CEMEC HANDBOOK SERIES 3

European Centre
for Disaster Medicine

Safety and Emergency Medical Care in CBRN Mass Casualty Incidents

European Centre
for Disaster Medicine

Safety and Emergency Medical Care in CBRN Mass Casualty Incidents

Safety in Emergencies

Your security, the priority!

by Roberto Mugavero and Heejun Shin

INDEX

Introduction

Emergency professionals responding to Chemical, Biological, Radiological, and Nuclear (CBRN) Mass Casualty Incidents face highly complex and demanding challenges that require specialized expertise, rapid adaptability, and a high level of preparedness. These scenarios are among the most difficult in emergency medicine, calling for swift, coordinated responses, interdisciplinary collaboration, and a deep understanding of decontamination procedures and management strategies to minimize casualties and mitigate damage.

This guide provides essential strategies for delivering effective medical care while ensuring the safety of both individuals and teams in high-risk environments. It equips professionals to address the unique challenges of CBRN incidents, where conventional medical approaches may fall short due to the extreme and hazardous conditions involved.

Offering a practical framework, the guidelines focus on assessing risks in non-permissive environments, ensuring effective decision-making under pressure, clear communication, and maintaining the psychological well-being of those involved.

The content is organized into chapters that cover critical topics such as mass casualty management, personal protective measures, and psychological support for both victims and responders. Recognizing the unique nature of these crises, which pose both immediate and long-term risks to public health, the guide also highlights best practices for interagency cooperation, resource allocation, and establishing effective command structures during emergencies

Key Sections

• **Understanding Non-Permissive Environments**: Offers a detailed explanation of what defines a non-permissive environment in CBRN incidents, focusing on risks like ongoing chemical dispersal or radiation. Emphasizes the need for situational awareness and effective preparation to manage these complex and hazardous conditions.

• **Introduction to CBRN Threats**: Provides an overview of various CBRN threats, including chemical, biological, radiological, and nuclear incidents. Explores their potential health impacts and outlines the necessary response measures for each type of threat.

• **Personal Safety and Protective Measures**: Focuses on the correct use of personal protective equipment (PPE) and safety protocols to reduce exposure to harmful agents, ensuring healthcare professionals can provide care while protecting themselves.

• **Medical Care in CBRN Environments**: Offers guidance on triage, treatment, and patient stabilization in contaminated environments, addressing the specific challenges of providing medical care in CBRN scenarios.

• **Managing Mass Casualty Events**: Covers strategies for organizing and managing large numbers of casualties in CBRN situations, balancing patient care with responder safety, and addressing the high-pressure demands of these events.

• **Decontamination Procedures**: Explains the essential steps for decontaminating individuals exposed to CBRN agents, ensuring healthcare providers remain safe and prevent secondary contamination.

• **Evacuation and Patient Transport**: Focuses on best practices for safely evacuating and transporting patients from contaminated areas, minimizing further exposure to CBRN agents during the process.

• **Psychological First Aid**: Highlights the importance of providing psychological support to both victims and responders, offering practical approaches to managing stress, trauma, and other mental health challenges during and after a CBRN incident.

• **Recap - Safe Behavior**: Summarizes the key safety protocols and practices for healthcare professionals responding to CBRN incidents, reinforcing critical behaviors for ensuring safety.

• **Contact Information and Resources**: Lists essential contacts and additional resources to support healthcare providers during CBRN responses, offering guidance and assistance in emergency situations.

1. Understanding Non-Permissive Environments: Challenges and Risks in CBRN Incidents

Non-permissive environments are high-risk, complex settings where response teams face significant operational constraints, often due to the presence of hostile elements, severe logistical challenges, or extreme environmental conditions. In such environments, safety concerns are amplified, making it difficult for emergency responders, health professionals, and security personnel to carry out their duties effectively. When combined with Chemical, Biological, Radiological, and Nuclear (CBRN) incidents, the complexity increases exponentially, as the very nature of these threats requires highly specialized skills, protective equipment, and operational strategies.

CBRN incidents in non-permissive environments can be particularly challenging due to the toxic, infectious, or radioactive materials involved, which not only pose immediate physical risks to responders but also create long-term health and environmental hazards. These environments can include conflict zones, areas with civil unrest, regions experiencing natural disasters, or locations contaminated by industrial or accidental releases. In such situations, responders must navigate limited access, poor infrastructure, and potentially hostile populations, all while mitigating the risks posed by CBRN agents.

This overview explores the specific threats inherent to non-permissive environments during CBRN incidents and highlights the critical role of situational awareness in mitigating these challenges.

Characteristics of Non-Permissive Environments

Non-permissive environments are typically defined by high levels of hostility, instability, or contamination, making them hazardous for responders. These environments are often shaped by factors such as:

High Threat Levels: The presence of hostile actors, ongoing conflict, or widespread civil unrest can impede emergency response operations. Responders may face direct threats from armed groups or individuals, necessitating coordination with security forces to ensure their safety.

Severe Contamination: The release of hazardous substances such as chemical agents, biological pathogens, or radiological materials can pose immediate and severe health risks. Contamination can spread rapidly, requiring stringent decontamination protocols, and can create zones that are inaccessible without specialized protective equipment.

Logistical Constraints: Limited access to resources, communication difficulties, and disrupted infrastructure can hinder response efforts. Roads may be blocked, communication networks may be down, and access to critical supplies such as personal protective equipment (PPE) and medical resources may be restricted. Planning and logistical coordination are crucial to overcoming these obstacles.

