, 47(8), 1257-1275.

Vandamme, K., Vermeire, L., Decuyper, B., Herbelet, S., & Van de Voorde, P. (2024). Dispatcher-assistance in lay rescuer infant CPR: Promoting the enhancement of the guiding protocol. Resuscitation. https://doi.org/10.1016/j.resuscitation.2024.110248

Wagenplast, A., Gräsner, J., Hannappel, L., Brinkrolf, P., Corzillius, M., Rösch, P., … & Seewald, S. (2022). Resuscitation academy Germany – systemic improvements for OHCA outcomes. BMJ Open Emergency Medicine.

Wang, W., Han, P., Yang, L., Meng, Z., Gan, H., Wu, Z., & Dou, G. (2023). A novel sodium polyacrylate-based stasis dressing to treat lethal hemorrhage in a penetrating trauma swine model. The Journal of Trauma and Acute Care Surgery.

Wang, J. L. (2024). Snakebite envenomation: first aid and rescue network. The Lancet, 403(10430), 908.

Warbung, B., Wahyudi, B., Widodo, P., & Management, D. (2024). Navigating the Terrain: Opportunities and Challenges of Implementing Psychological First Aid in Disaster Response. International Journal Of Humanities Education and Social Sciences (IJHESS). https://doi.org/10.55227/ijhess.v4i1.1062.

Wawrzynek, J., & Mścisz, Ł. (2024). Ventilation in cardiac arrest. Emergency Medical Service.

Werner, K., Singh, R., & Galliers, C. (2024). Safeguarding wildlife and human life: Rangers as first responders. Parks.

West, J., Morganstein, J., & Benedek, D. (2021). Fourteen Years Later: Hobfoll and Colleagues Five Principles of Psychological First Aid through the Lens of the COVID-19 Global Pandemic. Psychiatry, 84, 373 - 377. https://doi.org/10.1080/00332747.2021.2005440.

WHO, Control of Neglected Tropical Diseases, Available at: https://www.who.int/teams/control-of-neglected-tropical-diseases/snakebite-envenoming/treatment

World Health Organization (WHO). *Vector-borne Diseases Fact Sheet.* 2023. Available at: https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases

World Health Organization Regional Office for Africa. (2018). Primary eye care training manual: A course to strengthen the capacity of health personnel to manage eye patients at primary-level health facilities in the African Region (CC BY-NC-SA 3.0 IGO). https://apps.who.int/iris/handle/10665/275359

World Health Organization. (WHO) (2023). Primary ear and hearing care training manual. https://www.who.int/publications/i/item/9789240069152

World Health Organization. (WHO) (2021). *Noncommunicable diseases in emergencies*. Retrieved from https://www.who.int/publications/i/item/9789240034929

World Health Organization. (2022). Cardiovascular diseases (CVDs). https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

World Health Organization. (WHO). (2005). *Prehospital Trauma Care Systems*. World Health Organization. Available at https://www.who.int/publications/i/item/prehospital-trauma-care-systems

Xiao, X., & Wu, Z. (2022). A Narrative Review of Different Hemostatic Materials in Emergency Treatment of Trauma. Emergency Medicine International, 2022, Article 6023261.

Xiong, L., Le, J., Zhao, C., Yuan, R., Yang, M., & Shen, H. (2023). Clinical application of upper limb fracture fixator in emergency treatment of upper limb fracture. Pakistan Journal of Medical Sciences, 39, 1818 - 1823. https://doi.org/10.12669/pjms.39.6.7097.

Xue, F., Xiong, J., Zhang, P., Kou, Y., Han, S., Wang, T., Zhang, D., & Jiang, B. (2017). Pre-hospital and in-hospital first aid programs and specifications for spine and spinal cord injury in Beijing, China: study protocol for a prospective, multicenter, nonrandomized controlled trial. Asia Pacific Journal of Clinical Trials: Nervous System Diseases, 2, 58 - 65. https://doi.org/10.4103/2542-3932.205195.

Yiannakis CP, Hilmi OJ, (2024). Evaluation and management of acute upper airway obstruction, HEAD AND NECK, 42, 9, P675-683.

Zemaitis, M. R., Cindass, R., Lopez, R. A., & Huecker, M. R. (2025). Electrical Injuries. In StatPearls. StatPearls Publishing.

Zhong, R., Northrop, J., Sahota, P., Glick, H., & Rostain, A. (2019). Informed about informed consent: A qualitative study of ethics education. Online Journal of Health Ethics.

Zideman, D., Singletary, E., Borra, V., Cassan, P., Cimpoesu, C. D., De Buck, E., ... & Poole, K. (2021). European Resuscitation Council Guidelines 2021: First aid. Resuscitation, 161, 270–290.

Chapter 3: SIMULATION in DISASTER EDUCATION

Malin Andtfolk, Susanna Nylund, Otniel Didraga, Gabriela Mariutac

Picture 3.1-1. Picture from canva.com

3.1 Clinical Skills Development

Simulation-based education plays a critical role in preparing healthcare professionals for disaster scenarios (Picture 3.1-1.). It offers a safe, structured, and immersive environment where learners can gain practical experience without risking patient safety. In disaster preparedness training, simulations enable the replication of complex, high-pressure scenarios—such as natural disasters, pandemics, or mass casualty incidents—which are difficult to replicate in traditional classroom settings (Alinier et al., 2006; Gaba, 2004).

By providing realistic, risk-free environments, clinical simulations help learners develop core competencies such as triage, emergency response, effective communication, and decision-making under pressure (Okuda et al., 2009). These scenarios encourage learners to apply theoretical knowledge in a hands-on, controlled setting that closely mirrors real-life conditions. For instance, learners can participate in mock disaster drills, use manikins for trauma response, or engage in digital simulations of complex emergencies. Simulation fosters the development of both technical and non-technical skills. Technical skills include resuscitation, hemorrhage control, airway management, intravenous access, and patient stabilization (Issenberg et al., 2005). High-fidelity manikins and task trainers can replicate physiological responses, allowing trainees to practice and refine procedures that are time-sensitive and critical during disasters. Equally important are non-technical skills, which encompass communication, collaboration, leadership, teamwork, and situational awareness. These skills are essential in disaster response, where multidisciplinary teams must coordinate efficiently under high stress. Simulation enables learners to assume different roles—such as team leader or responder—and receive structured feedback on their performance (Salas et al., 2008; Rudolph et al., 2006). This debriefing process enhances reflective learning, critical thinking, and adaptability in complex scenarios. Moreover, repeated practice in simulated settings enhances long-term retention of knowledge and skills. Studies have shown that simulation-based training leads to improved confidence and competence among healthcare providers, as well as better preparedness for real-world disaster situations (Wayne et al., 2008; Mahdi et al., 2023). Simulation also supports interprofessional education (IPE). This collaborative approach fosters mutual understanding and communication, aligning with the team-based nature of disaster response (Reeves et al., 2013).

As global health threats increase—from pandemics to climate-related emergencies—the need for well-prepared healthcare workers has never been more urgent. Integrating simulation into disaster education ensures that professionals can respond with both clinical expertise and coordinated teamwork in high-risk, high-stakes situations.

3.1.1. The Role of Simulation in Disaster Preparedness Education

Simulation-based education refers to the use of carefully constructed, immersive scenarios that mimic real-life events to enhance learning and preparedness. In the context of disaster preparedness, simulation offers a powerful pedagogical approach to train healthcare professionals in managing complex and high-stakes situations. Unlike traditional didactic instruction, simulation engages learners in active, experiential learning, helping them internalize procedures, protocols, and critical decision-making. Traditional training methods often fall short in preparing for disaster scenarios due to their static, predictable nature. Textbook learning and classroom lectures cannot replicate the urgency, uncertainty, and high-pressure environment characteristic of real disasters. Furthermore, practical drills are often constrained by logistical challenges, safety concerns, and cost (O'Reilly & Brandenburg, 2006).

Simulations address these gaps by providing realistic, safe, and repeatable environments. Learners can engage in lifelike scenarios involving mass casualties, limited resources, or sudden environmental changes, all without risking patient safety. This controlled exposure enhances preparedness and enables structured reflection and skill refinement.

One of the primary strengths of simulation in disaster education lies in the opportunity to practice and perfect essential hands-on skills. Critical technical competencies such as resuscitation, airway management, intravenous access, and hemorrhage control are core to effective disaster response. Simulation allows learners to repeatedly practice these procedures, reinforcing muscle memory and procedural fluency (Smith et al., 2022; van Straaten et al., 2022). High-fidelity manikins and specialized task trainers play a central role in this learning process. These technologies offer tactile feedback, physiological responses, and realistic anatomical features, enabling users to engage in authentic procedural practice. Moreover, simulations can be designed to introduce time pressure and resource constraints, allowing learners to perform technical skills under conditions that mimic the chaos of real-world disasters. These high-intensity scenarios foster resilience, enhance decision-making under stress, and ensure that vital skills become second nature (Smith et al., 2022).

3.1.2. Development of Non-Technical (Soft) Skills

While technical competence is essential, effective disaster response also demands robust non-technical or "soft" skills (Table 3.1-1). Communication, leadership, teamwork, situational awareness, and decision-making are critical in coordinating care, allocating resources, and maintaining safety during high-stress incidents. Simulation-based education provides an ideal platform to develop and refine these competencies. Through role-playing, learners assume various roles within the response team, gaining insight into both leadership and followership dynamics. Scenarios can be designed to test communication under pressure, ethical decision-making, and cross-disciplinary coordination. Structured feedback and facilitated debriefings following each simulation allow learners to reflect on their performance, identify areas for growth, and build self-awareness. Practicing decision-making in safe, simulated environments increases confidence and promotes the cognitive flexibility required in real disasters (Greco et al., 2021).

Table 3.1-1. Contrasting technical and non-technical skills in disaster response

Theme	Description	Simulation-based education role
Technical competence	Practical skills such as triage, resuscitation, airway management, hemorrhage control, etc.	Provides realistic, hands-on practice with manikins and procedural trainers.
Communication	Clear information exchange under pressure to coordinate care and resource allocation	Scenarios test communication under stress; role-playing enhances skills.
Leadership	Guiding teams, making timely decisions, and managing resources during crisis situations	Learners assume leadership roles in simulations; develop decision-making.
Teamwork	Collaborative functioning of multidisciplinary teams to ensure efficient disaster response	Simulations foster interprofessional collaboration and role understanding.
Situational awareness	Perceiving, understanding, and anticipating evolving conditions in dynamic environments	Scenarios designed to challenge and improve awareness and adaptability.
Decision-making	Making ethical and effective choices rapidly under uncertainty and stress	Safe environment to practice critical thinking and adaptive problem-solving.
Structured feedback & reflection	Debriefings help identify strengths and growth areas, promoting self-awareness	Facilitated reflection supports continuous learning and cognitive flexibility.

Disasters are complex events that demand a coordinated response from professionals across multiple disciplines. Interprofessional education through team-based simulation fosters collaboration and understanding among nursing, medicine, pharmacy, emergency services, and other healthcare fields. By engaging in joint simulations, participants gain appreciation for the roles and expertise of their colleagues. These experiences promote effective team dynamics, clarify role distribution, and strengthen interprofessional communication—critical elements when time and clarity are of the essence (Mahdi et al., 2023). Furthermore, team-based simulation encourages shared decision-making and resource prioritization. By practicing as a unified team in a controlled setting, healthcare professionals can reduce role confusion, enhance mutual respect, and improve overall system performance during real emergencies (Aluisio, et al., 2016).

Effective learning in simulation is significantly enhanced through structured feedback and debriefing. These processes offer learners an opportunity to analyze their actions, examine thought processes, and gain insights from instructors and peers. Various debriefing models support this process. A study has shown that debriefing enhances critical thinking, improves communication, and supports behavior change. It transforms simulation from an isolated activity into a cycle of continuous learning and professional development (van Straaten et al., 2022).

3.1.3. Interprofessional Education and Team-Based Simulation

Interprofessional education and team-based simulation have become increasingly important in preparing healthcare professionals for the realities of disaster response. In high-stakes, fast-paced situations such as mass casualty incidents or public health emergencies, effective team performance is essential. Joint training activities that bring together learners from nursing, medicine, pharmacy, emergency services, and other health disciplines foster a shared understanding of roles, responsibilities, and communication strategies necessary for coordinated care delivery. Simulation-based interprofessional education allows learners to engage in realistic disaster scenarios while actively practicing interdisciplinary collaboration. These team-based exercises provide opportunities to clarify professional roles, negotiate shared tasks, and solve complex problems collectively, key aspects of safe and effective disaster response (Reeves et al., 2013). By working together in simulated environments, participants gain insight into the capabilities and perspectives of other professions, promoting mutual respect and reducing hierarchical barriers that may hinder communication in real-world settings (WHO, 2010).

A core strength of interprofessional simulation lies in its ability to enhance team dynamics and communication. Scenarios that require rapid decision-making and information exchange allow learners to develop essential non-technical competencies such as leadership, assertiveness, listening, and closed-loop communication (Salas et al., 2008). A study has shown that IPE simulation improves both individual confidence and collective team performance during emergency care and disaster response situations (Zook et al., 2022). Role distribution within simulation scenarios is carefully designed to reflect real-life healthcare team structures. Learners rotate through different roles—such as team leader, responder, or observer—enabling them to experience varied responsibilities and develop adaptability (Luctkar-Flude et al., 2012). These structured experiences contribute to stronger interprofessional trust, better coordination, and more efficient task delegation in clinical settings. Ultimately, integrating interprofessional education and team-based simulation into disaster preparedness curricula prepares healthcare professionals not only with technical proficiency but also with the collaborative mindset necessary for effective interdisciplinary response in crises.

3.1.4. Feedback and Debriefing in Simulation Training

Structured feedback and debriefing are essential components of simulation-based education, significantly enhancing the learning experience and promoting long-term retention. In disaster preparedness training, where scenarios often involve complex, high-stress situations, post-simulation debriefings offer learners the opportunity to reflect on their actions, decisions, and emotional responses in a safe and supportive environment. Effective debriefing transforms experience into insight by facilitating guided reflection, self-assessment, and the identification of performance gaps. Structured feedback processes help learners understand not just what they did, but why certain decisions were effective or could be improved. This supports deeper cognitive processing, which is essential for developing clinical judgment, situational awareness, and adaptive expertise in high-stakes environments (Rudolph et al., 2006).

Several evidence-based debriefing techniques are commonly used in healthcare simulation. Plus-Delta encourages learners to articulate what went well and what could be improved, fostering a balanced perspective (Figure 3.1-1.). Advocacy-Inquiry combines an instructor's observations with open-ended questions to prompt reflection and deeper discussion (Rudolph et al., 2006). The PEARLS framework (Promoting Excellence and Reflective Learning in Simulation) blends learner self-assessment with instructor-led feedback, structured teaching, and focused discussion, making it particularly well-suited for interprofessional teams and complex scenarios (Eppich & Cheng, 2015). Studies have shown that structured debriefing leads to measurable improvements in critical thinking, self-awareness, and behavioral change among healthcare learners. These reflective practices are not only linked to increased confidence and competence but also to better preparedness for future real-world disaster responses (Wayne et al., 2008; Mahdi et al., 2023). Moreover, debriefing enhances team learning, as interprofessional groups can explore communication dynamics, role clarity, and decision-making strategies, improving future team performance (Zook et al., 2022).

Figure 3.1-1. Example of using Plus-Delta in encouraging learners in simulations

By embedding feedback and debriefing as a standard part of simulation-based training, educators can foster a culture of continuous improvement, psychological safety, and reflective practice—qualities essential for effective disaster response.

3.1.5. Innovations in Simulation Technology for Disaster Training

The field of simulation in disaster preparedness is rapidly evolving, driven by emerging technologies that offer immersive, scalable, and flexible learning opportunities. Virtual reality (VR) and augmented reality (AR) are at the forefront of this innovation, enabling learners to engage with fully immersive 360-degree environments or overlay digital elements onto real-world settings to enhance realism and situational awareness (Khanal et al., 2022; NOAA, 2025). These immersive approaches facilitate experiential learning by placing learners in authentic, high-stakes scenarios that are difficult to replicate in traditional training.

In parallel, remote or telesimulation methods have gained significant traction, particularly in response to the growing demand for accessible, high-quality disaster education amid logistical constraints and global training needs. By leveraging internet-based platforms, geographically dispersed learners can participate simultaneously in real-time simulations, interact with instructors, and receive immediate feedback regardless of location. This capability not only democratizes access but also supports continuous professional development across diverse healthcare and emergency response communities. Interactive digital platforms now support sophisticated scenario customization, enabling educators to tailor training content to specific learning objectives, participant roles, or evolving disaster contexts. Adaptive learning technologies adjust difficulty levels and challenge complexity based on learner performance, fostering optimal skill development and engagement. Furthermore, real-time performance tracking and analytics provide data-driven insights that inform personalized feedback, competency assessment, and curriculum refinement. Together, these technological advancements contribute to more effective, learner-centered disaster preparedness training programs (Wechdorn, 2024).

3.2. Education with Virtual Reality and Augmented Reality: Basic Principles and Methods, Technologies and Applications in Health Education

Virtual reality and augmented reality are transformative tools in health education that offer immersive, interactive, and highly engaging learning experiences (Table 3.2-1.). These technologies are particularly valuable in disaster preparedness training, where high-fidelity and context-rich environments are essential for developing decision-making and clinical skills under pressure (Pottle, 2019; Liu et al., 2023).

Table 3.2-1. Main points about VR and AR in disaster preparedness education

Technology	Description	Educational benefits
VR	Fully immersive 3D simulated environments for emergency scenarios and medical procedures	Enhances situational awareness, decision-making, and emotional engagement
AR	Overlays digital content on the real world via devices like tablets or AR glasses	Supports real-time procedural guidance and accuracy without losing real-world context

VR enables learners to enter fully simulated 3D environments where they can navigate emergency scenarios, carry out medical procedures, or take on roles such as first responders or patients. For example, VR-based simulations can recreate mass casualty incidents or natural disasters where learners must perform triage, manage trauma, or coordinate evacuation under time constraints. The immersive nature of VR helps enhance situational awareness and emotional engagement, which are critical components of disaster education (Jensen & Konradsen, 2018).