Political and Social Instability: In some cases, political restrictions or community resistance can further complicate the response to CBRN incidents. Navigating bureaucratic obstacles, gaining community trust, and dealing with misinformation are all critical components of operating effectively in these settings.

Strategies for Effective Response

Responding effectively in non-permissive environments requires a multi-layered approach that encompasses preparedness, adaptability, and collaboration. Key strategies include:

Situational Awareness: Maintaining situational awareness is crucial for understanding the dynamics of a non-permissive environment. This includes real-time monitoring of threats, understanding the local socio-political landscape, and being aware of environmental hazards. Technologies such as drones, satellite imagery, and chemical and radiological sensors can enhance situational awareness, providing valuable data to guide decision-making.

Risk Assessment and Decision-Making: Risk assessment must be continuous and dynamic. Response teams should evaluate the level of threat, the extent of contamination, and the availability of resources to determine the most appropriate course of action. Decision-making under pressure is a critical skill, and training exercises that simulate high-stress scenarios can help responders prepare for real-world incidents.

Interagency Collaboration: Effective response in non-permissive environments often requires coordination between multiple agencies, including military, law enforcement, healthcare, and humanitarian organizations. Clear communication channels and predefined roles and responsibilities are essential to prevent misunderstandings and ensure a unified response.

Training and Preparedness: Healthcare professionals and response teams must undergo rigorous training to operate in non-permissive environments. This includes training in the use of PPE, decontamination procedures, communication protocols, and defensive tactics. Regular drills and simulations help to reinforce these skills and ensure that responders are prepared for the challenges they may face.

Importance of Communication and Coordination

Communication is the foundation of effective operations in non-permissive environments. Clear and reliable communication ensures that all team members are aware of the current situation, understand their roles, and can adapt to changes as they occur. Communication challenges, such as disrupted networks or language barriers, must be addressed proactively. Establishing redundant communication systems, such as satellite phones and radio networks, can provide critical backup during an incident.

Coordination among different response teams—such as medical personnel, security forces, and logistics providers—is equally important. A well-coordinated response minimizes confusion, reduces risks, and enhances the overall effectiveness of emergency operations. Incident Command Systems (ICS) and joint operation centers (JOC) are useful structures that can facilitate coordination in complex environments.

Adapting to Changing Conditions

Non-permissive environments are inherently unpredictable, and conditions can change rapidly. Response teams must be flexible and ready to adapt their strategies as new information becomes available. This might involve adjusting evacuation routes, reallocating resources, or altering decontamination procedures based on the evolving nature of the threat. Flexibility is a key attribute of successful response teams operating under these conditions.

Common CBRN Threats in Non-Permissive Environments

During CBRN incidents, several specific threats intensify the risks in non-permissive environments:

Chemical Threats

Chemical threats include the release of Toxic Industrial Chemicals (TICs), chemical warfare agents (CWAs), or hazardous materials. These substances can cause mass casualties through inhalation, ingestion, or skin absorption. The volatility and rapid dispersion of chemicals can create widespread areas of contamination, complicating both the identification of affected zones and the safe deployment of medical teams. Responding to chemical threats requires rapid identification, deployment of appropriate PP), and efficient implementation of decontamination procedures to minimize harm.

Examples: Sarin gas attacks, chlorine leaks, accidental release of industrial chemicals.

Biological Threats

Biological threats arise from the intentional or accidental release of pathogens, such as bacteria, viruses, or toxins. These threats are often invisible, spread rapidly, and can cause widespread public health crises. The delay in symptom onset and the difficulty of diagnosing exposure complicate response efforts, creating challenges for timely containment. Strategies to counter biological threats

include rapid detection, the establishment of containment zones, quarantine measures, and mass vaccination or prophylaxis to curb the spread.
Examples: Anthrax spores, smallpox, pandemics like Ebola or H1N1 influenza.

Radiological and Nuclear Threats

Radiological threats involve the release of radioactive materials, while nuclear threats involve the detonation of nuclear devices. Both types of threats present challenges such as acute radiation syndrome (ARS), environmental contamination, and significant long-term health risks, including cancer. The invisible nature of radiation, along with its delayed health effects, makes managing these threats particularly complex. Effective management involves using radiation detection devices, setting up exclusion zones, and providing medical treatment for radiation exposure to affected individuals.
Examples: Dirty bombs, nuclear reactor accidents, detonation of a nuclear weapon.

Effective responses to these threats require meticulous planning, including the use of specialized equipment, medical interventions, and robust communication strategies to prevent escalation and contain the impact on public health.

The Importance of Situational Awareness

In non-permissive environments, situational awareness is a critical component of effective CBRN response. It involves the continuous assessment and understanding of the environment, potential hazards, and operational constraints. Situational awareness allows response teams to make informed decisions, anticipate potential threats, and adapt strategies as conditions evolve. Key aspects of situational awareness in CBRN incidents include:

Real-Time Intelligence Gathering
Accurate and timely information about the type and extent of the CBRN threat is essential. This includes data on the location of the incident, the nature of hazardous agents, weather conditions affecting dispersion, and the presence of hostile actors. Technologies such as drones, satellite imagery, and chemical sensors can enhance situational awareness by providing real-time data, allowing responders to make informed decisions and allocate resources effectively.

Risk Assessment and Analysis
Understanding the specific risks associated with the CBRN agent and the environment is crucial. This involves evaluating the potential impact on responders, the local population, and critical infrastructure. Risk assessment tools and models can help predict the spread of contaminants, identify high-risk areas, and guide the deployment of response teams. Continuous risk analysis ensures that response measures are adapted as new information becomes available, reducing the likelihood of exposure and optimizing resource allocation.

Communication and Coordination
Effective communication among response teams, local authorities, and international agencies is vital to maintaining situational awareness. Clear channels of communication ensure that all parties have access to the same information and can coordinate their actions accordingly. Secure

communication systems are necessary to avoid misinformation and maintain operational security. Establishing protocols for information sharing and decision-making helps ensure that response activities are synchronized and effective.

Personal and Team Safety

In a non-permissive CBRN environment, the safety of response personnel is paramount. This requires the use of personal protective equipment (PPE), adherence to safety protocols, and the establishment of safe zones for operations. Decontamination procedures must be in place to protect responders from secondary contamination. Maintaining situational awareness includes monitoring the health and safety of team members, identifying potential hazards in real-time, and adapting protective measures as the situation evolves. Regular health checks and psychological support are also important components of ensuring the well-being of responders.

2. Introduction to CBRN Threats: Types and Their Impact on Public Health and Safety

CBRN threats represent a broad spectrum of hazards, each with distinct characteristics that pose serious risks to public health, safety, and environmental stability. These threats can emerge from a variety of sources, including natural disasters like pandemics or radiation leaks, industrial accidents involving toxic chemicals or radioactive materials, and intentional acts of terrorism aimed at causing mass casualties, widespread fear, and long-term disruption. The ability to effectively prepare for, respond to, and mitigate those threats requires a deep understanding of their unique attributes and the potential challenges they present.

Chemical threats, for example, could arise from toxic substances spreading through air, water, or food, causing poisoning and health issues like respiratory distress or neurological damage. Biological threats may come from harmful pathogens, leading to infectious outbreaks that strain healthcare systems and increase mortality rates. Radiological and nuclear threats, including radiation sickness and cancer, could result from exposure to radioactive materials. RDDs ("dirty bombs") might contaminate large areas, while nuclear incidents from accidents or weapons could cause widespread destruction and lasting social, economic, and environmental impacts.

This section provides an overview of CBRN threats, exploring their nature, modes of dissemination, and potential consequences on human health and community resilience.

Chemical Threats

<u>Nature of Chemical Threats</u>

Chemical substances can be categorized into Toxic Industrial Chemicals, chemical warfare agents, and hazardous materials accidents. Chemical threats are particularly dangerous due to their ability to spread rapidly and affect large populations in a short time. Chemical substances can be classified as:

- Toxic Industrial Chemicals (TICs): Commonly used in industry and agriculture, TICs include substances like chlorine, ammonia, and hydrogen sulfide. Accidental releases, such as during a transportation incident or industrial fire, can lead to widespread exposure and have severe health consequences.
- Chemical Warfare Agents (CWAs): Specifically designed for use in warfare to cause mass casualties, CWAs include nerve agents (e.g., sarin, VX), blister agents (e.g., mustard gas), and blood agents (e.g., cyanide). CWAs are highly toxic and can incapacitate or kill rapidly, posing significant challenges for emergency response teams due to their toxicity and rapid onset of effects.
- Hazardous Materials (HazMat): Accidental releases of hazardous materials, such as pesticides or solvents, can also pose significant risks to public health and the environment. HazMat incidents often occur during industrial processes, transportation, or storage, requiring rapid intervention to prevent escalation.

The response to chemical threats involves swift identification of the chemical agent, implementation of appropriate decontamination procedures, and providing specific medical countermeasures. The use of PPE and establishing exclusion zones are crucial to minimizing responder and public exposure.

<u>Impact on Public Health and Safety</u>

The impact of chemical threats on public health can be severe and immediate. Symptoms of exposure can range from mild irritation to severe respiratory distress, neurological damage, or death. Long-term health effects may include chronic respiratory diseases, neurological disorders, and cancers. Chemical incidents can overwhelm healthcare systems, necessitating rapid triage, decontamination, and treatment of large numbers of affected individuals.

Biological Threats

<u>Nature of Biological Threats</u>

Biological substances are pathogens (bacteria, viruses, fungi) or biotoxins that can cause widespread illness and death. These threats can be naturally occurring, such as emerging infectious diseases, or intentionally released in acts of bioterrorism. Biological agents can be classified as:

- *Bacteria:* Pathogens like Bacillus anthracis (anthrax) and Yersinia pestis (plague) can cause severe infections with high mortality rates if not treated promptly.
- *Viruses:* Highly infectious viruses, such as Ebola, smallpox, or novel influenza strains, can spread rapidly through populations, leading to pandemics.
- *Biotoxins:* These are toxic substances produced by living organisms, such as botulinum toxin, which can cause paralysis and death even in minute quantities.

Impact on Public Health and Safety

Biological threats can lead to mass casualties and widespread fear, significantly disrupting social and economic stability. The incubation period of some pathogens means that initial cases may go undetected, allowing the disease to spread widely before containment measures are implemented. Healthcare systems can become overwhelmed by a surge of patients requiring isolation, intensive care, and specialized treatment. Public health measures such as quarantine, vaccination, and mass prophylaxis are crucial in containing outbreaks and preventing secondary transmission.

Radiological Threats

Nature of Radiological Threats

Radioactive materials, which emit ionizing radiation, can cause harm to living tissue. These threats can result from accidents, such as:

- Accidental Releases: Events such as the Chernobyl and Fukushima nuclear accidents released significant amounts of radioactive materials into the environment, leading to long-term contamination and health risks.
- Occupational and Environmental Exposure: Workers in certain industries, such as nuclear power or medical radiology, may be at risk of accidental exposure to radiological materials.
- Dirty Bombs (Radiological Dispersal Devices - RDDs): These are conventional explosives laced with radioactive materials, designed to spread contamination over a wide area.