AR, in contrast, blends digital content with the real world by superimposing information—such as images, data, or animations—onto a physical environment via mobile devices, tablets, or AR glasses. In healthcare training, AR can guide learners through procedures by projecting step-by-step instructions onto the patient's body or a mannequin. This facilitates real-time learning and supports procedural accuracy without removing the learner from the real-world context (Berryman, 2012; Zhu et al., 2014).

3.2.1. Foundational Concepts and Educational Principles

Education and training with VR and AR incorporate various educational methods, including scenario-based learning, procedural walkthroughs, simulation-based assessments, and gamification elements. These methods promote active learning, self-regulation, and motivation among students (Radianti et al., 2020). Learners are placed in dynamic, problem-solving situations where they must apply clinical judgment and practice teamwork—skills that are difficult to develop through traditional didactic instruction.

The technologies used in VR/AR training range from head-mounted displays (e.g., Oculus Quest, HTC Vive, Meta Quest Pro) to mobile-based AR applications and haptic feedback devices that simulate the tactile feel of medical procedures (Moro et al., 2021). These platforms enable multimodal interaction—visual, auditory, and kinesthetic—making the learning process more engaging and effective. Applications in health education are wide-ranging. VR is used in cardiopulmonary resuscitation (CPR) training, disaster drills, trauma and surgical simulations, and psychological preparation for high-stress medical events (Tunc et al., 2024). AR is used to enhance anatomical visualization, provide real-time feedback during emergency care, and support infection control training in pandemic preparedness (Freina & Ott, 2015; Maresky et al., 2019). Moreover, VR/AR tools facilitate repetitive, scalable, and personalized learning experiences that can be adapted for different learner needs. These technologies also enable remote training, which is particularly useful in the context of global emergencies or when access to physical simulation labs is limited.

VR boosts presence and emotional engagement, which promotes retention and deeper understanding. AR offers situationally embedded guidance, enhancing realism and cognitive integration (Vidak et al., 2023). Immersive VR facilitates scenario-based decision-making, procedural walkthroughs, and assessments through high-fidelity simulation (Fernandes et al., 2022). AR overlays real-time instructions onto real-world environments, enhancing anatomical understanding, procedural accuracy, and cognitive load management (Vidak et al., 2023). A pilot AR–VR program for Israeli paramedics showed improved intubation confidence, resilience, and engaging realism—suggesting AR/VR integration supports remote/differentiated training. In summary, VR and AR technologies represent a paradigm shift in health and disaster education. They support the development of both clinical and cognitive skills in immersive environments that promote experiential learning, confidence-building, and readiness for real-world disaster response. Shortly, VR and AR are immersive computing technologies: VR places the user in a fully virtual world, while AR overlays digital information into the physical environment. These technologies support experiential and constructivist learning by enabling active engagement and contextualized practice, consistent with Kolb's experiential learning model (Fernandes et al., 2022).

3.2.2. VR in Health and Disaster Education

VR offers fully immersive environments that enable learners to engage in realistic, high-risk scenario training without the associated real-world dangers. These environments are particularly valuable in health and disaster education, where hands-on experience with critical situations is essential but often difficult to safely replicate (Al-Saud et al., 2017). VR has been effectively employed in various health-related training domains, including CPR, trauma management, surgical simulations, and large-scale disaster drills (Kyaw et al., 2019; Lin et al., 2020). By simulating these scenarios, learners can practice technical skills, decision-making, and teamwork in controlled yet realistic settings, which enhances skill retention and confidence (Kneebone, 2003). The psychological immersion provided by VR—through multisensory stimulation and interactive components—fosters emotional engagement that enhances learning outcomes. This heightened engagement helps prepare learners not only technically but also emotionally, reducing anxiety and improving their readiness for real-life emergencies (Johnsen et al., 2021; Parsons & Rizzo, 2008).

Example Technologies: Common VR platforms used in health and disaster education include the Oculus Quest and Meta Quest Pro by Meta, as well as the HTC Vive system. These head-mounted displays offer high-fidelity visual and auditory experiences and support interactive simulations that are critical for immersive learning (Slater & Sanchez-Vives, 2016).

3.2.3. AR in Health and Clinical Training

AR technology enhances health and clinical training by overlaying digital information onto real-world environments, thereby supporting learners with context-sensitive instructions and visual aids. This capability allows trainees to interact with both physical and virtual elements simultaneously, bridging the gap between theoretical knowledge and practical application (Bacca et al., 2018). AR applications improve anatomical comprehension by projecting 3D models onto actual patients or training mannequins, which helps learners visualize internal structures in relation to external landmarks. This spatial augmentation supports greater procedural accuracy and confidence during clinical tasks (Barsom, Graafland, & Schijven, 2016). One of AR's key benefits in clinical training is the provision of real-time guidance and immediate feedback during procedures. This interactive support can reduce errors and accelerate skill acquisition by highlighting critical steps and alerting trainees to deviations from best practice (Sielhorst, Feuerstein, & Navab, 2008).

Example Devices: Widely used AR devices include AR-enabled tablets and head-mounted displays such as Microsoft HoloLens, which offer hands-free access to interactive overlays and data visualization essential for hands-on clinical education (Davenport et al., 2020).

3.2.4. Educational Benefits and Outcomes with VR/AR

Virtual reality and augmented reality offer significant pedagogical and practical advantages in health education. These technologies support experiential learning by providing dynamic and engaging environments that are difficult to replicate in traditional classrooms. Below are key advantages substantiated by research (Table 3.2-2.).

Table 3.2-2. Advantages of VR/AR in health education

Immersive Learning	Strengthens knowledge retention, motivation, and emotional engagement; enhances critical thinking and problem-solving skills. Provides realistic and compelling scenarios.
Safe Practice Environment	Enables learners to perform clinical procedures and make decisions without posing any risk to patients; this is especially important in disaster training.
Risk-Free, Experiential Practice	Offers opportunities to make mistakes and repeat actions in high-risk, realistic scenarios; supports reflective thinking, confidence, and experiential learning.
Repetition and Standardization	Provides learners with consistent and repeatable training. Promotes mastery, fairness, and guided learning at one's own pace.
Accessibility and Scalability	Delivers instant feedback and learning analytics. Supports personalized coaching and formative assessment.

Immersive learning: One of the most significant benefits of VR/AR is the ability to immerse learners in lifelike scenarios that promote deeper engagement and understanding. Immersion enhances knowledge retention, motivation, and emotional connection to the content (Moro et al., 2021). For instance, learners can experience the high-pressure environment of a disaster response situation or visualize complex anatomical structures from multiple perspectives. This active participation encourages the development of critical thinking and problem-solving skills (Makransky & Lilleholt, 2018).

Safe practice environment: VR/AR simulations provide a risk-free space for learners to practice clinical procedures, make decisions, and learn from mistakes without endangering patients. This is particularly important in disaster preparedness training, where real-world experience may be limited or dangerous to replicate (Liu et al., 2023). Errors in a virtual setting can become powerful learning opportunities, enhancing competence and confidence before real-life application.

Risk-free, experiential practice: VR and AR allow learners to engage in realistic, high-stakes scenarios without the risk of real-life harm to patients or learners. This is particularly vital in disaster preparedness, where scenarios often involve rare, high-impact, and unpredictable events (Liaw et al., 2020). Learners can fail safely, reflect on outcomes, and retry scenarios, which supports iterative learning and increased confidence.

Repetition and standardization: VR/AR enables repeated, deliberate practice of clinical and procedural skills—essential for mastery. Unlike traditional training that may vary in consistency, VR/AR modules ensure that each learner receives the same experience, which supports standardized education and fair assessment (Issenberg et al., 2005). Trainees can repeat simulations at their own pace, promoting self-directed learning and reinforcement of competencies over time.

Accessibility and scalability: Once developed, VR/AR training programs can be deployed broadly, reaching learners in different geographic locations and institutions. This scalability makes VR/AR a cost-effective solution for health education, especially in contexts where access to high-quality, hands-on training is limited (Radianti et al., 2020). Mobile AR apps and standalone VR systems further increase accessibility by eliminating the need for complex infrastructure.

Real-time feedback and analytics: Many VR/AR platforms are equipped with integrated performance tracking tools that collect data on learner actions, timing, decision-making, and outcomes. These analytics provide immediate feedback to learners and actionable insights for instructors (Zhu et al., 2014). Feedback loops enhance learning by identifying strengths and areas for improvement, supporting formative assessment and personalized coaching.

3.2.5. Challenges and Considerations in VR/AR in Health Education

Despite the growing interest and promising potential of VR and AR technologies in health education, several challenges hinder their full integration and scalability. These obstacles include economic, technical, pedagogical, and equity-related concerns, all of which must be critically examined to ensure sustainable and inclusive adoption. Below are key challenges substantiated by research (Table 3.2-3.).

Table 3.2-3. Challenges with VR/AR in health educatio

Challenges with VR/AR in health education

Challenge	Description
High Development Costs	Developing high-quality, pedagogically sound VR/AR content often requires significant financial investment and interdisciplinary collaboration.
Technical Limitations	VR/AR plafforms may have high hardware requirements, frequent software updates, and compatibility issues, leading to potential disruptions in learning.
Economic Barriers	High initial costs and ongoing expenses for hardware and software can limit adoption, particularly in low-resource educational institutions.
User Adaptation and Physical Discomfort	Some learners may experience cybersickness or struggle with navigating immersive environments, reducing the effectiveness of training.
Limited Curricular Integration	VR/AR learning modules may lack alignment with establ. e-shed curricula and assessment frameworks, limiting their integration into formal education.

High development costs: Developing high-quality, pedagogically sound VR/AR content is resource intensive. It often requires interdisciplinary collaboration between healthcare professionals, educators, 3D artists, software engineers, and UX designers. The process includes the design, testing, and maintenance of interactive environments and realistic scenarios, which demands substantial time and financial investment (Radianti et al., 2020). Furthermore, the initial cost of acquiring compatible hardware (e.g., VR headsets, motion controllers, or haptic gloves) can be prohibitive for many educational institutions, particularly in low- and middle-income countries.

Technical limitations: While immersive technology is rapidly evolving, it is still subject to technical shortcomings that can negatively impact learning. Many VR platforms require high-end computers and frequent updates to both software and hardware to ensure smooth performance. Interruptions caused by software crashes, limited compatibility, long loading times, or outdated drivers can disrupt the learning process and reduce user satisfaction (Rizzetto et al., 2020). These issues may also place an additional burden on information technology support staff and faculty, who may not have specialized training in troubleshooting immersive systems.

Economic barriers: One of the primary challenges to integrating virtual and augmented reality into disaster preparedness education is the high upfront cost of technology and content development. These include expenses for purchasing head-mounted displays, high-performance computing hardware, licensing fees for software platforms, and the cost of creating or customizing realistic educational scenarios (Radianti et al., 2020). High-fidelity simulations often require interdisciplinary teams of programmers, subject matter experts, instructional designers, and 3D artists—making development labor-intensive and costly (Hamilton et al., 2021).

User adaptation and physical discomfort: Not all learners are equally comfortable using immersive technologies. A notable proportion of users may experience cybersickness, a form of motion sickness caused by the disconnect between visual input and physical movement in virtual environments (Chang et al., 2020). Symptoms can include dizziness, nausea, headaches, and fatigue, which may limit the duration and frequency of sessions. Additionally, some users—particularly those unfamiliar with video game interfaces—may struggle with navigation, interactivity, or hand-eye coordination, reducing the overall effectiveness of training.

Limited curricular integration: Another challenge lies in aligning VR/AR learning experiences with established educational frameworks and assessment standards. While many VR/AR modules are engaging and technically sophisticated, they are not always explicitly linked to specific learning outcomes, professional competencies, or national accreditation requirements (Kavanagh et al., 2017). This lack of integration may lead educators to view these technologies as supplementary rather than central to the curriculum, ultimately limiting their pedagogical impact and sustainability.

Curricular integration and pedagogical alignment: A significant barrier to the widespread adoption of VR/AR in disaster preparedness education is the lack of alignment with established curricula and competency-based learning outcomes. Many VR/AR modules are developed as stand-alone experiences, making them difficult to embed seamlessly into existing syllabi or accredited training programs (Johnsen et al., 2018). Without clear mapping to national accreditation standards or clinical competency frameworks, these technologies may be perceived as optional enhancements rather than essential components of education.

Equity concerns and access disparity: The digital divide remains a significant concern when implementing immersive technologies. Not all students or institutions have equal access to the devices, internet bandwidth, or physical space required to engage with VR/AR content (Zhang et al., 2024). Students in rural areas, underfunded schools, or those with physical disabilities may face additional barriers to participation. Unless deliberately addressed, the implementation of VR/AR risks reinforcing existing inequalities in health education, rather than bridging them.

3.2.6. Strategies to Address and Overcome Challenges

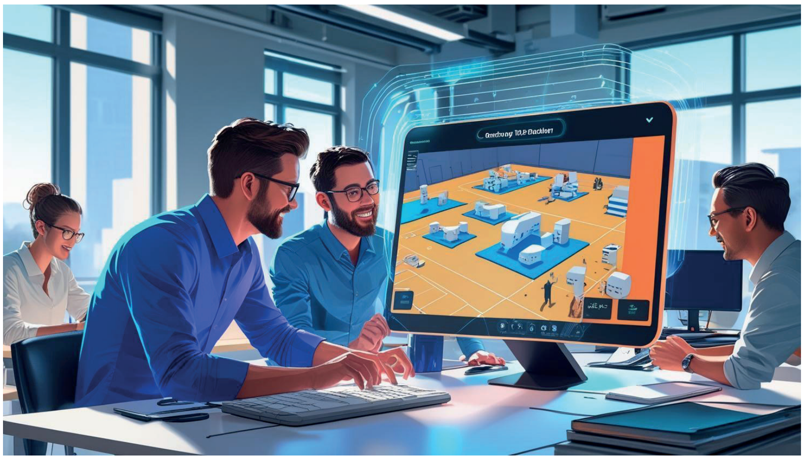
Despite the promising potential of VR/AR in disaster preparedness education, several challenges—such as high costs, curricular misalignment, accessibility barriers, and limited faculty expertise—must be addressed to enable broad and effective implementation. High initial investment in specialized hardware and software can limit widespread adoption, particularly in resource-constrained settings. However, cost-effective deployment can be supported by leveraging mobile VR solutions, open-source platforms, and shared scenario libraries, which reduce both development expenses and hardware demands (Radianti et al., 2020; Hamilton et al., 2021). These approaches enable institutions to adopt immersive technologies without prohibitive financial burdens, fostering broader access and scalability.

Ensuring that VR/AR applications align effectively with existing curricula presents another challenge. The integration of immersive learning tools must be pedagogically sound and mapped clearly to learning objectives to avoid redundancy or disconnection from core content. Inclusive design practices, guided by universal design for learning principles, address accessibility by accommodating diverse learner needs. Features such as adjustable audio-visual settings, haptic feedback, and customizable interaction modalities enhance usability and engagement for learners with varying abilities (Barmaki & Hughes, 2019). This commitment to accessibility ensures that VR/AR technologies do not inadvertently exclude participants, promoting equity in disaster preparedness training. Institutional policies and support mechanisms play a critical role in sustaining VR/AR integration. Aligning immersive tools with accreditation standards encourages formal recognition and legitimization of these new educational modalities. Funding initiatives aimed at faculty development build essential expertise, empowering educators to design, implement, and evaluate VR/AR learning experiences effectively. Additionally, fostering multidisciplinary collaboration among educators, technologists, and subject matter experts helps bridge knowledge gaps and enriches scenario development (Haque & Srinivasan, 2021).

Ongoing evaluation through learning analytics and continuous stakeholder engagement—including educators, learners, and technical staff—supports iterative refinement of VR/AR interventions. This process ensures that the learning experiences remain relevant, effective, and responsive to user feedback (Makransky & Mayer, 2022; Kavanagh et al., 2021). Collectively, these strategies pave the way for scalable, equitable, and pedagogically sound VR/AR-based education that enhances disaster preparedness by improving learners' skills, confidence, and readiness for real-world emergencies.

3.3. Development of VR/AR based training content

The creation of effective VR/AR-based training content for disaster education requires a multidisciplinary and iterative approach. To ensure educational relevance, technological usability, and clinical accuracy, collaboration between educators, healthcare professionals, instructional designers, and developers is essential. A systematic development process helps align immersive training experiences with learning outcomes and maximizes their pedagogical and operational value in disaster preparedness education (Picture 3.3-2.).



Picture 3.3-2. Multidisciplinary collaboration and project planning in developing VR/AR for health education. Picture from canva.com.

3.3.1. Needs Assessment and Educational Targeting

The first critical step in developing immersive training content, such as VR and AR applications, is conducting a thorough needs assessment to identify specific educational gaps or competencies that stand to benefit most from such technologies. In disaster education, these often include scenarios that are both high-stakes and low-frequency, where traditional training opportunities are limited but the consequences of poor performance are severe. Examples include mass casualty triage, hazardous material exposure response, and infectious disease outbreak containment (Hsieh et al., 2025). A robust needs assessment process typically involves multiple complementary approaches:

Engagement with subject matter experts: Interviews and focus groups with clinical educators, emergency responders, and disaster management professionals help surface critical skills and knowledge areas that require reinforcement or innovative teaching methods. Their practical insights ensure that the training content aligns with real-world demands and challenges (Kneebone et al., 2015).

Analysis of competency frameworks: Reviewing established competency models, such as those from health professional regulatory bodies or disaster preparedness organizations, ensures alignment between training objectives and recognized professional standards. This also aids in identifying key measurable outcomes for evaluation (Frank et al., 2010).

Critical incident and incident report reviews: Examining historical data from critical incidents and after-action reports can reveal common errors, system vulnerabilities, and skill deficits that immersive simulation might address effectively. This data-driven approach prioritizes scenarios that have demonstrated potential for improvement in real events (Patel et al., 2018).

Learner needs and feedback: Surveys and needs assessments among the target learner population (e.g., nursing students, paramedics, public health workers) provide insight into self-perceived gaps, confidence levels, and preferred learning modalities, guiding user-centered design for immersive content (Alinier, 2011).

Through these multi-layered needs assessment, developers can ensure that VR and AR interventions are purposefully targeted, maximizing educational impact and resource efficiency. Identifying these priority areas is fundamental to creating immersive training that addresses critical skill shortages and prepares learners for complex, high-pressure disaster response scenarios.