Impact on Public Health and Safety

Radiological threats can cause both acute and long-term health effects. acute radiation syndrome (ARS) results from high doses of radiation over a short period, leading to symptoms like nausea, fatigue, and potentially life-threatening damage to internal organs. Long-term exposure to lower doses can increase the risk of cancers, particularly leukemia and thyroid cancer. Radiological incidents can also lead to large-scale evacuations, environmental contamination, and long-lasting psychological and social impacts on affected communities.

Nuclear Threats

Nature of Nuclear Threats

Nuclear threats are characterized by the detonation of a nuclear device, which releases massive amounts of energy in the form of blast, heat, and ionizing radiation. These threats include:

- Nuclear Reactor Accidents: Failures at nuclear power plants, such as the 1986 Chernobyl disaster or the 2011 Fukushima Daiichi accident, can release large amounts of radioactive material into the environment.
- Nuclear Weapons: The detonation of a nuclear bomb causes widespread destruction and long-term radiation fallout, with catastrophic loss of life and infrastructure.

Impact on Public Health and Safety

The immediate effects of a nuclear explosion include severe blast injuries, burns, and radiation sickness. Thermal radiation can cause widespread fires, while the ionizing radiation can lead to ARS and long-term health consequences, including cancer and genetic damage. The fallout from a nuclear explosion can contaminate large areas, making them uninhabitable for decades. The psychological impact of a nuclear event is profound, leading to widespread fear, anxiety, and displacement of populations.

Comparative Impact of CBRN Threats on Public Health

Each type of CBRN threat poses distinct challenges for public health and safety. The severity of impact varies based on the nature of the threat, the scale of the incident, and the preparedness and response capabilities of affected communities (Table 1).

Table 1. Comparative Impact of CBRN Threats on Public Health

	Chemical Threats	Biological Threats	Radiological Threats	Nuclear Threats
Characteristics	Immediate health effects, rapid onset of symptoms, and the need for swift decontamination and medical intervention.	Potential for widespread infection, prolonged response efforts, and the need for containment and mass prophylaxis.	Acute and long-term health effects, environmental contamination, and psychological impacts.	Catastrophic loss of life, long-term environmental damage, and profound psychological and societal consequences.

3. Personal Safety and Protective Measures: Safeguarding Healthcare Professionals During CBRN Incidents

First responders dealing with Chemical, Biological, Radiological, and Nuclear incidents face significant risks due to potential exposure to highly hazardous agents. These agents can cause a wide range of health effects, from immediate symptoms like respiratory failure or skin irritation to long-term conditions such as cancer or neurological disorders. The volatile nature of CBRN environments makes personal safety a top priority, requiring strict adherence to protective protocols.

To safeguard healthcare professionals and emergency responders during these incidents, the use of appropriate Personal Protective Equipment is vital. PPE forms the first line of defense, including respirators, protective suits, gloves, and face shields, all designed to minimize exposure to harmful substances. Additionally, it is essential that responders follow well-established decontamination procedures to prevent the spread of contaminants and ensure that both personnel and patients remain safe during treatment.

Operational safety also extends to maintaining clear communication and coordination among teams, managing resources efficiently, and ensuring ongoing monitoring of environmental conditions. By following these comprehensive recommendations, first responders can deliver critical care while minimizing their own risk in CBRN environments.

This section provides detailed guidance on these measures, aimed at protecting those who serve on the frontlines of such hazardous situations.

Key Risks for Healthcare Professionals in CBRN Environments

Healthcare professionals are vulnerable to multiple routes of exposure during CBRN incidents:

- *Inhalation:* Breathing in airborne chemicals, biological pathogens, or radioactive particles can result in rapid absorption into the respiratory system, leading to acute and potentially life-threatening conditions. Inhalation is one of the primary routes of exposure, especially in incidents involving toxic industrial chemicals or biological aerosols. The risk can be heightened in confined spaces, where the concentration of hazardous agents may be higher.
- *Ingestion:* Consuming contaminated food or water, or inadvertently ingesting particles while performing duties, poses a serious risk, especially with biological agents or radiological contaminants. Healthcare professionals must be vigilant in maintaining strict hygiene practices, including handwashing and avoiding eating or drinking in contaminated zones. Contaminants can easily be transferred from hands or surfaces to the mouth, making proper decontamination of equipment and PPE crucial to reducing the risk of ingestion.
- *Dermal Contact:* Direct contact with hazardous substances can lead to skin absorption, chemical burns, or radiation-induced injuries. Even small breaches in PPE can lead to significant exposure. Some chemical agents, such as blister agents or nerve agents, can be absorbed through the skin, causing severe local and systemic effects. Proper donning and doffing procedures are essential to prevent accidental dermal exposure, and healthcare professionals should be trained in recognizing early signs of skin contamination and responding appropriately.
- *Injection/Inoculation:* Accidental needle sticks or cuts from contaminated sharp objects can introduce hazardous agents directly into the bloodstream, increasing the risk of severe systemic effects. This is particularly concerning when dealing with biological agents or contaminated patients. Safe handling of sharps, the use of puncture-resistant gloves, and proper disposal of medical waste are critical to minimizing the risk of inoculation. Healthcare workers should also be aware of the protocols for post-exposure prophylaxis in case of accidental exposure through injection.

Protective Strategies for Healthcare Professionals

To mitigate these risks, healthcare professionals must adhere to stringent safety practices, including:

<u>Personal Protective Equipment</u>

PPE is the primary barrier between healthcare workers and hazardous agents. The proper selection, use, and maintenance of PPE are vital for safety. PPE is categorized into four levels, each providing varying degrees of protection based on the known or suspected hazards:

- Level A: The highest level of protection, including a fully encapsulating chemical-resistant suit with a Self-Contained Breathing Apparatus (SCBA).
  Use Cases: Unknown agents, high concentrations of chemicals, or the presence of highly toxic substances such as nerve agents.
- Level B: Provides high respiratory protection with a chemical-resistant suit but less skin protection than Level A.
  Use Cases: Situations where the type and concentration of the chemical hazard are known, but full-body encapsulation is not required.
- Level C: Uses air-purifying respirators and chemical-resistant clothing. Suitable for environments with lower concentrations of known agents.

Use Cases: When contaminants are known, and levels are low enough to be effectively filtered by an air-purifying respirator.

- Level D: Minimal protection, consisting of a standard work uniform. Used only when there is no risk of CBRN contamination.
  Use Cases: Low-risk environments where CBRN agents are not present.

Proper Donning and Doffing Procedures

Correct procedures for donning (putting on) and doffing (taking off) PPE are critical to avoid contamination:

- Donning: Should be conducted systematically in a contamination-free area, ensuring all components fit properly and are secure.
- Doffing: Requires careful removal to prevent self-contamination, with contaminated areas of the PPE facing outward and disposed of or decontaminated properly.

Medical Protection

The direct impact of CBRN incidents is a function of the environmental hazards they generate and the resulting health effects on exposed personnel. Hazards, which are of agent-specific duration and severity, can pose an ongoing risk to operational units and first responders in the area. Additionally, casualties contaminated or suffering from contagious diseases may pose a secondary risk to others. CBRN Medical Protection provides measures to limit the secondary health risks posed by and to casualties from contamination or contagious disease. Medical Protection is divided into prophylaxis and therapy:

Prophylaxis: Treatment or action taken to prevent disease. It is divided into:

- Active Immunoprophylaxis: Use of an antigenic agent to stimulate the immune system.
- Passive Immunoprophylaxis: Use of antiserum or hyperimmune globulin from another person or animal for temporary protection against a specific infectious or toxic agent.
- Chemoprophylaxis: Use of drugs to prevent or combat disease.

Therapy: Treatment intended to counter or mitigate the effects of a disease. This involves using serums, antitoxins, and drugs to relieve symptoms or eliminate harmful agents from the body.

Fit Testing and Training

Regular fit testing for respirators ensures a secure seal and effective protection. Training in the correct use of PPE, including donning and doffing, should be mandatory and regularly refreshed.

Decontamination Protocols and Procedures

Decontamination is essential to prevent secondary contamination of healthcare workers and facilities. Types of decontamination include:

- Immediate Decontamination: Rapid removal of contaminants using water or decontamination wipes to prevent absorption. Critical if the substance is on the skin or clothing.
- Gross Decontamination: Conducted at the scene using showers or water spray systems to remove the bulk of contaminants.
- Technical Decontamination: Performed at a designated site, using specialized equipment and procedures to ensure complete decontamination. Key steps of decontamination procedures include:

- Establishing a decontamination corridor with clearly designated entry and exit points to manage the flow of individuals and equipment.
- Using large volumes of water or appropriate decontamination solutions to thoroughly wash away contaminants. It is crucial to control water runoff to prevent secondary environmental contamination.
- Carefully removing contaminated clothing and containing it for safe disposal. The skin should be gently washed with soap and water to remove residual contaminants, taking care not to abrade the skin, which could increase absorption of hazardous substances.

<u>Operational Safety Measures</u>
Effective operational guidelines are essential to protect healthcare workers during CBRN incidents:
Triage and Treatment
- Prioritize the decontamination of patients before initiating medical treatment to avoid cross-contamination.
- Implement specialized triage protocols for CBRN incidents, considering the nature and severity of exposure.

Safe Handling of Contaminated Materials
- Use double-bagging techniques for contaminated waste, and clearly label it as hazardous material.
- Avoid standard medical waste disposal procedures for CBRN-contaminated materials. Follow hazardous waste management protocols instead.

Monitoring and Detection
- Use detection equipment to identify the presence and concentration of hazardous agents.
- Regularly monitor healthcare workers for signs of exposure and implement immediate action if symptoms develop.

Maintaining a Safe Work Environment
- Limit personnel in contaminated areas to essential staff only.
- Ensure proper ventilation and use negative pressure isolation rooms for patients with airborne biological threats.
- Implement a buddy system, where healthcare professionals work in pairs to monitor each other for signs of contamination or equipment failure.

<u>Psychological and Emotional Resilience</u>
CBRN environments are highly stressful, and healthcare professionals may experience psychological strain. Main elements of psychological resilience include:
Psychological Support Measures
- Include psychological preparedness in pre-deployment training to help staff cope with high-stress environments.
- Provide access to mental health support during and after deployment to address traumatic experiences.
- Encourage regular debriefings and peer support to allow healthcare workers to express concerns and share experiences.

Stress Management Techniques
- Use relaxation techniques, such as deep breathing exercises, to reduce acute stress levels.
- Maintain regular communication with team members to reduce uncertainty and anxiety.
- Rotate staff to prevent burnout and ensure adequate rest periods away from high-risk areas.