3.3.2. Pedagogical and Scenario Design Principles

Designing effective VR and AR scenarios for disaster preparedness education requires the clear articulation of learning objectives that span the cognitive (knowledge), affective (attitudes and emotions), and psychomotor (skills) domains (Bloom, 1956; Anderson et al., 2001). These multidimensional objectives serve as foundational guides for developing immersive content that balances clinical accuracy with narrative authenticity, thereby enhancing learner engagement and ensuring relevance to real-world disaster response contexts (Gentry et al., 2019). Embedding decision points and branching logic within scenarios enables learners to actively explore the consequences of their actions, fostering critical thinking, situational awareness, and adaptive problem-solving abilities. This interactive design empowers learners to navigate complex and unpredictable situations in a safe environment, promoting experiential learning and resilience (Cook et al., 2013).

Moreover, incorporating reflective learning structures—such as embedded pauses for self-assessment or guided reflection prompts—facilitates deeper cognitive processing and long-term knowledge retention. These opportunities for reflection align with experiential learning theories, emphasizing the importance of integrating concrete experiences with active reflection to support meaningful learning (Kolb, 1984). By aligning immersive scenario design with well-defined learning objectives and evidence-based instructional strategies, VR and AR training modules can effectively prepare healthcare professionals and emergency responders to perform competently under the pressures of disaster situations.

Following the comprehensive needs assessment, the next phase involves designing pedagogically sound and clinically realistic scenarios tailored to address identified gaps. Effective scenario design integrates clear, measurable learning objectives that guide the training focus and provide benchmarks for learner assessment. These objectives should align with both technical competencies and non-technical skills such as communication, decision-making, and teamwork, which are critical in disaster and health emergency contexts (Issenberg et al., 2005). Well-crafted scenarios incorporate key decision points and critical challenges that stimulate active problem-solving and reflective thinking. By presenting learners with realistic dilemmas and time-sensitive choices, the scenarios encourage engagement, critical reasoning, and adaptive learning strategies (Lateef, 2010).

To further enrich the learning experience, scenarios often incorporate branching logic that allows multiple pathways and outcomes depending on learner decisions. This dynamic structure promotes exploration of consequences, fosters deeper understanding, and enhances replayability, making it possible for learners to revisit and refine their approach in subsequent attempts (Cook et al., 2013). The inclusion of such adaptive elements is particularly valuable in preparing learners for the unpredictability inherent in disaster response and clinical emergencies.

3.3.3. Content Development and Technological Implementation

This stage involves transforming the educational blueprint into a fully functional VR or AR environment through the application of advanced technological tools and collaborative expertise. Key technologies utilized include 3D modeling software, motion capture systems, and game engines such as Unity and Unreal Engine, which together enable the creation of rich, interactive simulations with high visual and functional fidelity (Pottle, 2019). The development process integrates detailed character animations, realistic medical equipment, environmental hazards, and immersive audio effects to build a believable and engaging learning environment. These elements work synergistically to stimulate multiple senses and enhance learner presence within the simulation (Cheng et al., 2021).

Close collaboration with subject matter experts is essential throughout development to ensure anatomical and procedural accuracy, compliance with clinical guidelines, and the conveyance of appropriate emotional and contextual cues. This partnership guarantees that the simulation content remains clinically relevant and pedagogically sound (Al-Saud et al., 2017). The level of interactivity incorporated into the simulation is carefully tailored to the learners' expertise and training objectives. For novices, guided procedural walkthroughs with step-by-step instructions may be appropriate, whereas more advanced learners benefit from open-ended scenarios that require autonomous decision-making and complex problem-solving (Kneebone, 2003). By aligning interactivity with learner needs, developers maximize engagement and facilitate skill transfer to real-world clinical or disaster situations.

3.3.4. Usability Testing and Iterative Refinement

Involving end users early and continuously throughout the development process is essential to optimize the usability, engagement, and educational effectiveness of VR/AR training modules. Usability testing typically begins with formative evaluations where both learners and instructors interact with functional prototypes and provide structured feedback on critical aspects such as navigation ease, clarity of instructions, realism of the simulation, and the cognitive load imposed by the interface (Radianti et al., 2020). This user-centered feedback informs iterative refinement cycles, allowing developers to address technical issues, fix bugs, enhance interface intuitiveness, and improve instructional design elements. Iteration based on real user experience helps balance immersive complexity with usability, ensuring learners remain focused on learning objectives rather than struggling with system mechanics (Schmidt et al., 2019).

Pilot testing with small representative groups also plays a vital role in assessing whether the VR/AR modules meet accessibility and inclusion standards. Such testing identifies potential barriers related to physical, sensory, or cognitive limitations and informs necessary adaptations to make the training equitable and effective for diverse learner populations (Kroth et al., 2021). Through this iterative, participatory approach, immersive training solutions become more learner-friendly, robust, and impactful, thereby increasing the likelihood of successful adoption and sustained educational outcomes.

3.3.5. Integration into Educational Programs and Evaluation

Following development and rigorous usability testing, VR and AR training content is integrated into broader disaster education programs. This integration can take multiple forms, including standalone modules, blended simulation approaches combining immersive technology with traditional training, or as preparatory tools that enhance readiness for in-person exercises (Aggarwal & Darzi, 2011). To systematically evaluate the effectiveness of these immersive training interventions, frameworks such as Kirkpatrick's model are commonly employed. This model assesses outcomes across multiple levels: learner satisfaction, knowledge acquisition, skills performance, and real-world application of competencies (Kirkpatrick & Kirkpatrick, 2006). Complementing these assessments, embedded analytics within VR/AR platforms—such as task completion times, error rates, and decision pathways—enable objective measurement of learner performance and facilitate personalized feedback and progress tracking (Andersen et al., 2010).

Qualitative feedback from learners and instructors further enriches the evaluation process by highlighting usability issues, engagement factors, and contextual relevance, informing iterative refinements and content updates (Radianti et al., 2020). Looking forward, the future of disaster education is likely to embrace hybrid simulation models that integrate traditional manikin-based training with VR/AR technologies. Such blended approaches offer the flexibility, repeatability, and scalability of immersive platforms while preserving hands-on tactile skill development and opportunities for interprofessional team training (McGaghie et al., 2010).

As immersive technologies become increasingly accessible and pedagogically embedded, VR and AR will play a central role in preparing healthcare professionals and emergency responders to navigate the complexities of dynamic disaster environments effectively.

3.3.6. Multidisciplinary Collaboration and Project Planning

Effective development of VR and AR content for disaster preparedness education requires a multidisciplinary approach that integrates diverse expertise to ensure both educational and clinical validity. Healthcare professionals play a crucial role by providing clinical accuracy, ensuring that scenarios are relevant, evidence-based, and reflective of real-world challenges faced during disaster response (Bower et al., 2017). Their insights help maintain fidelity to current protocols and practices, which is essential for learner trust and skill transfer.

Educators contribute pedagogical expertise by designing learning objectives, instructional strategies, and assessment frameworks that optimize knowledge retention, skill acquisition, and critical thinking within immersive environments. Their input helps tailor the training to different learner levels and ensures alignment with competency-based education principles (Kirkpatrick & Kirkpatrick, 2006). Meanwhile, software developers, graphic artists, and game designers translate these clinical and educational requirements into engaging, interactive virtual environments. They blend technical functionality—such as real-time responsiveness, user interface design, and system stability—with compelling visuals, soundscapes, and narrative elements that foster immersion and motivation (Radianti et al., 2020). This collaborative synergy is vital to create simulations that are not only realistic and accurate but also pedagogically effective and user-friendly.

3.4. Methods Used in Evaluation (Reflective Learning) of VR/AR Training

Effective evaluation of VR/AR training programs in disaster nursing requires comprehensive approaches that assess both technical competencies and reflective learning outcomes. Integrating VR groups into the nursing curriculum on disaster response could enhance disaster preparedness, confidence, and performance among nursing students (Shujuan et al., 2022). Reflective learning models are essential for facilitating experiential knowledge transfer in simulation-based environments (Casler et al., 2024). Recent evidence demonstrates the efficacy of immersive VR disaster training in enhancing disaster preparedness and self-efficacy among emergency nurses, while evaluation metrics reveal that VR exercises are much more effective in planning disaster preparedness training when several evaluation metrics are put in place. Moving beyond traditional assessment methods is necessary to capture the unique benefits and challenges of immersive technologies.

3.4.1. Reflective Practice Tools

A. Integrated Digital Reflection Systems

Digital reflection tools embedded within VR/AR platforms facilitate immediate and delayed reflection on learning experiences. Digital journals should be integrated into training platforms, allowing learners to document thoughts, emotional responses, and insights immediately following scenario completion. These tools should include structured prompts that guide reflection on specific competency areas, decision-making processes, and collaborative interactions. Such structured digital reflections have been associated with improved metacognition and clinical reasoning skills in immersive learning (Chang et al., 2022). Modern VR platforms like NursingXR utilize scalable and flexible architectures tailored to support a variety of nursing lessons with modular designs that can incorporate sophisticated reflection tools. Implementation examples:

Immediate post-scenario journaling: VR training platforms can automatically transition learners from high-stress disaster scenarios to calm reflection environments where they complete digital journals using voice-to-text or gesture-based input systems.

Emotion recognition integration: Advanced platforms can analyse physiological responses (heart rate, stress indicators) during scenarios and prompt targeted reflection questions about emotional responses and stress management strategies.

Collaborative reflection spaces: Virtual environments where cohorts can gather post-training to share experiences and insights in structured reflection sessions.

B. Real-Time Metacognitive Interventions

Pause-and-reflect prompts during scenarios provide opportunities for metacognitive awareness without disrupting immersive experiences. These interventions represent a sophisticated balance between maintaining flow states and promoting critical thinking. The timing and frequency of prompts should be carefully calibrated to enhance rather than interrupt learning flow. Advanced implementation strategies:

Adaptive prompting systems: Artificial intellingence (AI)-driven algorithms that analyse learner performance in real-time and deploy metacognitive prompts only when decision-making patterns suggest the need for reflection.

Biometric-triggered interventions: Systems that monitor stress levels and cognitive load, automatically initiating brief reflection moments when learners appear overwhelmed or making hasty decisions.

Scenario-specific prompt libraries: Curated reflection questions aligned with specific disaster scenarios (mass casualty events, infectious disease outbreaks, natural disasters) and learning objectives.

A study has shown these embedded metacognitive checkpoints foster critical thinking in high-pressure environments (Lin et al., 2024), with participants demonstrating improved response times, more effective decision-making under pressure, and a greater sense of preparedness when metacognitive elements are integrated into VR training.

C. Comprehensive Self-Assessment Integration

Post-simulation self-assessment tools should incorporate validated instruments that measure confidence levels, perceived competency, and emotional responses to training scenarios. Modern evaluation frameworks extend beyond simple satisfaction surveys to include sophisticated psychometric assessments. These assessments should align with disaster nursing competency frameworks and provide longitudinal tracking of learner development. Integration with learning analytics platforms enables personalized feedback and targeted skill development recommendations (Casler et al., 2024). Examples of validated assessment tools:

Disaster nursing knowledge and skills assessment (DNKSA): Pre/post training instrument measuring knowledge acquisition in disaster response protocols

Emergency response confidence scale (ERCS): Validated tool measuring self-efficacy in disaster nursing competencies.

Moral distress scale-revised (MDS-R): Assessment of ethical stress responses in disaster scenarios.

Simulation effectiveness tool (SET): Measures perceived learning and confidence gains from simulation experiences

D. Multi-Perspective Performance Review

Video review capabilities allow learners to revisit their performance from multiple perspectives, including first-person experiences and observer viewpoints. Advanced VR systems can provide unprecedented access to performance data through various technological approaches (Lavoieet al., 2025). Innovative review technologies:

360-degree scenario playback: Learners can revisit scenarios from any vantage point, observing their interactions with patients, team members, and environment.

Performance heat maps: Visual representations showing where learners focused attention, movement patterns, and decision-making bottlenecks

Comparative analysis tools: Side-by-side viewing of expert performances versus learner attempts, highlighting best practices and improvement opportunities

Augmented replay systems: Real-time overlays during video review showing physiological data, decision rationales, and alternative action options

This multi-perspective review enhances self-awareness and supports identification of improvement opportunities that might not be apparent during initial scenario participation.

3.0.2. Debriefing Approaches

A. Framework-Based Debriefing Models

Structured debriefing represents a critical component of VR/AR training evaluation, facilitating transformation of experiences into learning outcomes. The PEARLS (Promoting Excellence and Reflective Learning in Simulation) model provides a robust framework for conducting effective debriefing sessions that address both technical performance and emotional processing of challenging scenarios (Shujuan et al., 2022). PEARLS model adaptation for VR/AR contexts:

Reactions phase: Enhanced by reviewing biometric data and stress response patterns captured during VR scenarios

Descriptive phase: Supplemented with multi-angle video review and objective performance metrics

Analysis phase: Enriched through access to decision-making data and alternative scenario outcomes

Application phase: Strengthened by immediate practice opportunities in modified virtual scenarios

B. Hybrid Virtual-Physical Debriefing Environments

Virtual debriefing environments can extend traditional face-to-face discussions by enabling review of scenario recordings, performance metrics, and decision-making data. These environments should support both synchronous and asynchronous debriefing activities, accommodating diverse learning schedules and preferences while maintaining the collaborative benefits of group reflection. Virtual debriefings in VR-based education are proven to be effective in promoting emotional processing and peer learning (Magi et al., 2023). The majority of articles focused on the outcomes and effectiveness of VR simulation exercises in disaster preparedness training, revealing diverse advantages and challenges of VR usage. Implementation models:

Synchronous virtual debriefing rooms: Shared virtual spaces where geographically distributed learners can gather immediately post-simulation with facilitators for real-time discussion.

Asynchronous reflection platforms: Discussion forums and video annotation tools allowing learners to process experiences across different time zones and schedules.

Hybrid reality debriefing: Physical debriefing rooms enhanced with VR replay capabilities and shared virtual data visualization.

C. Specialized Facilitator Development

Facilitator training for VR/AR debriefing requires specialized competencies that extend beyond traditional simulation education. Effective VR/AR facilitators must understand the unique psychological and physiological aspects of virtual learning environments. Core competency areas for VR/AR facilitators:

Technology fluency: Understanding platform capabilities, common technical issues, and troubleshooting strategies

Virtual presence psychology: Recognition of how altered sense of presence affects emotional responses and learning transfer

Motion sickness management: Strategies for identifying and addressing VR-induced discomfort that may affect learning

Digital native vs. technology-anxious learner needs: Adaptive facilitation approaches for diverse technology comfort levels

Multi-modal data ınterpretation: Ability to synthesize performance metrics, biometric data, and qualitative observations

D. Peer-to-Peer Learning Networks

Peer-to-peer debriefing approaches can supplement facilitator-led sessions by enabling learners to process experiences with colleagues who shared similar training scenarios. VR training provides confidence when interacting with live patients, as students already know how to assess the patient and what to do, making patients feel better about the situation (Chang et al., 2022). Structured peer learning formats:

Buddy system debriefing: Paired learners who complete scenarios together and engage in structured peer reflection using guided prompts

Cross-cohort experience sharing: Virtual forums where learners from different training cycles share insights and lessons learned

Mentorship integration: Advanced students or recent graduates serving as peer mentors for novice learners navigating VR training experiences

These informal debriefing opportunities should be supported through discussion forums, video chat platforms, and collaborative reflection tools that maintain privacy while encouraging open communication.

D. Advanced Clinical Reasoning Analysis

Analysis of clinical reasoning processes during debriefing should focus on the cognitive skills underlying decision-making rather than simply evaluating outcome correctness. This approach helps learners develop transferable reasoning patterns that can adapt to novel disaster scenarios not specifically addressed in training programs (Lin et al., 2023). Clinical reasoning assessment strategies:

Think-aloud protocol analysis: Review of recorded verbalizations during scenario performance to understand thought processes

Decision tree mapping: Visual representation of decision pathways taken during scenarios compared to expert reasoning models

Cognitive load assessment: Analysis of mental effort required for different decision points and identification of areas requiring additional practice

Pattern recognition development: Focus on helping learners identify recurring decision-making patterns applicable across disaster contexts

F. Emotional Response Processing Protocols

Emotional response processing represents an essential debriefing component, particularly given the potentially distressing nature of disaster scenarios. Debriefing protocols should include strategies for identifying and addressing moral distress, anxiety, or other emotional responses that might interfere with learning or future clinical performance (Mao et al., 2025). Comprehensive emotional processing approaches:

Trauma-informed debriefing: Recognition that disaster scenarios may trigger personal trauma responses requiring specialized intervention

Moral distress identification: Systematic assessment of ethical conflicts arising from resource-limited disaster scenarios

Resilience building strategies: Specific techniques for developing emotional resilience in high-stress disaster environments

Professional identity development: Processing how disaster response experiences align with nursing professional values and identity

3.4.3 Evaluation Techniques

A. Comprehensive Pre-Post Training Evaluation

Comprehensive evaluation of VR/AR disaster nursing training requires multiple assessment methods that capture diverse learning outcomes and competency dimensions. Meta-analysis research evaluates the effectiveness of VR in nursing education in areas of knowledge, skills, satisfaction, confidence, and performance time, indicating the need for multifaceted evaluation approaches (Shujuan et al., 2022). Validated assessment instruments:

Disaster nursing competency scale (DNCS): Measures specific disaster response skills and knowledge

Emergency preparedness information questionnaire (EPIQ): Assesses disaster preparedness knowledge and attitudes

Professional self-care in disaster response scale: Evaluates ability to maintain personal wellness during disaster response

Cultural competence in disaster response assessment: Measures ability to provide culturally sensitive care in diverse disaster contexts

B. Advanced Qualitative Analysis Methods

Qualitative reflection analysis provides insights into learner thinking processes, emotional responses, and perceived value of training experiences. Modern qualitative analysis benefits from digital tools and sophisticated analytical frameworks. Thematic analysis of reflection journals, debriefing transcripts, and open-ended survey responses can identify common learning patterns, persistent misconceptions, and areas requiring additional training emphasis (Casler et al., 2024). Enhanced qualitative analysis techniques:

Natural language processing (NLP) analysis: Automated analysis of reflection journals and debriefing transcripts to identify common themes and sentiment patterns

Video content analysis: Systematic analysis of recorded debriefing sessions and reflection videos using structured coding frameworks

Phenomenological inquiry: In-depth exploration of learner lived experiences within virtual disaster environments

Grounded theory development: Building theoretical models of effective disaster nursing preparation based on VR/AR training experiences

C. Objective Performance Metrics Integration

Performance metrics embedded within VR/AR platforms offer objective measures of technical competency that complement subjective assessments. Multiple instruments are utilized to evaluate disaster education methods, including immersive VR simulations with various data collection approaches. These metrics should be carefully selected to reflect meaningful clinical outcomes rather than simply measuring platform engagement or task completion (Lavoie et al., 2025). Sophisticated performance measurement systems:

Response time analytics: Measurement of decision-making speed across different scenario complexity levels

Assessment accuracy scoring: Evaluation of clinical assessment skills using standardized patient presentations

Protocol adherence tracking: Automatic monitoring of compliance with disaster response protocols and guidelines

Resource management efficiency: Assessment of appropriate resource allocation and triage decision-making

Communication quality metrics: Analysis of therapeutic communication effectiveness with patients and team coordination

D. Comprehensive Instructor Assessment Tools

Instructor feedback mechanisms should incorporate structured observation tools that assess competencies not easily measured through automated systems. These tools require development of sophisticated observation frameworks tailored to VR/AR learning environments (Lin et al., 2024). Advanced ınstructor assessment approaches:

Competency-based observation rubrics: Detailed scoring systems aligned with professional nursing standards and disaster response competencies

360-degree feedback integration: Multiple perspective assessments from patients (actors), team members, and supervisors within VR scenarios

Real-time performance coaching: Immediate feedback delivery within virtual environments without disrupting immersion

Portfolio-based assessment: Comprehensive collection of artifacts demonstrating growth over time across multiple training experiences

These might include communication effectiveness, leadership behavior, ethical decision-making, and adaptability to changing scenario conditions.