4. Medical Care in CBRN Environments: Recommendations for Delivering Medical Care in Contaminated Settings

Providing medical care in CBRN environments is an exceptionally complex task, requiring a combination of specialized training, precise protocols, and advanced equipment. These hazardous settings expose both patients and responders to unique risks, from acute chemical toxicity to prolonged exposure to biological agents or radiological contamination. The constantly shifting nature of these environments demands a flexible, adaptive approach to care.

Ensuring the safety of healthcare professionals and patients involves not only strict adherence to established guidelines but also the effective use of Personal PPE to minimize exposure to harmful agents. Decontamination procedures are critical, as is the ability to assess risks in real time, adjusting strategies as conditions evolve. Traditional medical procedures often need to be modified or adjusted to account for the extreme nature of CBRN incidents, where hazardous agents can hinder patient access and complicate the use of standard medical tools or interventions.

Moreover, working in CBRN environments requires healthcare professionals to be well-prepared and adaptable. This includes rigorous pre-incident planning, constant situational awareness, and the capacity to make quick decisions to safeguard both personal and public health. Clear communication, both within response teams and with external support agencies, is essential for coordinating efforts and ensuring operational success.

This section offers a comprehensive set of recommendations aimed at helping healthcare professionals deliver effective, life-saving care in contaminated environments, focusing on preparedness, adaptability, and maintaining continuous safety protocols.

General Principles of Medical Care in CBRN Environments

Safety First: Protect the Healthcare Provider

- Ensure healthcare providers are equipped with appropriate Personal Protective Equipment based on the level of contamination and the specific agent involved.
- Implement strict safety protocols to minimize exposure risks, including proper donning and doffing procedures for PPE.
- Establish a clear line of command and communication within the medical response team to ensure coordinated and efficient operations.

Decontamination Before Treatment

- Prioritize decontamination of patients before initiating medical care to prevent secondary contamination of healthcare personnel and facilities.
- Set up designated decontamination areas equipped with showers, protective barriers, and waste disposal systems.
- Use dry decontamination methods (such as brushing off contaminants) when water is not immediately available, followed by wet decontamination as soon as possible.

Triage and Classification

- Implement a specialized triage system for CBRN incidents, which accounts for the type and severity of exposure and symptoms.
- Use the "CBRN Triage Model" which categorizes patients based on contamination, severity of symptoms, and the urgency of medical intervention:

  -Immediate: Life-threatening conditions requiring urgent intervention.
  -Delayed: Serious but stable conditions where treatment can be postponed.
  -Minimal: Minor injuries or symptoms that do not require immediate care.
  -Expectant: Severe conditions with low chances of survival given the available resources.

Medical Management of CBRN Casualties

Each type of CBRN agent requires specific medical management strategies. Below are tailored recommendations for each category:

Chemical Incidents

Clinical Management

- Nerve Agents: Administer antidotes such as atropine and pralidoxime as soon as exposure is confirmed. Use benzodiazepines to control seizures if needed.
- Blister Agents: Remove contaminated clothing and irrigate the skin with water. Apply burn dressings and analgesics for pain management.
- Opioid Agent: Administer antidotes such as Naloxone as soon as exposure is confirmed.
- Blood Agent: Administer antidotes such as Hydroxocobalamin as soon as exposure is confirmed.
- Toxic Industrial Chemicals: Treat symptomatically based on the specific agent involved (e.g., bronchodilators for chlorine exposure).

Respiratory Support

- Ensure airway protection and consider advanced airway management (e.g., intubation) for patients with severe respiratory compromise.

Decontamination

- Remove contaminated clothing and rinse skin with large amounts of water. Use mild soap if available, avoiding harsh scrubbing which may increase absorption.
- Prioritize dislobing and dry decontamination in case of expected delay of wet decontamination

<u>Biological Incidents</u>

Clinical Management

- Isolation and Infection Control: Implement strict isolation procedures for suspected contagious biological agents such as Ebola or smallpox.
- Supportive Care: Administer supportive care, including fluids and antipyretics. Use antivirals or antibiotics based on the suspected pathogen.
- Mass Prophylaxis: Distribute prophylactic treatments such as antibiotics or vaccines to potentially exposed individuals.

Containment and Surveillance

- Establish quarantine zones and initiate active surveillance for secondary cases among responders and the general population.

Decontamination

- Implement basic decontamination procedures, such as hand hygiene and the use of alcohol-based hand sanitizers. For highly infectious agents, use more rigorous decontamination protocols.

<u>Radiological Incidents</u>

Clinical Management

- Acute Radiation Syndrome (ARS): Assess radiation dose and onset of symptoms. Use supportive care and hematopoietic growth factors for bone marrow suppression.
- Internal Contamination: Administer decorporation agents such as Prussian blue or potassium iodide based on the contaminant involved.
- Burns and Injuries: Treat radiation burns and mechanical injuries following standard burn care protocols but consider radiation effects on wound healing.

Decontamination

- Remove external contamination by carefully removing clothing and washing exposed skin. Prevent the spread of radioactive particles to unaffected areas.

Radiation Monitoring

- Use dosimeters and radiation detectors to monitor exposure levels of patients and healthcare personnel. Adjust safety measures based on contamination levels.

<u>Nuclear Incidents</u>

Clinical Management

- Mass Casualty Triage: Expect many casualties with combined injuries (trauma and radiation). Triage is based on survivability and available resources.
- Supportive Care: Focus on managing shock, burn injuries, and trauma. Use aggressive wound care and infection control measures.

- Radiation Sickness Management: Administer cytokines and blood transfusions to manage bone marrow suppression. Stem cell therapy may be considered for severe cases.

Decontamination

- Establish field decontamination stations to remove radioactive fallout from patients and responders. Use water and mild soap for effective decontamination.

Sheltering and Evacuation

- Depending on the scale of the incident, implement evacuation or shelter-in-place strategies. Use radiation shielding principles to protect patients and responders from ongoing exposure.

Operational Considerations in CBRN Environments

<u>Establish CBRN-Specific Medical Response Teams</u>

- Form dedicated medical response teams with training in CBRN hazards. Teams should include toxicologists, infectious disease specialists, and radiation experts.

<u>Adapt Facilities for CBRN Care</u>

- Designate CBRN-specific treatment areas with negative pressure isolation rooms, decontamination zones, and radiation shielding.

<u>Communication and Coordination</u>

- Use secure and reliable communication channels to coordinate between different response agencies and healthcare facilities. Ensure accurate information flow to manage patient care effectively.

<u>Psychological Support and Resilience</u>

- Provide psychological support to both patients and healthcare workers. Address anxiety and stress related to CBRN exposures and the high-stress nature of these incidents.

5. Managing Mass Casualty Events: Advice for Effectively Managing Large-Scale Emergencies Involving CBRN Agents

Mass casualty events involving Chemical, Biological, Radiological, and Nuclear (CBRN) agents present unique challenges due to the high number of affected individuals and the complexities of contamination, decontamination, and specialized medical care. Effective management requires meticulous planning, rapid decision-making, and coordinated multi-agency responses. This section provides comprehensive advice for healthcare professionals, emergency managers, and response teams to effectively handle large-scale CBRN emergencies.

Key Strategies for Managing CBRN Mass Casualty Events

Preparation and Pre-Incident Planning

- Risk Assessment and Vulnerability Analysis: Conduct detailed assessments of potential CBRN threats specific to the location, including industrial sites, research facilities, and transportation routes for hazardous materials. Identify vulnerable populations and critical infrastructure. Utilize tools such as GIS modelling and predictive software for hazard assessment and developing risk profiles.

- Develop and Exercise CBRN Response Plans: Create comprehensive response plans incorporating CBRN-specific protocols. Regularly conduct drills and simulations with all stakeholders, including healthcare facilities, emergency services, and government agencies.

Include incident site management scenarios that address contamination control and coordination across different response levels.

- Training and Resource Allocation: Ensure all responders and healthcare workers are trained in CBRN incident management, use of PPE, and decontamination procedures. Establish a multi-level training system, basic for all personnel, intermediate, and advanced for specialized response units. Stockpile necessary resources such as antidotes, protective gear, and decontamination supplies, considering surge capacity.

Incident Command and Control

- Establish a Unified Command System: Implement the Incident Command System (ICS) with a designated Incident Commander who has CBRN expertise. The quality of the decision-making process during initial emergency stages is crucial for effective rescue operations. A unified system must integrate local, regional, and national resources for a coordinated response.

- Activation of Emergency Operations Centers (EOCs): Activate EOCs to facilitate communication, resource allocation, and decision-making. EOCs should be equipped to handle CBRN-specific information and coordinate with various agencies, including law enforcement, public health, and hazardous materials teams. Effective emergency communications are crucial in saving the lives of first responders and the affected population.

- CBRN Incident Site Management: Secure and isolate the incident site to prevent further contamination and control the movement of affected individuals. Establish “hot,” “warm,” and “cold” zones based on contamination levels to manage access and activities within each area, ensuring that operational and non-operational areas are clearly defined.

Triage and Medical Management

- CBRN-Specific Triage Protocols: Utilize specialized triage protocols to assess and prioritize casualties based on the type and severity of CBRN exposure. Use modified versions of the "S.T.A.R.T." (Simple Triage and Rapid Treatment) method to include considerations for contamination and resource availability. Rapid triage and coordination at the scene help prevent the spread of contaminants.

- Immediate Decontamination: Implement rapid decontamination procedures at the scene to prevent secondary contamination and reduce toxin absorption. Use dry decontamination followed by wet decontamination for chemical and radiological exposures. Establish a structured decontamination process that includes a setup for mass decontamination, technical decontamination, and collection of contaminated wastewaters.

Medical Treatment Prioritization

- Chemical Exposure: Administer appropriate antidotes (e.g., atropine for nerve agents) and supportive care. Monitor for delayed symptoms and provide ongoing treatment.
- Biological Exposure: Isolate and quarantine as needed. Provide prophylaxis or post-exposure treatment. Follow infection control measures to limit secondary transmission.

- <u>Radiological Exposure</u>: Assess radiation dose and begin treatment for acute radiation syndrome if indicated. Use decorporation agents like potassium iodide or Prussian blue for internal contamination.

- <u>Nuclear Exposure</u>: Treat blast injuries and burns along with radiation sickness management, prioritizing life-threatening conditions.

Logistics and Resource Management

- <u>Surge Capacity Management:</u> Expand healthcare capacity to handle large patient influxes. Set up temporary field hospitals or alternate care sites. Coordinate with nearby facilities to distribute the patient load effectively.

- <u>Resource Allocation:</u> Prioritize limited resources, such as ventilators, antidotes, and PPE, using crisis standards of care based on triage assessments. Efficient logistical support and resource planning are critical to ensuring a smooth emergency response.

- <u>Staffing and Fatigue Management:</u> Implement a rotation schedule for healthcare workers and responders to prevent burnout. Psychological support and stress management resources must be made available to maintain workforce resilience.

Public Information and Communication

- <u>Risk Communication:</u> Deliver clear, accurate, and timely information to the public about the nature of the CBRN threat, protective actions, and available resources. Use multiple communication channels (e.g., social media, radio, and TV) to reach diverse audiences.