E. Longitudinal Development Tracking

Longitudinal assessment approaches track competency development over time, identifying learning trajectories and retention patterns that inform program optimization. VR is an effective teaching-learning strategy to reinforce nursing concepts and build competencies, though it is not a substitute for clinical education (Casler et al., 2024). Comprehensive longitudinal assessment framework:

Immediate post-training (T1): Knowledge retention, confidence levels, and immediate skill demonstration

Short-term follow-up (T2- 4-6 weeks): Skill retention, transfer to clinical practice, and continued confidence

Medium-term evaluation (T3- 3-6 months): Integration with ongoing clinical practice and professional development

Long-term ımpact assessment (T4- 12+ months): Career impact, professional advancement, and sustained competency growth

These assessments should occur at multiple time points, including immediate post-training, short-term follow-up (4–6 weeks), and longer-term evaluation (6–12 months) to assess knowledge and skill retention.

F. Comparative Effectiveness Research

Comparative evaluation studies should assess VR/AR training effectiveness relative to traditional simulation methods, clinical experiences, or didactic education approaches. Studies explore the effectiveness of VR in training paramedic students for mass casualty incidents and compare outcomes to conventional training methods (Chang et al., 2022). Rigorous comparative study designs:

Randomized controlled trials (RCTs): Gold standard for evaluating training effectiveness with proper control groups

Quasi-experimental designs: Practical alternatives when randomization is not feasible in educational settings

Mixed-methods approach: Combination of quantitative outcome measures with qualitative experience analysis

Cost-effectiveness analysis: Economic evaluation comparing VR/AR training costs with traditional methods and outcomes achieved

Multi-site validation studies: Research conducted across different institutions to establish generalizability

These studies should employ rigorous research designs that control for confounding variables while measuring relevant patient care outcomes and professional development indicators.

3.4.4. Use in Disaster Contexts

A. Time-Critical Decision-Making Assessment

Evaluation methods must consider the unique challenges of disaster nursing practice, including time pressure, resource limitations, and high-stress environments that may affect learning and performance. VR could be used for disaster preparedness training for nurses without prior disaster response experiences, whereas tabletop drills were more suitable for nurses with prior experiences (Chang et al., 2022). Time-sensitive performance evaluation:

Rapid triage accuracy: Assessment of ability to quickly and accurately categorize patients using Simple Triage and Rapid Treatment (START) protocols

Critical decision timelines: Measurement of time from scenario presentation to key intervention decisions

Stress-performance correlation analysis: Evaluation of how increasing time pressure affects decision quality

Multi-tasking competency: Assessment of ability to manage multiple simultaneous priorities effectively

Assessment of time-sensitive decision-making should evaluate both speed and accuracy of clinical judgments, recognizing that disaster scenarios often require rapid decisions with incomplete information. Evaluation metrics should reflect the reality that optimal disaster care may differ from standard clinical practice due to resource constraints and population-level considerations.

B. Complex Scenario Management Evaluation

Complex scenario evaluation should assess learners' ability to manage multiple competing priorities, adapt to changing conditions, and maintain situational awareness during chaotic events (Mao et al., 2025). Multi-dimensional scenario assessment:

Situational awareness measurement: Assessment of ability to maintain awareness of overall disaster scene while focusing on individual patients

Priority adaptation skills: Evaluation of flexibility when scenario conditions change (e.g., additional casualties, resource depletion)

Ethical decision-making under pressure: Assessment of ability to make difficult triage decisions consistent with utilitarian principles

Team leadership and communication: Evaluation of ability to coordinate with other responders and maintain team cohesion

These assessments should measure cognitive flexibility, stress management, and the ability to prioritize interventions based on greatest good for greatest number principles.

C. Learning Transfer Validation

Transfer of learning from virtual environments to actual disaster responses represents a critical evaluation outcome that requires longitudinal assessment methods. VR simulation technology offers a viable alternative with inherent features of reproducibility, just-in-time training, and repeatability for disaster preparedness training (Shujuan et al., 2022). Transfer assessment strategies:

Simulated-to-real performance correlation: Studies comparing VR performance with actual emergency response effectiveness

Self-efficacy transfer measurement: Assessment of confidence levels when facing real disaster situations after VR training

Supervisor evaluation integration: Structured assessment tools for supervisors to evaluate disaster response competency in real situations

Performance during actual events: When available, objective measures of performance during real emergency situations

This evaluation should include self-reported confidence in real disaster situations, supervisor assessments of disaster response competency, and objective measures of performance during actual emergency events when available.

D. Professional Development Integration

Integration with continuing education requirements should ensure that VR/AR training evaluation supports professional development goals and regulatory compliance. Modern healthcare requires sophisticated approaches to competency validation and professional growth tracking (Casler et al., 2024). Professional development alignment:

Competency validation documentation: Generation of certificates and documentation suitable for regulatory compliance

Continuing education credit integration: Alignment with nursing continuing education requirements and professional development planning

Career advancement portfolio development: Creation of comprehensive learning portfolios demonstrating disaster nursing competency growth

Professional network integration: Connection with professional organizations and disaster response teams for career development opportunities

Evaluation systems should generate documentation suitable for competency validation, continuing education credit, and professional portfolio development.

3.5. Competency Based Assessments

Competency-based assessment in VR/AR disaster nursing training ensures that learning outcomes align with professional standards and practice requirements. VR simulation use in graduate nursing education is a growing innovative trend that can help with competency-based education (Casler et al., 2024). This approach focuses on measurable performance outcomes rather than time-based training completion, ensuring that nurses demonstrate required capabilities before assuming disaster response roles.

3.5.1 Competency Mapping

A. Professional Standards Alignment and Competency Mapping

Effective competency mapping requires alignment between VR/AR training objectives and established disaster nursing standards from professional organizations such as the International Nursing Coalition for Mass Casualty Education, the American Nurses Association, and the World Health Organization Emergency Medical Teams initiative. The National League for Nursing 2024 Education Summit focused specifically on "Competency-Based Education" as a daring proposition for nursing education transformation, highlighting the growing emphasis on outcome-based learning approaches (Lin et al., 2024). Modern competency framework examples:

SimX VR competency integration: SimX VR revolutionizes competency-based learning by providing seven key ways to transform nursing education through immersive simulation experiences.

Oxford medical simulation (OMS) frameworks: This tracks progress towards key competencies from 10 in-built frameworks, directly aligning actions in-scenario to core components of competency.

VRpatients® customization: A no-code platform for creating immersive, AI-driven VR simulations with flexible authoring tools that allow alignment with specific competency requirements.

This mapping process ensures that virtual training addresses all essential competency domains while avoiding redundancy or gaps in coverage.

B. Core Competency Domains

Clinical Assessment and Triage Competencies

Core competency domains should include clinical assessment and triage, where learners demonstrate proficiency in rapid patient evaluation, priority assignment, and appropriate care escalation decisions. VR allows students to practice psychomotor and critical thinking skills over and over in a risk-free environment, enabling deliberate practice that allows students the ability to 'fail safely' in a simulated environment (Tan et al., 2023). Implementation examples:

Standardized triage protocols: VR scenarios implementing START and SALT methodologies

Multi-patient assessment scenarios: Immersive environments where learners must evaluate multiple casualties simultaneously while maintaining systematic assessment approaches

Resource-constrained decision making: Scenarios that test appropriate triage decisions when medical supplies and personnel are limited

Assessment criteria should specify observable behaviors such as systematic assessment approaches, accurate vital sign interpretation, and appropriate use of triage categories based on injury severity and resource availability.

Disaster Response Coordination Competencies

Disaster response coordination competencies encompass communication with incident command systems, resource management, and interdisciplinary collaboration. Virtual simulations help nursing students practice clinical skills in a controlled environment, which is particularly useful for complex or high-stakes patient care situations (Magi et al., 2023). Real-world integration examples:

Incident command system (ICS) integration: VR training scenarios that replicate actual ICS structures and communication protocols

Multi-agency coordination: Simulations involving coordination with FEMA, Red Cross, and local emergency management agencies

Resource request and tracking: Virtual systems that mirror real disaster response resource management platforms

VR/AR assessments should evaluate learners' ability to participate effectively in unified command structures, request appropriate resources, and coordinate care across multiple agencies and disciplines.

Psychological and Social Competencies

Psychological and social competencies address the emotional and behavioral aspects of disaster nursing, including stress management, cultural sensitivity, and ethical decision-making under pressure. Assessment frameworks should include measures of emotional regulation, cultural competence demonstration, and ethical reasoning in resource-scarce situations (Mao et al., 2025). Advanced assessment approaches:

Moral distress scenarios: Situations requiring difficult ethical decisions about resource allocation and end-of-life care

Cultural competency challenges: Multi-cultural disaster scenarios requiring culturally sensitive communication and care approaches

Stress response monitoring: Integration of biometric monitoring to assess stress management and emotional regulation during high-pressure scenarios

Leadership Competencies

Leadership competencies become increasingly important as nurses advance in their disaster response roles. VR/AR assessments should evaluate delegation skills, team coordination abilities, and decision-making under uncertainty. These competencies should be assessed through scenarios that require learners to assume charge nurse or team leader roles during simulated disasters (Casler et al., 2024). Leadership assessment examples:

Team coordination scenarios: Multi-person VR environments where learners must coordinate virtual team members during disaster response.

Crisis communication exercises: Scenarios requiring clear communication with families, media, and other stakeholders during disasters.

Decision-making under uncertainty: High-stakes scenarios with incomplete information requiring rapid leadership decisions.

Competency Progression Models

Competency progression models should reflect different experience levels, from entry-level disaster awareness to advanced specialist capabilities. Experiential learning theory works well for virtual reality situations where the learner can explore and experiment and then cognitively process those experiences through concrete experience, reflective observation, abstract conceptualization, and active experimentation (Lin et al., 2024). Tiered competency framework:

Novice level: Basic disaster awareness, personal safety, and fundamental triage concepts

Competent level: Independent disaster response functions, team coordination, and specialized skill application

Proficient level: Advanced clinical decision-making, leadership responsibilities, and mentoring capabilities

Expert level: System-level thinking, policy development, and disaster preparedness planning.

This tiered approach allows for appropriate assessment expectations while providing clear pathways for professional development in disaster nursing practice.

3.5.2. Assessment Methods

Scenario-based performance metrics provide objective measures of competency demonstration within authentic contexts. Using platforms like OMS allows organizations to assess clinical competence in a way that is the same every time, for every candidate, with scenarios that are standardized and performance benchmarked against best practice.

A. Decision-Making Accuracy Assessment

These assessments should evaluate decision-making accuracy by comparing learner choices to evidence-based best practices and expert consensus recommendations (Lavoie et al., 2025). Advanced metrics examples:

Decision tree analysis: Mapping of learner decision pathways compared to expert consensus approaches.

Evidence-based correlation: Alignment of learner choices with current clinical guidelines and research recommendations.

Alternative outcome modeling: Analysis of potential consequences from different decision approaches.

B. Timeliness and Efficiency Metrics

Timeliness assessments must balance the need for rapid response with thorough clinical evaluation. Assessment criteria should reflect realistic time constraints faced during actual disasters while recognizing that excessive speed may compromise care quality (Chang et al., 2022). Practical implementation:

Contextual time standards: Different timing expectations based on disaster phase (immediate response vs. sustained operations).

Quality-speed balance: Metrics that penalize both excessive delays and rushed decisions that compromise patient safety.

Adaptive timing: Scenarios that adjust time pressure based on learner competency level and experience.

C. Multi-Dimensional Accuracy Measurements

Accuracy measurements should encompass multiple dimensions of clinical performance, including assessment accuracy, intervention appropriateness, and documentation completeness. These measurements should account for the reality that perfect accuracy may not be achievable in disaster conditions, focusing instead on clinically acceptable performance levels (Lin et al., 2024). Comprehensive accuracy assessment:

Clinical assessment accuracy: Precision in patient evaluation and diagnostic reasoning

Intervention appropriateness: Selection of evidence-based interventions suitable for disaster conditions

Documentation quality: Completeness and accuracy of patient records under time-pressured conditions

Safety compliance: Adherence to safety protocols for both patients and responders

D. Behavioral and Communication Assessment

Behavioral assessment components should evaluate communication effectiveness, teamwork skills, and professional demeanor during high-stress scenarios. These assessments require sophisticated observation tools and trained evaluators who can distinguish between stress-related performance decrements and fundamental competency deficits (Casler et al., 2024). Advanced behavioral metrics:

Communication quality scoring: Analysis of therapeutic communication techniques and family interaction skills

Team collaboration ratings: Assessment of ability to work effectively within interdisciplinary teams

Professional demeanor evaluation: Maintenance of professional standards under extreme stress conditions

3.5.3. Data and Feedback Systems

Automated scoring systems must balance efficiency with accuracy, utilizing sophisticated algorithms that can interpret complex performance data and generate meaningful competency assessments. Scoring and evaluation methods for VR training simulators capable of capturing detailed multidimensional performance data are proposed and examined. Advanced Automated scoring features (Lavoie et al., 2025):

Multi-modal data integration: OMS platform provides dynamic clinical experiences on-demand, with objective measures of competence to optimize performance.

Real-time performance analysis: Immediate feedback on critical decisions with comprehensive performance tracking.

Biometric integration: Incorporation of physiological responses when available through monitoring systems.

Pattern recognition algorithms: Identification of performance patterns that predict clinical competency.

Comprehensive Performance Analytics

Performance analytics should provide detailed feedback on specific competency areas, highlighting strengths and identifying improvement opportunities through granular data analysis. The OMS platform automates, standardizes and unbiases all clinical assessments, getting a clear picture of learners' critical thinking and clinical reasoning abilities (Lavoie et al., 2025). Advanced analytics examples:

Competency heat maps: Visual representations of performance across different skill domains

Learning trajectory tracking: Longitudinal analysis of competency development over time

Comparative performance analysis: Benchmarking against peer groups and expert standards

Predictive performance modeling: Algorithms that predict future performance based on current assessment data

Learners should receive immediate feedback on critical decisions while comprehensive performance reports support longer-term learning planning and professional development goal setting.

Personalized Learning Analytics

Progression tracking systems should monitor competency development over time, identifying learning trajectories and predicting future performance based on current assessment data. These systems should flag learners who may require additional support or remediation while recognizing exceptional performers who might benefit from advanced training opportunities (Chang et al., 2022). Personalized analytics features:

Individual learning path optimization: Customized training recommendations based on performance patterns

Competency gap identification: Specific areas requiring additional focus and practice

Adaptive difficulty adjustment: Automatic scenario complexity modification based on demonstrated competency

Professional development planning: Long-term competency tracking aligned with career goals

Data Visualization and Reporting

Data visualization tools should present complex performance information in accessible formats that support learning and professional development. Platforms provide intuitive, no-code authoring capabilities and the flexibility to customize existing scenarios while objectively tracking progress towards key competencies (Magi et al., 2023). Advanced visualization examples:

Interactive performance dashboards: Real-time displays of competency progress with drill-down capabilities

3D performance modeling: Immersive visualization of performance data within VR environments

Collaborative analytics: Shared dashboards for educators and learners to review progress together

Mobile-friendly reporting: Performance insights accessible across devices and platforms

Interactive dashboards should allow learners to explore their performance data, identify trends, and track progress toward competency goals.

3.5.4. Validation and Ethics

Assessment validation requires rigorous research approaches that demonstrate the reliability, validity, and fairness of VR/AR competency evaluations. Construct validity should be established through comparison with established assessment methods and correlation with actual disaster response performance when possible (Casler et al., 2024). Reliability studies should examine both internal consistency and test-retest reliability across diverse learner populations and assessment conditions. Inter-rater reliability is particularly important for components requiring human evaluation (Lin et al., 2024).

- Fairness considerations must address potential biases related to technology familiarity, cultural backgrounds, and learning differences. Assessment systems should be designed to minimize technological barriers while ensuring that competency evaluation focuses on clinical capabilities (Magi et al., 2023).
- Transparency requirements demand clear communication about assessment criteria, scoring methods, and competency standards. Appeals processes should be available for learners who question assessment results or believe their performance was affected by technical issues (Chang et al., 2022).
- Responsible data use protocols must protect learner privacy while enabling appropriate use of assessment information for educational improvement and competency validation. Data governance policies should specify authorized uses and sharing restrictions while ensuring compliance with privacy regulations (Casler et al., 2024).
- Continuous validation processes should monitor assessment performance over time, identifying drift in scoring algorithms or changes in learner populations that might affect validity. Regular validation studies help maintain assessment quality and relevance (Lavoie et al., 2025).

Ethical oversight mechanisms should include institutional review board approval for research uses of assessment data and ongoing monitoring of potential negative consequences from competency-based evaluation systems (Mao et al., 2025).

As VR/AR competency assessment becomes more widespread, efforts toward global standardization of disaster nursing competencies and assessment methods will become increasingly important for professional mobility and consistency of care quality.

The integration of comprehensive competency-based assessment systems in VR/AR disaster nursing training represents a significant advancement in nursing education quality and professional preparedness. Through careful implementation of validated assessment methods, sophisticated analytics systems, and ethical oversight mechanisms, these technologies can ensure that nurses are truly prepared for the complex challenges of disaster response while maintaining the highest standards of professional accountability and patient safety.

3.6. Future Outlook: Hybrid Simulation and Scalable Solutions

As virtual and augmented reality technologies mature, the future of disaster nursing education is increasingly trending toward hybrid simulation models and scalable, accessible learning ecosystems. These forward-looking strategies aim to combine the strengths of traditional manikin-based training with the immersive, data-rich environments offered by VR/AR, maximizing realism, pedagogical impact, and institutional reach (Casler et al., 2024; Magi et al., 2023).

3.6.1. Blended Simulation Models

The integration of VR/AR systems with physical manikin-based simulators presents a powerful hybrid approach to disaster training that addresses the limitations of purely virtual or physical training methods. Nursing programs have had to consider ways to look beyond their physical simulation labs and start exploring other innovative and immersive learning platforms using hybrid approaches (Chang et al., 2022; Lavoie et al., 2025). Leading hybrid simulation examples:

SimX virtual manikin series: A collection of VR simulated patient encounters that can be customized in real time to meet the needs of educators and learners, allowing seamless integration with physical manikins

TraumaVR hybrid systems: A hybrid VR simulator that combines both hardware and software to optimize the simulation-based educational environment, enabling learners to acquire life-saving procedure skills with realistic visual effects

AI-powered manikins: AI-powered manikins like HAL S5301 provide lifelike simulation and training for healthcare students, creating responsive physical interactions that complement VR scenarios

While VR enables large-scale scenario visualization and interactive decision-making, tactile feedback and procedural realism are enhanced when learners also engage with high-fidelity manikins. This multimodal format replicates the full continuum of patient care—from cognitive assessment to hands-on skills—improving clinical preparedness for mass casualty situations (Lavoie et al., 2025). Scenario coordination across both physical and virtual modalities supports seamless transitions between cognitive decision points and manual interventions, fostering deeper learning and skill retention (Chang et al., 2022).

3.6.2. Mobile, Cloud-Based, and Remote-Accessible Platforms

Scalability and accessibility will define the next phase of VR/AR training development. Platforms like VRpatients offer no-code solutions for creating immersive, AI-driven VR, MR, and web-based patient simulations—available anytime, anywhere, with flexible authoring tools and 24/7 access (Casler et al., 2024). Key cloud-based platform features:

Centralized content management: Cloud-based platforms enable centralized scenario updates, learner data management, and performance analytics while reducing the need for complex local installations

Multi-site deployment: Platforms like OMS drive clinical competency by combining healthcare education and competency assessment with dynamic virtual reality simulations across multiple institutions

Real-time collaboration: SimInsights develops innovative human factors VR simulations that enable clinicians to enact realistic healthcare facility use scenarios with distributed teams.

Remote-access functionality facilitates asynchronous training and assessment, allowing nurses to engage with simulation content regardless of location, time zone, or institutional affiliation. This approach has proven particularly valuable for continuing education and emergency preparedness training across geographically dispersed healthcare systems (Casler et al., 2024).

Low-Cost and Mobile-Accessible AR/VR Systems

Cost-effectiveness and accessibility remain critical barriers to widespread VR/AR adoption in nursing education. Mobile-ready VR solutions using lightweight headsets or smartphone-compatible viewers can extend training to resource-constrained or geographically remote settings (Lin et al., 2024). Affordable implementation strategies:

Smartphone-based VR: Cardboard and plastic headset adapters that transform smartphones into basic VR training devices

Standalone VR headsets: Meta Quest and similar devices providing full VR capabilities without expensive computer requirements

Web-based AR: Browser-based augmented reality applications requiring only tablets or smartphones with cameras

Cost-benefit analysis: It has been demonstrated that adoption of virtual reality technology may be delayed due to high initial costs, but cost analyses show positive returns on investment for VR training tools.

3.6.3. Institutional Licensing and Scalability Models

To achieve widespread adoption, VR/AR training programs must support flexible licensing models suited to institutional needs. Subscription-based, per-learner, or enterprise-level licensing structures can enable cost-effective scaling across nursing schools, hospitals, and national emergency preparedness programs. Customizable modules should allow institutions to align training content with local protocols, cultural considerations, and legal frameworks. Furthermore, centralized analytics dashboards can support multi-site performance benchmarking and compliance tracking for large organizations (Magi et al., 2023).

3.6.4. Emerging Innovations in Personalization and Engagement

A. AI-Driven Adaptive Simulation Scenarios

Advanced AI integration is poised to transform VR/AR disaster training by enabling personalized learning trajectories that respond to individual learner needs and performance patterns. AI algorithms can analyze learner performance data to dynamically adjust scenario complexity, recommend focused skill modules, and deliver just-in-time feedback. These intelligent systems enhance learning efficiency and target individual competency gaps (Casler et al., 2024). AI-enhanced training features:

Adaptive difficulty scaling: Scenarios that automatically adjust complexity based on learner performance and confidence levels

Predictive analytics: Systems that identify learners at risk of poor performance and provide targeted interventions

Natural language processing: AI-powered virtual patients that can engage in realistic conversations and respond to diverse communication approaches

Performance pattern recognition: Algorithms that identify common errors and provide personalized remediation strategies

Gamification elements—such as achievement badges, progression tiers, and interactive leaderboards—can increase learner motivation, especially in repetitive skills training or longitudinal competency development. Evidence shows that gamified environments enhance engagement and persistence, particularly among digital-native learners in nursing programs (Lavoie et al., 2025).

B. Open-Source and Shared Simulation Libraries

The development of open-source simulation platforms and shared content libraries represents a significant opportunity to democratize access to high-quality disaster nursing training. Collaborative development models can reduce costs while improving content quality through peer review and continuous improvement (Lin et al., 2024). Collaborative development models:

Open-source platforms: Community-developed VR/AR frameworks that institutions can customize and extend

Shared scenario libraries: Centralized repositories of validated disaster scenarios available for adaptation across institutions

Peer review networks: Communities of educators collaborating on content development and quality assurance

Global knowledge exchange: International partnerships sharing culturally adapted scenarios and best practices

Another promising direction is the deployment of large-scale disaster simulations in VR, such as pandemic outbreaks, terrorist events, or natural disasters. These simulations test not only individual competencies but also team coordination, resource prioritization, and ethical decision-making under system-level stress. Such high-fidelity virtual exercises could complement or even replace costly full-scale physical drills in the future.

C. Equity and Access in Global Health Education

Addressing global health education equity requires intentional design of VR/AR systems that consider diverse technological, cultural, and economic contexts. According to the WHO, the planet will need more than 40 million new doctors, nurses, frontline healthcare workers, and other healthcare professionals, highlighting the urgent need for scalable training solutions (WHO, 2010). Global access strategies:

Low-bandwidth solutions: VR/AR applications optimized for limited internet connectivity and older hardware

Cultural adaptation: Simulation scenarios that reflect diverse populations, cultural practices, and healthcare systems

Language localization: Multi-language support and culturally appropriate content for global deployment

Partnership models: Collaborations between developed and developing nations for technology transfer and capacity building

Sustainable implementation: Training programs designed for long-term sustainability without ongoing technical support

Regional Implementation Examples

Examples of regional implementations are (Magi et al., 2023):

Rural healthcare training: Mobile VR units bringing disaster preparedness training to remote areas

International development: Partnerships providing VR training systems to resource-limited healthcare systems

Refugee camp applications: Portable simulation systems for training healthcare workers in humanitarian settings.

Disaster-prone regions: Specialized training programs for areas with high risk of specific disasters (hurricanes, earthquakes, tsunamis)

Furthermore, centralized analytics dashboards can support multi-site performance benchmarking and compliance tracking for large organizations. These systems enable identification of best practices, standardization of competency requirements, and evidence-based improvements to training programs across diverse settings.

REFERENCES

Aggarwal, R., & Darzi, A. (2011). Simulation to enhance patient safety: Why aren't we there yet? *Chest, 140*(4), 854–858. https://doi.org/10.1378/chest.11-0039

Alinier, G., Hunt, B., Gordon, R., & Harwood, C. (2006). Effectiveness of intermediate-fidelity simulation training technology in undergraduate nursing education. *Journal of Advanced Nursing, 54*(3), 359–369. https://doi.org/10.1111/j.1365-2648.2006.03810.x

Al-Saud, L. M., Mushtaq, F., Allsop, M. J., Culmer, P. R., Mirghani, I., Yates, E., ... & Manogue, M. (2017). Feedback and motor skill acquisition using a haptic dental simulator. *European Journal of Dental Education, 21*(4), 240–247. https://doi.org/10.1111/eje.12214

Aluisio, A. R., Daniel, P., Grock, A., Freedman, J., Singh, A., Papanagnou, D., & Arquilla, B. (2016). Case-based Learning Outperformed Simulation Exercises in Disaster Preparedness Education Among Nursing Trainees in India: A Randomized Controlled Trial. *Prehospital and Disaster Medicine, 31*(5), 516–523. https://doi.org/10.1017/S1049023X16000789

Andersen, P. O., Jensen, M. K., Lippert, A., Østergaard, D., & Klausen, T. W. (2010). Development of a formative assessment tool for measurement of performance in multi-professional resuscitation teams. *Resuscitation, 81*(6), 703–711. https://doi.org/10.1016/j.resuscitation.2010.01.034

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2018). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology & Society, 21*(2), 133–149.

Barmaki, R., & Hughes, C. E. (2019). Accessible virtual reality for people with disabilities: A user-centered design study of a VR navigation aid. *International Journal of Human–Computer Interaction, 35*(11), 995–1008. https://doi.org/10.1080/10447318.2018.1507151

Barsom, E. Z., Graafland, M., & Schijven, M. P. (2016). Systematic review on the effectiveness of augmented reality applications in medical training. *Surgical Endoscopy, 30*(10), 4174–4183. https://doi.org/10.1007/s00464-016-4800-6

Berryman, D. R. (2012). Augmented reality: A review. *Medical Reference Services Quarterly, 31*(2), 212–218. https://doi.org/10.1080/02763869.2012.670604

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. David McKay Company.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2017). Augmented reality in education – cases, places and potentials. *Educational Media International, 54*(1), 1-15. https://doi.org/10.1080/09523987.2017.1335074

Casler, K., Gawlik, K. S., & Messinger, J. (2024). *Virtual reality to aid in competency-based online nurse practitioner curriculum (VR-NP). Journal of Professional Nursing, 55*, 125–132. https://doi.org/10.1016/j.profnurs.2024.09.009

Chang, C. W., Lin, C. W., Huang, C. Y., Hsu, C. W., Sung, H. Y., & Cheng, S. F. (2022). Effectiveness of the virtual reality chemical disaster training program in emergency nurses: A quasi experimental study. *Nurse education today*, *119*, 105613. https://doi.org/10.1016/j.nedt.2022.105613

Chang, E., Kim, H. T., & Yoo, B. (2020). Virtual reality sickness: A review of causes and measurements. *International Journal of Human–Computer Interaction, 36*(17), 1658–1682. https://doi.org/10.1080/10447318.2020.1778351

Cheng, A., Runnels, V., & Haji, F. A. (2021). Simulation in health professions education: A systematic review. *Medical Teacher, 43*(2), 150-160. https://doi.org/10.1080/0142159X.2020.1760080

Cook, D. A., Erwin, P. J., & Triola, M. M. (2013). Computerized virtual patients in health professions education: A systematic review and meta-analysis. *Academic Medicine, 88*(6), 930–937. https://doi.org/10.1097/ACM.0b013e3182937f17

Davenport, T., Guha, A., Grewal, D., & Bressgott, T. (2020). How artificial intelligence will change the future of marketing. *Journal of the Academy of Marketing Science, 48*(1), 24–42.

Eppich, W., & Cheng, A. (2015). Promoting Excellence and Reflective Learning in Simulation (PEARLS): Development and rationale for a blended approach to healthcare simulation debriefing. *Simulation in Healthcare, 10*(2), 106–115. https://doi.org/10.1097/SIH.0000000000000072

Feng, Z., González, V. A., Amor, R., Spearpoint, M., Thomas, J., Sacks, R., & Lovreglio, R. (2019). An immersive virtual reality serious game to enhance earthquake behavioral responses and post-earthquake evacuation preparedness in buildings. *Automation in Construction, 122*, 101118. https://doi.org/10.1016/j.aei.2020.101118

Fernandes, F. A., Rodrigues, C. S. C., Teixeira, E. N., & Werner, C. (2022). Immersive Learning Frameworks: A systematic literature review. *arXiv*. https://arxiv.org

Frank, J. R., Snell, L., Ten Cate, O., Holmboe, E. S., Carraccio, C., Swing, S. R., ... & Harris, P. (2010). Competency-based medical education: Theory to practice. *Medical Teacher, 32*(8), 638-645. https://doi.org/10.3109/0142159X.2010.501190

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. *The International Scientific Conference eLearning and Software for Education, 1*, 133–141. https://doi.org/10.12753/2066-026X-15-020

Gaba, D. M. (2004). The future vision of simulation in healthcare. *Quality and Safety in Health Care, 13*(suppl 1), i2–i10. https://doi.org/10.1136/qhc.13.suppl_1.i2

Gentry, S., Gauthier, A., L'Estrade Ehrstrom, B., Wortley, D., Lilienthal, A., Tudor Car, L., & Car, J. (2019). Virtual reality for pediatric pain and anxiety management: A systematic review and meta-analysis. *Children, 6*(10), 104. https://doi.org/10.3390/children6100104

Goyal, A., Raj, H., Venkatesh, S., Joshi, P., Adwaith, A., & Krishna, P. S. S. (2025). Virtual reality simulation for natural disasters preparedness. *International Journal for Research Trends & Innovation, 10*(4). https://ijrti.org/papers/IJRTI2504069.pdf

Greco, M., et al. (2021). Simulation in disaster nursing education: A scoping review. *Nurse Education Today*. https://doi.org/10.1016/j.nedt.2021.105119

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education, 8*(1), 1–32. https://doi.org/10.1007/s40692-020-00169-6

Haque, S., & Srinivasan, S. (2021). Navigating the integration of virtual reality into the health professions curriculum: A scoping review. *Medical Teacher, 43*(6), 650–660. https://doi.org/10.1080/0142159X.2020.1856992

Haynes IV, J. L. D. (2025). Enter: Graduated Realism: A pedagogical framework for AI powered avatars in VR teacher training. *arXiv*.

Hsieh, J. Y., Lin, P. C., Sun, W. N., Lin, T. R., Kuo, C. C., & Hsu, H. T. (2025). Effectiveness of immersive virtual reality in nursing education for nursing students and nursing staffs: A systematic review and meta-analysis. *Nurse Education Today, 151*, 106725. https://doi.org/10.1016/j.nedt.2025.106725

Issenberg, S. B., McGaghie, W. C., Hart, I. R., et al. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10–28. https://doi.org/10.1080/01421590500046924

Jeffries, P. R., & Rizzolo, M. A. (2006). Designing and implementing models for the innovative use of simulation to teach nursing care of ill adults and children: A national, multi-site, multi-method study. *Nursing Education Perspectives, 27*(2), 96-103.

Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies, 23*(4), 1515–1529. https://doi.org/10.1007/s10639-017-9676-0

Johnsen, H. M., Fossum, M., Vivekananda-Schmidt, P., Fruhling, A., & Slettebø, Å. (2018). Teaching clinical reasoning and decision-making skills using virtual simulation tools in nursing education: A literature review. *Clinical Simulation in Nursing, 13*(12), 585–592. https://doi.org/10.1016/j.ecns.2017.06.002

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2021). Building a sustainable virtual reality ecosystem in health education: Lessons from a multi-site collaboration. *Simulation in Healthcare, 16*(5), 337–344. https://doi.org/10.1097/SIH.0000000000000538

Khanal, S., Medasetti, U. S., Mashal, M., Savage, B., & Khadka, R. (2022). Virtual and augmented reality in the disaster management technology: A literature review. *Frontiers in Virtual Reality*. https://doi.org/10.3389/frvir.2022.843195

Kirkpatrick, D. L., & Kirkpatrick, J. D. (2006). *Evaluating training programs: The four levels* (3rd ed.). Berrett-Koehler Publishers.

Kneebone, R. (2003). Simulation in surgical training: Educational issues and practical implications. *Medical Education, 37*(3), 267–277. https://doi.org/10.1046/j.1365-2923.2003.01440.x

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Kroth, P. J., Al-Bataineh, A., & Sharma, A. (2021). Accessibility and inclusion in virtual reality education: Challenges and solutions. *Education and Information Technologies, 26*, 5945–5961. https://doi.org/10.1007/s10639-021-10556-2

Kyaw, B. M., Saxena, N., Posadzki, P., Vseteckova, J., Nikolaou, C. K., George, P. P., & Car, J. (2019). Virtual reality for health professions education: Systematic review and meta-analysis by the Digital Health Education Collaboration. *Journal of Medical Internet Research, 21*(1), e12959. https://doi.org/10.2196/12959

Lateef, F. (2010). Simulation-based learning: Just like the real thing. *Journal of Emergencies, Trauma, and Shock, 3*(4), 348-352. https://doi.org/10.4103/0974-2700.70743

Lavoie, P., Brien, L.-A., Ledoux, I., Gosselin, É., Khetir, I., Crétaz, M., & Turgeon, N. (2025). *Immersive and non-immersive virtual reality: A quasi-experimental study in undergraduate nursing education*. *Clinical Simulation in Nursing, 99*, 101682. https://doi.org/10.1016/j.ecns.2024.101682

Lin, C.-H., Tzeng, W.-C., Chiang, L.-C., Lu, M.-C., Lee, M.-S., & Chiang, S.-L. (2024). *Effectiveness of a structured disaster management training program on nurses' disaster readiness for response to emergencies and disasters: A randomized controlled trial*. *Journal of Nursing Management*. https://doi.org/10.1155/2024/5551894

Lin, L., Zhou, M., Wang, L., Chen, X., Dai, M., & Zhang, J. (2023). *Enhancing emergency nurses' disaster nursing ability and psychological resilience: A randomized controlled trial*. Nursing Research and Practice, 2023, Article 6108057. https://doi.org/10.1155/2023/6108057

Lin, S., Wang, X., & Zhang, W. (2020). Virtual reality training for disaster response: A systematic review. *International Journal of Disaster Risk Reduction, 49*, 101721. https://doi.org/10.1016/j.ijdrr.2020.101721

Liu, K., Zhang, W., Li, W., et al. (2023). Effectiveness of virtual reality in nursing education: A systematic review and meta-analysis. *BMC Medical Education, 23*, 710. https://doi.org/10.1186/s12909-023-04662-x

Luctkar-Flude, M., Groll, D., & Tyerman, J. (2012). Interprofessional simulation education for undergraduate nursing students: A systematic review. *Clinical Simulation in Nursing, 8*(10), e465–e472. https://doi.org/10.1016/j.ecns.2011.04.005

Magi, C. E., Bambi, S., Iovino, P., El Aoufy, K., Amato, C., Balestri, C., Rasero, L., & Longobucco, Y. (2023). Virtual Reality and Augmented Reality Training in Disaster Medicine Courses for Students in Nursing: A Scoping Review of Adoptable Tools. *Behavioral sciences (Basel, Switzerland)*, *13*(7), 616. https://doi.org/10.3390/bs13070616

Mahdi, S. S., Jafri, H. A., Allana, R., et al. (2023). Systematic review on the current state of disaster preparation Simulation Exercises (SimEx). *BMC Emergency Medicine, 23*, 52. https://doi.org/10.1186/s12873-023-00824-8

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development, 66*, 1141–1164. https://doi.org/10.1007/s11423-018-9581-2

Makransky, G., & Mayer, R. E. (2022). Benefits of immersive virtual reality in learning: A meta-analysis. *Educational Psychology Review, 34*(3), 1501–1528. https://doi.org/10.1007/s10648-021-09625-8

Mao, X., Suo, Y., Wei, X., & Luo, Y. (2025). Resilience enhancement interventions for disaster rescue workers: a systematic review. *Scand J Trauma Resusc Emerg Med* **33**, 91. https://doi.org/10.1186/s13049-025-01397-0

Maresky, H. S., Oikonomou, A., Ali, I., Ditkofsky, N., Pakkal, M., & Ballyk, B. (2019). Virtual reality and cardiac anatomy: Exploring immersive three-dimensional cardiac imaging, a pilot study in undergraduate medical anatomy education. *Clinical Anatomy, 32*(2), 238–243. https://doi.org/10.1002/ca.23292

Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 39*(3), 250–261. https://doi.org/10.1016/j.jbtep.2007.07.007

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Reeves, S., Fletcher, S., Barr, H., Birch, I., Boet, S., Davies, N., ... & Kitto, S. (2016). A BEME systematic review of the effects of interprofessional education: BEME Guide No. 39. *Medical Teacher, 38*(7), 656–668. https://doi.org/10.3109/0142159X.2016.1173663

Rudolph, J. W., Simon, R., Dufresne, R. L., & Raemer, D. B. (2006). There's no such thing as "nonjudgmental" debriefing: A theory and method for debriefing with good judgment. *Simulation in Healthcare, 1*(1), 49–55. https://doi.org/10.1097/01266021-200600110-00006

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a "Big Five" in teamwork? *Small Group Research, 36*(5), 555–599. https://doi.org/10.1177/1046496405277134

Sanddal, T. L., Loyacono, T., & Sanddal, N. D. (2004). Effect of JumpSTART training on immediate and short-term pediatric triage performance. *Pediatric emergency care*, *20*(11), 749–753. https://doi.org/10.1097/01.pec.0000144917.62877.8f

Shujuan, L., Mawpin, T., Meichan, C., Weijun, X., Jing, W., & Biru, L. (2022). The Use of Virtual Reality to Improve Disaster Preparedness Among Nursing Students: A Randomized Study. Journal of Nursing Education, 61(2), 93–96. https://doi.org/10.3928/01484834-20211213-05 (Original work published February 1, 2022)

Sielhorst, T., Feuerstein, M., & Navab, N. (2008). Advanced medical displays: A literature review of augmented reality. *Journal of Display Technology, 4*(4), 451–467. https://doi.org/10.1109/JDT.2008.922494

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. *Frontiers in Robotics and AI, 3*, 74. https://doi.org/10.3389/frobt.2016.00074

Smith, A. B., et al. (2022). Virtual reality simulation for disaster preparedness training in hospitals. *ScienceDirect*.

Tan, Y. T., Shin, C. K. J., Park, B., Bharath, A., Wing, R., Monteilh, C., Sanseau, E., Boswell, B., Pearce, J. I., Luetje, M., Enriquez, B., Cicero, M., & Thomas, A. (2023). *Pediatric emergency medicine didactics and simulation: JumpSTART secondary triage for mass casualty incidents*. *Cureus, 15*(6), e40009. https://doi.org/10.7759/cureus.40009

Wayne, D. B., Didwania, A., Feinglass, J., Fudala, M. J., Barsuk, J. H., & McGaghie, W. C. (2008). Simulation-based education improves quality of care during cardiac arrest team responses at an academic teaching hospital: A case-control study. *Chest, 133*(1), 56–61. https://doi.org/10.1378/chest.07-0131

Wechdorn, T. H. (2024). *Wide area disaster simulation for mobile VR devices* [Diploma thesis, TU Wien].

World Health Organization. (WHO) (2010). *Framework for action on interprofessional education and collaborative practice*. Geneva: WHO.

Yun, J., Lee, Y.J., Kang, K., & Park, J. (2023). Effectiveness of SBAR-based simulation programs for nursing students: a systematic review. *BMC Med Educ* **23**, 507. https://doi.org/10.1186/s12909-023-04495-8

Zook, M., Yager, P., Dye, L., & Allard, M. (2022). The impact of interprofessional simulation on healthcare team performance in disaster preparedness: A scoping review. *Disaster Medicine and Public Health Preparedness, 16*, 1–9. https://doi.org/10.1017/dmp.2021.153

Chapter 4. Guideline for Scenario Writing and AR/VR Development and AR/VR Scenario Examples

4.1. Guideline for scenario writing and AR/VR development

Andrea Hudáčková, František Dolák, Ivana Chloubová, Valérie Tóthová
Otniel Didraga, Gabriela Mariutac

4.0.1. Introduction Virtual Reality

Virtual Reality (VR) is a technology that enables users to immerse themselves in simulated environments created through computer graphics. Its main goal is to induce a sense of presence in a completely different, so-called virtual space. VR finds applications in various fields, including gaming, education, medicine, architecture, and training (Jerald, 2015).

4.0.2. Main Characteristics of Virtual Reality

Interactivity: Users can manipulate objects and influence the environment using devices such as VR headsets and controllers.

Immersive experience: VR provides realistic perceptions that fully engage the user visually, auditorily, and tactilely.

Simulation: Technology allows for the simulation of situations that would otherwise be dangerous or inaccessible in the real world.

Sensory stimulation: In addition to visual experience, VR often includes sound and haptic feedback, enhancing realism and immersion (Burdea & Coiffet, 2003; Slater & Sanchez-Vives, 2016).

4.0.3. The Importance of VR in Education and Simulation

Virtual reality offers a safe and controlled environment for learning, which is crucial in areas requiring precision and critical decision-making, such as medicine. Students can practice skills without real-world risks, enabling more confident learning (Makransky & Lilleholt, 2018). Another advantage is the ability to repeat training scenarios. Unlike traditional methods that often allow only one-time practice, VR lets students revisit simulations multiple times, ensuring mastery of the subject matter. Active involvement through interactive experiences enhances motivation and memory retention (Radianti et al., 2020). VR also improves retention through experiential learning. Learners remember information better when they can 'touch' or experience it, rather than just read or watch. Visualizing 3D scenarios helps understand complex concepts and apply them in practice (Dede, 2009). One of VR's key benefits is immediate feedback. For example, while practicing medical procedures, the system can instantly analyze a student's performance and offer suggestions. This immediate feedback speeds up the learning process and improves skill development (Johnsen et al., 2016). Finally, VR supports various learning styles—visual, auditory, and kinesthetic, making it suitable for a wide range of learners and enhancing inclusive education (Merchant et al., 2014).

4.0.4. **VR Script**

A VR scenario is a detailed plan that describes how the experience will be structured and executed within the virtual environment. The virtual reality scenario is critical to the success of any VR project, as it determines how the experience will be structured and what interactions will be available. A good scenario not only increases user engagement rates but also improves learning efficiency and encourages repeat use, which can be invaluable in education, training and entertainment. The key to a successful VR experience is therefore a well thought out scenario that takes into account all aspects of user engagement within the virtual world.

Structure of VR Script

- Initial briefing and instructions: Providing clear objectives and instructions is key for effective VR engagement (Dede, 2025)
- Interactive decision-making moments: Integrating decision points allows users to influence the course of the simulation (Murray, 2021)
- Realistic visual and audio elements: The use of authentic visuals and sound enhances presence (McMahan, 2024)
- User performance evaluation: Feedback systems allow users to track their progress (Bautista & Lin, 2023)

Key Elements oF VR Scriptwriting

- Immersive storytelling and interactivity: Combining narrative with interaction enhances user engagement (Ryan, 2021)
- Branching storyline structure: Offers users multiple narrative paths (Murray, 2021)
- Use of 3D space and motion interaction: Enhances the realism of the simulation (Choi & Baek, 2022)
- Adapting difficulty levels to users: Dynamically adjusts challenge based on user abilities (Bautista & Lin, 2023)

Practical Script Development

- Selecting the simulation topic: Relevance and realism are crucial (Nguyen, 2020)
- Designing a storyboard: Helps organize and execute the scenario (Cummings, 2020)
- Identifying key decision points: Essential for simulation interactivity (Murray, 2021)
- Testing and iterating the script: Ensures quality and effectiveness (Bautista & Lin, 2023)

VR Technologies and Tools

- Hardware and software: Choosing the right devices and development tools (Vince, 2023)
- Importing 3D models: Realistic models increase credibility (Cummings, 2020)
- Programming interactions: Implemented via C# or Blueprints (Cummings, 2020)

Key Insights for VR Development

User-Centered Scenario Design

Scenarios should be designed based on cognitive load theory and situated learning principles, ensuring learners engage meaningfully with clinical content (Makransky & Lilleholt, 2018). Understanding learner profiles allows for the alignment of complexity with their training level (Radianti et al., 2020).

Technical Compatibility and Scalability

Development should prioritize platforms that allow cross-device deployment and future extensibility. Modular design frameworks help maintain flexibility as technological needs evolve (Smith & Duggan, 2020).

Integration of Realistic Medical Protocols

All interactions should align with current evidence-based guidelines. Involving clinical experts during scenario writing ensures accuracy and credibility, a key component in medical VR (Nguyen, 2020).

Effective Feedback Mechanisms

Feedback should be immediate and contextual, including both performance-based cues and educational debriefs (Johnsen et al., 2016; Bautista & Lin, 2023). Reflection supports deeper knowledge consolidation and clinical judgment.

Use of Branching Narratives

Branching paths allow users to face consequences based on their decisions, enhancing realism and agency (Murray, 2021). This technique has been shown to improve problem-solving and engagement in VR environments (Ryan, 2021).

Realism and Sensory Immersion

High-fidelity visuals, spatial audio, and haptic feedback can significantly improve immersion and knowledge retention (Slater & Sanchez-Vives, 2016; McMahan, 2024). Realistic physiological responses in patients—like bleeding or shock—should be used to simulate time pressure and stress.

Continuous Testing and Improvement

Scenario usability, technical stability, and educational value should be evaluated through iterative testing with end users (Freina & Ott, 2015). Feedback loops support continuous enhancement of both technical and pedagogical design (Radianti et al., 2020).

VR User Initiation and Guidance

To ensure a positive and effective learning experience in virtual reality, each VR scenario should begin with a brief onboarding and orientation module. This phase introduces the user to the VR environment, interaction mechanics, and scenario expectations—crucial steps for reducing anxiety, minimizing cognitive overload, and preventing early disengagement.

Purpose of Onboarding

Virtual environments can be disorienting or overwhelming for first-time users. An onboarding module provides a safe space to:

- Acclimate to the controls (e.g., grabbing objects, moving, looking around).
- Understand interaction cues (e.g., tool icons, hand prompts, gaze selection).
- Familiarize themselves with feedback systems (e.g., vibration, color changes, voice prompts).

By reducing initial confusion, onboarding frees cognitive resources for actual learning tasks (Makransky & Lilleholt, 2018).

Recommended Features

A well-structured onboarding experience should include (Dennison & D'Zmura, 2020):

1. Simple interaction tutorial: Users practice grabbing, dropping, or activating items in a low-pressure setting (e.g., a training room or virtual lab)
2. Mobility orientation: Introduce movement systems—teleportation, joystick navigation, or gaze walking—depending on the platform
3. Interface elements: Explain any heads-up display, icons, timers, or health indicators. Highlight critical symbols (e.g., bleeding status, task reminders)
4. Practice task (optional): Provide a sandbox or micro-task (e.g., pick up and apply gloves, speak to a virtual character) to reinforce skills without consequence
5. Skippable option: Allow experienced users to skip onboarding but always make it available again from the main menu
6. Comfort and accessibility check: Let users adjust settings: text size, subtitles, motion sensitivity (to reduce simulator sickness), and audio levels

Benefits

Research shows that onboarding modules:

- Reduce simulator sickness and disorientation (Dennison & D'Zmura, 2020)
- Increase confidence and immersion (Slater & Sanchez-Vives, 2016)
- Improve task performance in VR simulations—especially for novices (Makransky & Lilleholt, 2018)

Integration into the Scenario Flow

The onboarding module should be a mandatory first-time step but separated from the main scenario logic. It should feel like a "training room" or "briefing area" where users are introduced by a virtual assistant, voiceover, or user interface prompts.

Testing VR Simulations

- User testing and feedback: Helps improve the simulation (Bautista & Lin, 2023)
- Minimizing motion sickness: Optimizing movement reduces discomfort (Dennison & D'Zmura, 2020)
- Improving UX: Intuitive controls increase satisfaction (Vince, 2023)
- Adjusting the script: Error analysis drives iteration (Bautista & Lin, 2023)

Cross-Platform Design Recommendations

Cross-platform development in the realm of VR is paramount to guaranteeing that VR simulations are both inclusive and accessible, while simultaneously ensuring scalability within a variety of educational and institutional contexts. This section delineates comprehensive guidance on optimal practices for cross-platform VR design (Slater & Sanchez-Vives, 2016; Makransky & Lilleholt, 2018; Merchant et al., 2014; Vince, 2023).

Platform-Agnostic Development Frameworks

In order to enhance accessibility and mitigate the necessity for redevelopment:

- Employ the Unity XR Interaction Toolkit or Unreal Engine in conjunction with OpenXR to facilitate support across Oculus, HTC Vive, Windows Mixed Reality, and WebXR platforms
- Refrain from utilizing proprietary SDKs unless the objective is to target a specific platform
- Leverage WebXR to enable browser-based access, thereby permitting deployment without the prerequisite of high-end VR hardware

Performance Optimization for Low-End Devices

Performance consistency across diverse devices is imperative:

- Maintain low texture sizes and polygon counts to ensure seamless rendering on mobile headsets
- Implement occlusion culling, baked lighting, and level of detail techniques to diminish computational demands
- Simplify physics simulations by reducing reliance on real-time rigid body dynamics and cloth/hair physics

Input and Interaction Flexibility

Users of VR may interact through a myriad of input modalities:

- Incorporate gaze-based selection, hand tracking, controller input, and voice commands
- Design interaction zones with expansive hitboxes to account for varying tracking accuracies
- Ensure that all interactive components are accessible through multiple input modalities to promote accessibility

Modular and Scalable Architecture

Facilitate adaptability and maintainability:

- Decompose the VR scenario into modular components (e.g., environment loader, interaction handler, user interface layer)
- Promote updates and scalability by sustaining loosely coupled scripts and scene management systems

Session Design and Cognitive Load

VR sessions must be designed with consideration for user welfare and attention spans:

- Structure modules in segments of 3–7 minutes with well-defined learning objectives Integrate principles of cognitive load theory by constraining simultaneous stimuli (audio, text, motion)
- Provide opportunities for optional breaks and progress checkpoints during extended scenarios

Inclusive and Accessible Design

Ensure that VR content is usable by a diverse audience:

- Offer customization options including text scaling, audio level adjustments, subtitle toggling, and color contrast themes
- Implement strategies for motion sickness mitigation: employing teleportation in lieu of smooth locomotion, applying vignette effects, and maintaining stable horizon lines
- Facilitate audio cues and narration for users with visual impairments

4.0.5. **Benefits and Challenges of VR Training**

- Realistic and safe education: VR enables the simulation of real-life situations in a safe environment, which is especially valuable in fields such as medicine, aviation, or industrial operations. It allows students and workers to experience scenarios that would otherwise be dangerous or difficult to access (Jerald, 2015)
- Enhances retention and practical skills: Research shows that VR training supports better information retention and the development of practical skills through interactive user engagement (Smith & Duggan, 2020). Users are not just passive recipients of information, but actively participate in simulations, increasing learning efficiency
- Technological barriers and costs: One of the main challenges is the high cost of required hardware and software. Additionally, compatibility issues and technical problems during use must be considered (Radianti et al., 2020)
- Need for instructor training: Effective implementation of VR also requires training for instructors who will work with the technology. Without sufficient preparation, the potential of VR might be misused or even demotivate users (Freina & Ott, 2015)

4.0.6. **VR Development Workflow**

A meticulously organized workflow is pivotal for the development of efficacious, pedagogically sound, and technically proficient virtual reality experiences. Presented below is a comprehensive dissection of the virtual reality development pipeline, accompanied by actionable steps pertinent to each distinct phase.

Phase 1: Define Pedagogical Objectives

- Articulate fundamental learning outcomes predicated on curricular or training requisites
- Specify both technical competencies (e.g., CPR techniques) and interpersonal skills (e.g., decision-making in high-pressure situations)
- Ensure alignment with established educational frameworks, such as Bloom's Taxonomy (Makransky & Lilleholt, 2018)

Phase 2: Scenario Scriptwriting

- Select between linear and branching narrative structures
- Integrate authentic dialogue, interaction prompts, and outcomes contingent upon user decisions
- Incorporate emotional and contextual narrative elements to enhance immersion (Murray, 2021)

Phase 3: Environment and Character Design

- Construct precise three-dimensional environments pertinent to the scenario (e.g., hospital, urban street)
- Employ real-world references and architectural blueprints to augment realism
- Develop a diverse array of expressive virtual characters equipped with animation rigging to convey emotion and feedback (Jerald, 2015)

Phase 4: Interaction Design and Implementation

- Articulate the modalities through which users will engage with the scenario, including object manipulation, menu navigation, and dialogue systems
- Employ input mapping frameworks to generalize interactions across varying devices
- Incorporate immediate system feedback (visual, auditory, haptic) in response to user actions (Choi & Baek, 2022)

Phase 5: Feedback and Assessment Mechanisms

- Integrate both formative and summative feedback systems:
  - Real-time prompts: "Insufficient pressure applied. Please attempt again."
  - Post-scenario evaluations: scorecards and performance timelines
- Consider adaptive feedback systems informed by user behavior (Johnsen et al., 2016)

Phase 6: Internal Quality Assurance Testing

- Implement iterative testing cycles:
  - Conduct alpha testing to assess core mechanics and interactions
  - Engage in beta testing to evaluate narrative coherence, performance metrics, and bug identification
- Utilize debug logs, screen recordings, and in-simulation analytic tools

Phase 7: User Testing and Evaluation

- Recruit participants representative of the target demographic (e.g., nursing students)
- Gather both qualitative and quantitative data: Usability metrics (ease of interaction, navigational efficiency) Educational effectiveness (knowledge retention, skill enhancement) Engagement levels (emotional immersion, perceived realism) (Freina & Ott, 2015)

Phase 8: Deployment and Continuous Improvement

- Deploy the simulation within the designated educational environment
- Provide training for facilitators on the utilization of the virtual reality experience and the interpretation of results
- Monitor usage analytics, gather continuous feedback, and implement iterative improvements as necessary (Radianti et al., 2020)

Conclusion and Recommendations

- VR is a powerful tool for learning and training: VR represents a revolutionary tool for education and professional training. Its ability to simulate realistic scenarios supports deeper understanding and more effective skill acquisition (Radianti et al., 2020)
- The quality of scripts and realistic interactions is crucial: The key to successful VR training lies in the quality of scenarios and the level of interactivity. Realistic scripts allow users to immerse themselves in the environment and respond authentically, enhancing the learning effect (Smith & Duggan, 2020)
- Testing and feedback are essential: Regular testing of VR program effectiveness and user feedback collection help improve both content and delivery methods (Freina & Ott, 2015). Monitoring progress allows training to be tailored to individual needs

- The future: AI and haptic technologies: The future of VR lies in integration with artificial intelligence and haptic technologies, enabling content personalization and physical feedback – further bridging the gap between virtual experience and reality (Jerald, 2015)

4.0.7. Algorithm for Creating a VR Scenario

Overview of the process for designing an educational VR scenario (Figure 4.1-1.):

1. Define educational objectives (e.g., proper bleeding control techniques): Setting clear goals ensures that the VR experience aligns with learning outcomes and skills development (Radianti et al., 2020)
2. Identify the target audience (medical staff, laypeople, students): Knowing the users allows customization of difficulty level and instructional methods (Freina & Ott, 2015)
3. Design a realistic environment (e.g., street, home, hospital): A familiar and authentic environment enhances immersion and contextual learning (Jerald, 2015)
4. Choose a VR platform: The selection of hardware and software should consider accessibility, scalability, and technical capacity (Smith & Duggan, 2020)
5. Define interaction mechanisms (controllers, voice commands, gestures): Interaction design is key for user engagement and realism (Jerald, 2015)
6. Determine the level of graphical detail: Visual fidelity affects user immersion, cognitive load, and learning outcomes (Radianti et al., 2020)

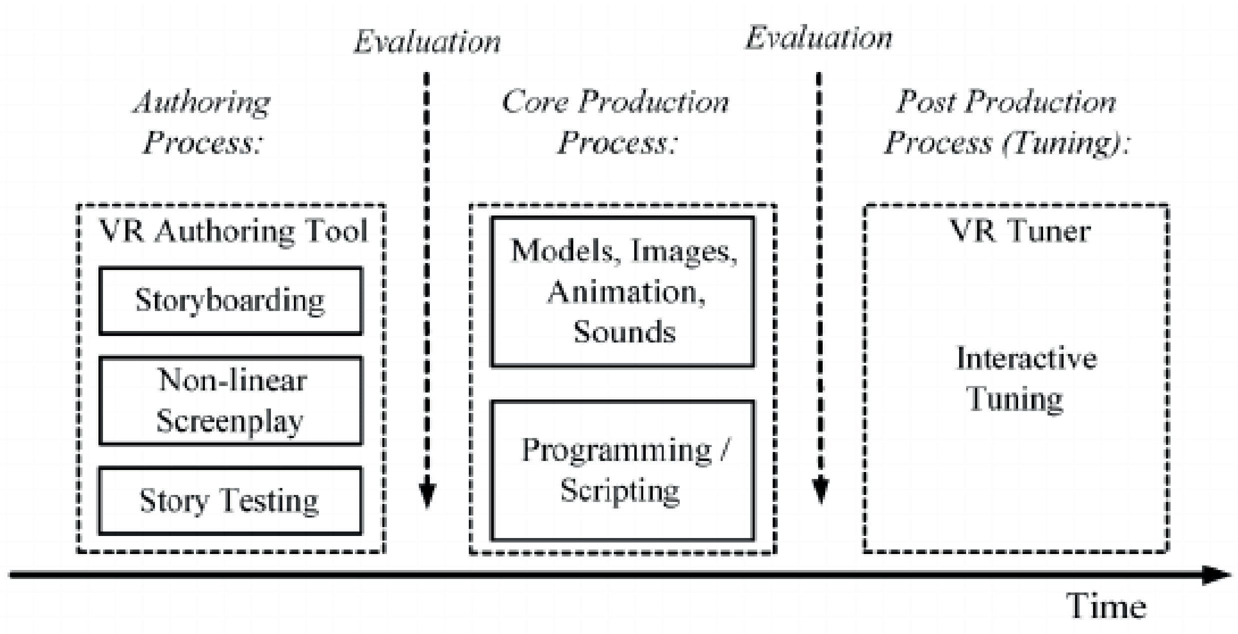


Figure 4.1-1. The proposed production process of a VR scenario [Wages et al., 2004]

4.0.8. Scenario Design

Scenario design should include:

- Introductory instructions: The user is introduced to the scenario with a tutorial that explains tasks and how to use controls, ensuring they are comfortable with the interaction mechanics (Freina & Ott, 2015).
- Situation simulation: A virtual character appears with a bleeding injury. The wound features realistic animation to simulate an emergency situation, providing an immersive and engaging experience (Jerald, 2015).
- Interaction options: The user is given multiple choices to respond to the situation, such as applying pressure to the wound, using a bandage, or applying a tourniquet. These choices influence the scenario's outcome and reflect decision-making skills (Smith & Duggan, 2020).
- Evaluation: The system evaluates the user's actions, providing immediate feedback on correctness, efficiency, and adherence to recommended medical procedures (Radianti et al., 2020).

Scenario Objectives

The scenario should clearly define why it is being created and what its main objectives are. These objectives should include and clearly define both soft and hard skills. Soft and hard skills are terms used to differentiate between different types of abilities that individuals can possess in professional life. Each type of skill is a key component of successful performance in various fields.

Hard Skills

Skill is the ability to use one's knowledge effectively and promptly in execution or performance. Hard skills are technical abilities and expertise specific to certain tasks and situations. They relate to technical or practical skills, as opposed to soft skills, which relate to interpersonal skills. These skills are essential for providing quality and safe patient care. According to the American Nurses Association (2015), technical skills are crucial for effective implementation of therapeutic interventions and monitoring of patients' condition.

Hard skills are measurable and are usually acquired through formal education, training, or practical experience. Hard skills are necessary for specific tasks and must be well mastered, especially in an environment where quick and accurate responses are required. They are necessary for specific tasks in an industry that requires specific expertise and skills (Lamri & Lubart, 2023).

Hard skills examples:

- Use of tourniquet, bandage
- Perform a quality heart massage
- Securing the airway
- Providing effective artificial respiration etc.

Soft Skills

Soft skills are social and emotional competencies related to interaction with others. Soft skills are a dynamic combination of cognitive, metacognitive, interpersonal, intellectual and practical abilities, as well as ethical values. These skills are not as easily measurable as hard skills and often include personality traits and behavioral patterns that influence the way individuals communicate and cooperate with others. They are the basis of critical thinking. They can be learned through appropriate and systematic training (Widad & Abdellah, 2022).

The basis of non-technical skills in acute medicine and crisis situations consists of four areas, which are connected by the main thing - communication. These areas include teamwork, team leadership itself, situational awareness, decision-making and the distribution of tasks among other team members (Peřan & Kubalová, 2017).

One of the main non-technical skills within teamwork is communication. Communication within the team should always be calm, assertive, and team members should support each other. Communication should be clear, distinct, with the aim of closing the communication loop (Peřan & Kubalová, 2017). For example: A specific instruction must be formulated clearly: “Peter, give 1 mg of adrenaline i.v.,” not “Someone give adrenaline…” The team member should then confirm receipt of the information: “I understand, I am giving 1 mg of adrenaline i.v.,” and then inform about the fulfillment: “1 mg of adrenaline i.v. given.” This is an example of a perfectly closed communication loop.

Situational awareness primarily concerns the collection of information, its understanding and, based on that, predicting where the situation will develop. Maintaining situational awareness is crucial for moving towards the right goal. It is necessary to identify the situation and get it under control. Furthermore, to predict how the situation will develop, analyze the available information and, based on this, plan and implement steps towards resolving the situation (Peřan & Kubalová, 2017). An example of situational awareness is that the team leader should have an overview of how many defibrillation shocks have been performed during CPR and be ready to issue an instruction for another shock at the right time.

One of the other non-technical skills is the ability to make decisions and make the right decisions. However, making the right decisions cannot be done without perfect situational awareness. These two skills therefore go hand in hand. The team leader can consult with the team in certain situations (Peřan & Kubalová, 2017). For example: The patient is very aggressive; I suggest this procedure. Do you agree?

Another non-technical skill is the distribution of tasks. Most crisis situations require the coordination of many tasks that need to be done in a short time interval and with the greatest possible accuracy. The task of the team leader is to oversee the even distribution of the load among all team members and the prioritization of task performance. With proper planning and preparation of individual activities, we have a greater chance of adhering to all standards of care and recommended procedures. It is a mistake to issue many instructions at once. In most cases, some of the quickly issued instructions are forgotten. Tasks should be distributed according to priorities and to specific individuals (Peřan & Kubalová, 2017).

Soft skills examples:

- Resistance to stress
- Team leadership
- Teamwork in simulation – if VR is multiplayer, cooperation with other participants is necessary
- Effective communication
- Ability to close the communication loop
- Decision making process
- Allocation of tasks among team members
- Assessing the situation and making decisions – recognizing critical bleeding and choosing the right course of action

Description of the Situation

The description of a situation in a VR scenario is a critical component that shapes the user's experience and engagement within the immersive environment. It sets the context for the actions the user will undertake, guiding them through the narrative and influencing their emotional and cognitive responses. A well-crafted situation description serves multiple purposes, including establishing a sense of realism, conveying urgency, and providing the necessary background for the user to effectively navigate the scenario.

The description of a situation in a VR scenario is a comprehensive and multifaceted element that encompasses the setting, character introductions, contextual background, challenges, and emotional tone.

The first step in describing a situation is to establish the setting. This includes geographic location, time period, and environmental conditions. Setting the scene effectively immerses users in the environment, allowing them to visualize their surroundings and feel as though they are truly present within the scenario. A vivid and detailed description of this environment can enhance users' emotional engagement, making them more invested in the unfolding events.

Next, the situation description should introduce the characters involved in the scenario. This includes key details about the characters' roles, backgrounds, and emotional states. In a VR medical training scenario, for instance, the primary character could be a patient with a visible injury, depicting realistic physical symptoms and displaying a range of emotions, from panic to pain. The presence of supporting characters, like nurses or doctors, can further enrich the narrative by providing context on the teamwork required in emergency situations.

Providing contextual background is essential for helping users understand the circumstances leading to the scenario. This can include previous events, the nature of the problem at hand, and potential challenges that may arise. For instance, a scenario might open with a brief synopsis explaining that the user is stepping into the shoes of a first responder who has arrived at the scene of a car accident. The description might highlight that several victims require immediate attention, and that time is of the essence.

Context not only enhances the narrative but also better prepares users for the decisions they must make. A well-defined background ensures that users comprehend the significance of their actions within the overarching narrative, motivating them to engage actively and responsibly.

For example:

In front of the user lies a young man who is bleeding profusely from a deep wound on his forearm. His clothes are stained with blood, and his breathing is fast and irregular. He looks up at the user with a frightened expression and says in a quiet voice: "Help me..." Next to him on the ground lies broken glass, probably the cause of his injuries.

The user must make a quick decision – assess the condition of the injured person, stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help.

As soon as he begins to administer first aid, the scenario reacts dynamically – if he presses the bandage correctly on the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation.

The aim of this scenario is to simulate realistic first aid training under pressure, where the player learns to react correctly in a crisis situation.

Description of the Environment

It describes the environment in which the action takes place, including visual and audio cues that create the overall atmosphere. Contextualising the scenario is important to engage users and ensure that the environment is relevant to the objective.

For example:

The user finds himself on the street next to an injured person lying on the ground. The surrounding environment is busy – you can hear muffled voices of people, the distant sound of sirens and the hustle and bustle of the city. The surrounding houses are damaged by the earthquake Curious passers-by are slowly gathering around.

Tools and Objects

Indicate the necessary tools and equipment based on the relevant textbook and standards; support with visuals as examples.

Interaction – What Should the Participant Do?

For example:

The user must make a quick decision – assess the condition of the injured person (physiological functions, general condition), stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help. As soon as he starts to perform first aid, the scenario reacts dynamically – if he applies the bandage correctly to the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation.

Development and Implementation

- Creation of 3D models for environments and characters:
  Designing and modeling realistic 3D environments tailored to the educational context
  Creating detailed character models with a focus on anatomical accuracy and realistic movements
- Programming interactions and physical simulations (e.g., bleeding behavior based on incorrect actions):
  Developing interaction systems that allow users to manipulate objects and characters
  Implementing physical simulations, such as realistic bleeding in response to incorrect medical procedures
- Integration of AI for dynamic response to user actions:
  Developing artificial intelligence that reacts to user actions in real time
  Setting up dynamic scenarios where errors or correct actions influence the course of the simulation

Testing and Optimization

- Internal testing by developers:
  Conducting ongoing functionality testing within the development team
  Identifying and fixing technical issues before broader user testing
- User testing with target audience:
  Organizing testing sessions with real users from the target audience (e.g., nursing students)
  Gathering feedback on usability, realism, and educational value
- Refining scenario and interactions based on feedback:
  Adjusting scenarios and interactions according to tester feedback
  Improving controls, visual quality, and AI reactions to maximize learning effectiveness

Deployment and Effectiveness Evaluation

- Deployment in educational institutions:
  Implementing the simulation in schools, universities, or training centers
  Providing necessary technical support and staff training
- Data collection on user success rates:
  Monitoring and recording user performance during simulation use
  Analyzing success rates and error patterns
- Interactive improvements based on performance analysis:
  Identifying learning weak points based on collected data
  Updating scenarios and AI systems to better support skill acquisition

How Detailed Scenario Should Be?

The virtual reality scenario should be thoroughly developed to simulate a real emergency situation as accurately as possible. The total length of the scenario should range between 3-7 minutes per case. Shorter scenarios (1-2 minutes) can be used to practice specific skills. The length should be adjusted according to the target group (children, adults, healthcare professionals). At the same time, it should cover as many details as possible, e.g. skin color - cyanosis, color of bleeding, sound phenomena - difficulty breathing.

Example of Errors that can be in a Virtual Scenario

Errors/Incorrect Procedure in VR Scenario	Consequence	How the VR Scenario Should Respond
Checking breathing only visually for 3 seconds	Breathing should be checked for 10 seconds using sight, hearing, and touch – otherwise, shallow breathing may be missed	Show correct technique (sight, hearing, touch), play 10-second timer, provide visual and voice guidance
Skipping the emergency call	Without calling EMS, professional help may be missing – endangering the patient's life	Scenario should include prompting to call 112/911, simulate call, and include follow-up questions
Incorrect hand placement during chest compressions	Compressing outside the chest center is ineffective and may cause injury	Show anatomy, highlight correct area, and provide visual feedback like "move hands"
Incorrect compression rate (e.g., 60/min)	Slow compressions are ineffective – insufficient oxygen to the brain	Use metronome or music at 100–120 bpm, provide visual tempo indicator
Ignoring rescuer safety	The rescuer may get injured – not assessing risk endangers more lives	Simulation should force safety check before approach – otherwise, scenario restarts

Template Linear Scenario

Scenario objectives: Describe what goals are to be achieved e.g. teach the user how to properly stop massive bleeding
HARD skills: Describe what hard skills a person is supposed to learn through a VR situation
SOFT skill: Describe what soft skills a person is supposed to learn through a VR situation
Description of the situation: Describe the situation in detail so that the designer can make it, approach it as if you were describing a story to someone. Describe in detail what steps the user will take to achieve the goal
Description of the environment: Describe the environment in which the story takes place, e.g. a street, a forest, a broken-down house, what it looks like, what is happening there
Interaction – what should the participant do: Describe what steps the participant should take and when is the situation finished
Tools and objects: Write down all the tools that the user has available in the VR situation and add an image so that the designer knows what to prepare, e.g. bandage, tourniquet, defibrillator, syringe. Draw from standards or professional sources

What Mistakes can Happen? What will be their Impact?

Error	Consequence

4.0.9. **Summary and Conclusion**

Virtual Reality is a technology that enables users to enter and interact with a simulated environment using devices such as virtual reality headsets, controllers, or haptic tools. The key features of virtual reality include interactivity, immersive experiences, simulation of real-world situations, and sensory stimulation. One of the most important applications of virtual reality is in education and training, where it provides a safe, repeatable, and realistic learning environment. Virtual reality allows learners to acquire both hard and soft skills with immediate feedback and a high level of engagement. To successfully create a virtual reality scenario, it is essential to define educational objectives, identify the target audience, design the environment, choose a platform, determine interaction methods, and develop a realistic description of the situation including characters and context.

A well-designed scenario should include initial instructions, decision-making moments, realistic elements, and user performance evaluation. A good scenario enhances user engagement and learning efficiency. Virtual Reality is a powerful tool for education and training, combining interactivity, realism, and safety.

The success of virtual reality applications depends on the quality of the scenario and the realism of interactions. Testing, user feedback, and continuous improvement are crucial. The future of virtual reality lies in integration with artificial intelligence and advanced haptic technologies, opening new possibilities in learning and professional development.

LINEAR SCENARIO FOR VR SIMULATION OF FIRST AID IN HEAVY BLEEDING

In a linear scenario, the user proceeds through predetermined steps without the possibility of branching the plot. This means that they must follow precisely defined steps that lead to successful bleeding arrest

SCENARIO OBJECTIVES

HARD Skills

1. Usage of a tourniquet, bandage

SOFT Skill

1. Resistance to stress
2. Assessing the situation and making decisions – recognizing critical bleeding and choosing the right course of action
3. Teamwork in simulation – if VR is multiplayer, cooperation with other participants is necessary

DESCRIPTION OF THE SITUATION

In front of the user lies a young man who is bleeding profusely from a deep wound on his forearm. Bright red blood is spurting from the wound.
His clothes are stained with blood, and his breathing is fast and irregular. He looks up at the user with a frightened expression and says in a quiet voice: "Help me..." Next to him on the ground lies broken glass, probably the cause of his injuries. The user must make a quick decision – assess the condition of the injured person, stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help. As soon as he begins to administer first aid, the scenario reacts dynamically – if he presses the bandage correctly on the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation. The aim of this scenario is to simulate realistic first aid training under pressure, where the player learns to react correctly in a crisis situation.

DESCRIPTION OF THE ENVIRONMENT

The user finds himself on the street next to an injured person lying on the ground. The surrounding environment is busy – you can hear muffled voices of people, the distant sound of sirens and the hustle and bustle of the city. The surrounding houses are damaged by the earthquake. Curious passers-by are slowly gathering around

TOOLS AND OBJECTS

List of the tools and objects include nylon bag, blue trainer, responder, gauze compressed, time instruction, gloves, trauma shears and marker (Figure 4.2-1.).

Figure 4.2-1. Aids' tools to stop bleeding North American Rescue, 2025

INTERACTION – WHAT SHOULD THE PARTICIPANT DO?
APPROACH TO THE PATIENT AND INITIAL REACTION

- On-screen instructions: "You see an injured person bleeding profusely. Get close to it and find out its condition"
- Interaction: The user approaches and receives visual and audible stimuli (bleeding, gasping for breath of the patient)

CHOICE (RIGHT AND WRONG ACTION)

- **"Reach out to the patient and find out about his condition"** (if the patient responds, the scenario continues)
- **"Ignore the patient and look for another solution"** (warning that the patient needs to be addressed first)

USER PROTECTION – PUTTING ON GLOVES

The user takes gloves and puts them on (does he choose them from the tools available via the tool icon?)

IDENTIFICATION OF THE SOURCE OF BLEEDING AND DIRECT PRESSURE

- The user clicks or grabs a sterile gauze and applies it to the wound
- If the pressure is too weak (can I do this with the joystick button?? – this may be an IT question), a warning will appear ("Push harder!")
- If the user does not intervene in time, a warning about patient shock will begin to appear

The wound is still bleeding

APPLICATION OF PRESSURE BANDAGE

The user selects the right aids for the pressure bandage

The wound is still bleeding

USE OF A TOURNIQUET (IF THE BLEEDING IS MASSIVE)

- The user takes the tourniquet, places it over the wound and tightens it
- If it tightens it correctly, the system will display confirmation
- If they deploy it too loosely, a warning and a repair option will appear

CALL THE AMBULANCE AND MONITOR THE PATIENT

- The user presses a button on the VR phone or asks a virtual character to call for help
- Then he monitors the patient, talks to him and checks his condition (breathing, reaction to stimuli)

SHOCK PREVENTION

- The user takes the thermofoil and covers the patient.

COMPLETION OF THE SCENARIO – ARRIVAL OF RESCUERS

- After all the steps have been carried out correctly, an animation of the arrival of the ambulance and the paramedics who are taking over the patient will appear
- At the end, the user's performance evaluation is displayed – for example, scores for correct and fast execution, effective selection of aids and evaluation of the entire case

REFERENCES

American Nurses Association. (2015). Nursing: Scope and standards of practice. American Nurses Association.

Bautista, S., & Lin, X. (2023). Feedback mechanisms in virtual training. Journal of Medical Internet Research, 25, e10622803. https://pmc.ncbi.nlm.nih.gov/articles/PMC10622803/

Burdea, G. C., & Coiffet, P. (2003). Virtual reality technology (2nd ed.). Wiley-Interscience.

Choi, S., & Baek, Y. (2022). 3D space interaction in educational simulations. Computers, 10(5), 66. https://www.mdpi.com/2073-431X/10/5/66

Cummings, J. (2020). Writing interactive cinematic VR stories. Academia.edu. https://www.academia.edu/42036368

Dede, C. (2009). Immersive interfaces for engagement and learning. Science, 323(5910), 66–69. https://doi.org/10.1126/science.1167311

Dede, C. (2025). The future of immersive learning environments. Interactive Learning Environments. https://doi.org/10.1080/10494820.2025.2450634

Dennison, M. S., & D'Zmura, M. (2020). Reducing motion sickness in virtual reality. International Journal of Human–Computer Interaction, 36(10), 923–935. https://doi.org/10.1080/10447318.2020.1778351

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. eLearning and Software for Education (eLSE), 1(133), 10–1007.

Jerald, J. (2015). The VR book: Human-centered design for virtual reality. Association for Computing Machinery and Morgan & Claypool.

Johnsen, K., Dickerson, R., Raij, A., Lok, B., Jackson, J., Shin, M., ... & Lind, D. S. (2016). Experience-based learning in virtual environments: Training clinical skills with virtual patients. IEEE Transactions on Visualization and Computer Graphics, 12(3), 365–372.

Lamri, J., & Lubart, T. (2023). Reconciling hard skills and soft skills in a common framework: the generic skills component approach. Journal of Intelligence, 11(6), 107. https://doi.org/10.3390/jintelligence11060107

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. Educational Technology Research and Development, 66(5), 1141–1164.

McMahan, T. (2024). Designing immersive audiovisual experiences. Digital Creativity, 35(1), 22–38. https://doi.org/10.1080/14626268.2024.2389886

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education, 70, 29–40.

Murray, J. (2021). Branching narratives and agency in virtual storytelling. Journal of Interactive Film and Media, 3(2), 112–129. https://journals.library.torontomu.ca/index.php/InteractiveFilmMedia/article/view/1693

Nguyen, H. (2020). Developing medical VR scenarios. BMC Medical Education, 20, 178. https://pmc.ncbi.nlm.nih.gov/articles/PMC7232669/

Peřan D., & Kubalová, J. (2017). Sledování netechnických dovedností při resuscitaci. Urgentní medicína. 20(4), 26–31. ISSN 1212-1924.

North American Rescue. (n.d.). Bleeding control kits trainer. AED Superstore. Retrieved April 25, 2025, from https://www.aedsuperstore.com/north-american-rescue-bleeding-control-kits-trainer.html

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education, 147, 103778.

Ryan, M. L. (2021). Narrative presence in interactive digital media. Convergence, 27(3), 314–329. https://doi.org/10.1080/15358593.2021.1881610

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. Frontiers in Robotics and AI, 3, 74.

Smith, J., & Duggan, M. (2020). Virtual reality in professional training: A review of the literature. Journal of Educational Technology Systems, 48(3), 383–407.

Vince, J. (2023). Hardware and tools for VR learning. Applied Sciences, 12(3), 1755. https://www.mdpi.com/2076-3417/12/3/1755

Wages, R., Grützmacher, B., Conrad, S. (2004). Learning from the Movie Industry: Adapting Production Processes for Storytelling in VR. In: Göbel, S., et al. Technologies for Interactive Digital Storytelling and Entertainment. TIDSE 2004. Lecture Notes in Computer Science, vol 3105. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-27797-2_16

Widad, A., & Abdellah, G. (2022). Strategies used to teach soft skills in undergraduate nursing education: a scoping review. Journal of Professional Nursing : official journal of the American Association of Colleges of Nursing, 42, 209–218. https://doi.org/10.1016/j.profnurs.2022.07.010

4.2. AR/VR Scenario Example

SCENARIO 1: Resuscitation of an Adult in Cardiac and Respiratory Arrest During an Earthquake

This VR scenario is designed for nursing students, nurses, and nurse educators to learn and practice first aid interventions in the event of cardiac and respiratory arrest during an earthquake.

Scenario Objectives

This scenario aims to provide participants with the knowledge and skills of basic life support (BLS) for an adult whose heart and breathing have arrested after an earthquake.

Target Audience

- Nursing students, nurses and nurse educators
- Other health staffs

HARD Skills

Participants receiving this training:

1. Recognizes cardiac and respiratory arrest.
2. Creates a safe environment for intervention.
3. Applies the steps of Basic Life Support (BLS) in the correct order (ABC approach).
4. Performs chest compressions at the correct rate and depth.
5. Uses the Automated External Defibrillator (AED) correctly.

SOFT Skill

Participants receiving this training:

1. Remains calm and in control during emergencies.
2. Acts quickly and effectively in decision-making processes.
3. Communicates clearly and gives guiding instructions to people around.

Description of the Situation:

Near the edge of a collapsed building, the user identifies an adult male lying motionless on the ground. His body is partially covered in dust and debris, indicating possible trauma. As the user approaches, it becomes evident that the individual is unresponsive. There is no visible chest movement, no audible breath sounds, and no signs of circulation. A carotid pulse check confirms cardiac arrest.

This is a critical life-threatening emergency. The participant must first ensure the scene is safe and then promptly begin a basic life support (BLS) protocol. This includes assessing responsiveness, opening the airway, checking for breathing and pulse, and immediately initiating CPR.

The simulation is designed to respond dynamically to the user's actions:

✅ **Correct and timely interventions** (e.g., high-quality CPR, use of AED) may lead to the return of spontaneous circulation and breathing.

❌ **Incorrect, delayed, or omitted actions** will cause the patient's condition to deteriorate, potentially leading to irreversible shock or death.

Description of the Environment:

The scenario takes place in a densely populated urban neighborhood that has been severely impacted by a recent earthquake. The surroundings are chaotic and hazardous. Collapsed buildings dominate the landscape, and large piles of debris obstruct the streets and sidewalks. A thick layer of dust hangs in the air, limiting visibility. Sounds of distress echo in the background—shouts for help, distant sirens, and the occasional rumble of aftershocks. Structural instability is evident, with partially damaged walls swaying slightly and loose objects scattered across the area.

Despite the devastation, several disoriented bystanders are present, standing at a distance in shock and confusion.

Interaction – what should the participant do:

Initial safety check

The participant moves through the debris-filled area.

- Be patient.
- "Let's check the surroundings. We need to find a safe spot."
- "This looks like a suitable place, away from power lines and debris."

Identifying the injured person

A scene shows a conscious adult lying on the ground

- "There is an injured person here! He looks unconscious. We need to intervene immediately."
- "Alright, I'll call 112 and request emergency assistance."

Situation assessment

- The participant kneels next to the individual, touches his/her shoulder, and says, "Can you hear me?".

System feedback: "No response from the patient."

Step 1: Breathing check

Participant

- Puts fingers in the patient's mouth for checking whether there are foreign objects in the mouth of the individual and remove them.
- Holds the individual's forehead and tilts his/her head back by lifting the chin point with his/her fingers**.**
- Monitors the individual's chest movements. Checks that the chest goes up and down in a regular manner.
- Checks whether he/she hears breathing sound by putting his/her ear close to the mouth and nose of the individual.
- Attempts to feel the breath coming from the individual's mouth or nose on his/her cheeks.
- Gives vocal feedback as "not breathing."
- If breathing is absent or abnormal, asks someone to call the emergency response system or call it themselves.
- Activates the speakerphone or "hands-free" feature of the phone so that he/she can stay with the individual and start CPR while talking to the attendant.

Step 2: Circulation check

Participant

- Places the fingers on the side of the neck, right next to the larynx (Adam's apple).
- Applies pressure.
- Spends a **maximum of 10 seconds** assessing whether he/she can feel a pulse.
- Gives vocal feedback as "no pulse".

Chest Compression, Respiration and Automated External Defibrillator (AED) Application

- The participant is expected to perform the following steps:

Step 3: Chest compression

Participant

- Lays the individual on their back on the hard floor
- Centers the individual's breastbone (sternum) and determines the midpoint of the sternum, places the hand on the lower half of the sternum.
- Holds the hand exactly on the sternum.
- Keeps the hands steady, the elbows and shoulders straight and perpendicular to the patient's body.
- While the participant's arms are in a perpendicular position and tense to the individual's chest, pushes the sternum down by applying body weight and releases the ribcage without lifting their hands.
- Performs 30 heart massages, then gives 2 breaths.
- The chest compression rate is 100-120 compressions per minute, the compression depth is 5-6 cm.

Step 4: Artificial respiration

Participant

- The participant places one hand on the individual’s forehead.
- Place fingers of the other hand on the individual’s chin.
- The head is pushed back, and the chin is lifted. (a head-chin position).
- Place the pocket mask with the narrow end at the bridge of the nose, covering both the nose and mouth.
- Creates a tight seal on the mask using both hands (thumb and index finger form a “C” on the mask rim; the other fingers lift the jaw to maintain the airway).
- Delivers rescue breaths through the one-way valve: place your lips fully around the valve (or mouthpiece) to create an airtight seal; one breath over about 1 second, watching for visible chest rise; allows full exhalation.
- Gives two artificial respirations through the airway**.**
- Artificial respiration is performed 12 times per minute, and the amount of air is such that the chest cage is lifted.

Step 5: AED usage

Participant

- Opens the device and places the electrode pads.
- Places one of the pads on the right upper chest (under the collarbone) and the other just be-low the left lower rib (near the armpit).
- The AED provides a voice prompt: *“Stand clear of the patient.”*
- The device analyzes the rhythm.
- The AED provides a voice prompt: *“Shock can be applied.”*
- The AED then prompts: *“Press the shock button.”*
- Participant presses the shock button, then continues CPR.

After giving a shock, chest compression is started again. This process is repeated about 5 cycles for 2 minutes.

- After 2 minutes, the participant checks the pulse of the carotid artery.
- “OK, he/she started breathing! We did it!”

“Now we are waiting for the ambulance to arrive. Let’s place him/her to the recovery position”

Tools and objects

Notes for developers:

- All tools should be interactive, with grabbable or drag-and-drop mechanics.
- AED must include voice instructions and error detection (e.g., wrong pad placement).
- Tools must only be available at relevant points in the scenario to guide proper sequencing.
- If UI is used: each object should include labels and short tooltips

Tool/Object	Description	Purpose of Use	Visual Reference (example)
Sterile gloves	Disposable, powder-free latex or nitrile gloves	To ensure rescuer's personal protection	Simple blue examination gloves
CPR manikin	Adult-sized training dummy with realistic chest recoil and airway features	For chest compressions and rescue breaths	♂ Medical training manikin
Automated external defibrillator (AED	With screen, voice prompts, and electrode pads	To analyze heart rhythm and deliver a shock if needed	AED device with display and buttons
Defibrillator pads	Adhesive electrodes placed on the upper right chest and lower left rib area	To deliver shock from AED to the patient	Stick-on chest pads
Pocket mask	One-way valve mask small enough to carry in a pocket	For more hygienic and effective rescue breathing	Transparent CPR mask with strap
Phone (Virtual interface)	In-VR interface or voice command to simulate emergency call (112/911)	To contact emergency services and receive instructions	Virtual phone icon or screen
Timer / Metronome (virtual)	Visual or auditory tool with 100–120 bpm tempo	To help maintain correct compression rate	Simple on-screen timer/metronome
Thermal blanket (optional)	Gold/silver foil emergency blanket	To prevent hypothermia after ROSC	Image of thermal emergency blanket

Evaluation and feedback

Performance analysis:

- Data such as the number, depth and rhythm of chest compressions performed by the participant are analyzed.
- The effectiveness and appropriateness of artificial breathing is evaluated.

Suggestion for improvement:

- Strengths and weaknesses are reported to the participant (e.g., "Your CPR rhythm was excellent, but pay more attention to breath control").

Score and certification:

- Participants demonstrating successful performance can earn a digital certificate of achievement.

Possible Errors and Consequences

Error	Consequence
Voices is disturbing	Can't hear the additional help
Don't check the environment	Additional accidents and wrong application of CPR
The participant too much nervous	Wrong application or no application
Patient position	CPR can't start immediately
Don't check or wrongly check vital functions	Death or complications, disabilities etc.
Forget to call 112 and don't bring or no AED	Delay to intervention
Wrong compression (area, hands position, wrong times, too many and less compression etc.)	Death or complications, disabilities (such as costa fracture)
Wrong artificial breathing (area, wrong time, too many and less giving air etc.)	Death or complications, ineffective artificial breathing
Wrong AED application (wrong place, touch victim etc.)	Ineffective AED application, electric shock of participant
Forgot to remove the metallic objects of victim	Electric shock of victim
No check breathing and pulse, if victim regain the vital function	Cardiac arrest
No give a recovery position, if victim regain the vital function	Decrease of the vital functions
Not enough equipment	Ineffective rescue
Incorrect technique head-tilt/ chin-lift	The airway may remain blocked, preventing proper breathing
Organization or coordination mistakes	Incorrect assessment of patient's condition Reduces CPR efficiency
Not being able to control emotions and feelings	Not take quick action, not effective CPR