- <u>Coordination with Media:</u> Establish a Joint Information Center (JIC) to coordinate media inquiries and press releases. Prepare for rapid media engagement, as representatives may arrive at the scene before the full mobilization of response units.

- <u>Public Health Messaging:</u> Provide guidelines on personal protective measures, symptoms to watch for, and instructions for seeking medical care. Emphasize avoiding contaminated areas and adhering to official directives.

Evacuation and Shelter-in-Place Strategies

- <u>Evacuation Plans:</u> Develop evacuation plans that consider contamination zones, transportation availability, and the needs of vulnerable populations. Coordinate routes and shelter locations with local authorities to ensure safe evacuation.
- <u>Shelter-in-Place Guidance:</u> Advise the public on when and how to shelter in place during chemical or radiological incidents. Provide detailed instructions on sealing homes, turning off ventilation systems, and staying indoors until further notice.

Long-Term Recovery and Rehabilitation

- Environmental Remediation: Collaborate with environmental agencies to decontaminate affected areas. Ensure hazardous waste is safely collected, transported, and disposed of per regulatory guidelines.

- Mental Health Support: Provide long-term psychological support to survivors, responders, and the community. Address PTSD and anxiety stemming from the incident through ongoing counseling and community support programs.

- Community Resilience Building: Engage the community in recovery efforts, providing education on preparedness and promoting resilience through public health initiatives and community programs.

Review and Adaptation of Response Plans

- After-Action Reviews: Conduct thorough reviews of the response efforts to identify strengths and areas for improvement. Ensure lessons learned are incorporated into updated response plans and training programs.

- Continuous Training and Drills: Regularly update training protocols and conduct drills to maintain readiness and ensure effective performance during future CBRN events. Emphasize multi-agency cooperation and integration during exercises to replicate real-life complexities.

Key Takeaways for CBRN Mass Casualty Management

- Managing CBRN mass casualty events requires a well-coordinated multi-agency response, effective incident command, and the rapid implementation of medical countermeasures and decontamination. A comprehensive approach involving preparation, real-time coordination, efficient resource allocation, and effective public communication is vital. Success hinges on rapid decision-making, maintaining the safety of responders, and engaging the affected community throughout response and recovery phases.

6. Decontamination Procedures: Instructions for Decontaminating Patients and Healthcare Providers Exposed to Hazardous Materials

Decontamination plays a critical role in the effective management of CBRN (Chemical, Biological, Radiological, and Nuclear) incidents, ensuring the immediate removal of hazardous substances and safeguarding the long-term health of patients, healthcare workers, and the surrounding community. It serves as both an emergency measure and a preventive strategy against the spread of contamination.

Successful decontamination depends on comprehensive planning, the availability of appropriate equipment, and the rigorous application of standardized protocols tailored to different types of CBRN threats. The process typically involves multiple stages, including gross decontamination for initial exposure reduction, technical decontamination to thoroughly cleanse affected areas, and secondary procedures to verify that all traces of hazardous materials have been eradicated.

This section offers comprehensive guidance on the decontamination of both patients and healthcare providers exposed to chemical, biological, radiological, or nuclear agents, covering everything from triage to post-decontamination care. It also highlights the importance of coordinated efforts between emergency responders, medical personnel, and public health authorities in executing these protocols seamlessly.

General Principles of Decontamination

Minimize Further Contamination

- Decontamination should be conducted as soon as possible to prevent the spread of contaminants. Establish decontamination zones (hot, warm, and cold) to control the movement and reduce cross-contamination.
- All personnel involved in the decontamination process must wear appropriate Personal Protective Equipment to protect themselves from exposure.
-

Prioritize Safety

- Patient and responder safety are paramount. If decontamination resources are limited, prioritize those who are most severely affected or at risk of spreading contaminants.

Avoid Aggressive Actions

- Use gentle techniques to avoid abrading the skin and potentially increasing absorption of contaminants. Do not use harsh scrubbing and avoid using high-pressure water on the skin.

Types of Decontamination

Dry Decontamination

- Involves removing contaminated clothing and using dry materials (e.g., cloths, powders) to absorb or remove contaminants from the skin.
- Effective for removing loose particles and when water is not available, or its use is contraindicated.

Wet Decontamination

- Uses water, often with soap or mild detergents, to remove contaminants from the skin and hair. It is the most common and effective method for removing soluble chemicals and biological agents.
- Should be performed as soon as possible after exposure to minimize the absorption of contaminants through the skin.

Technical Decontamination

- Conducted at a designated decontamination site using specialized equipment and procedures. This is more thorough than gross decontamination and is used for healthcare providers or those with persistent contamination.

Decontamination Procedures for Patients

Initial Assessment and Triage

- Assess patients for signs and symptoms of exposure and contamination. Prioritize decontamination for those with visible contamination or symptoms of chemical or radiological exposure.
- Use CBRN-specific triage tags to classify patients based on their need for decontamination and medical care.

Procedures for Dry Decontamination

- If liquid contaminants are not visible, start with dry decontamination. Instruct patients to remove all clothing and personal items, as this can remove up to 80-90% of contaminants.
- Use dry materials like paper towels, soft cloths, or commercial decontamination pads to gently wipe away contaminants from the skin.
- Bag and seal contaminated clothing and items in clearly marked hazardous waste bags.

Procedures for Wet Decontamination

- Use tepid water, preferably between 15-30°C (59-86°F), to wash the contaminated areas. Avoid high-pressure water, as it can spread contaminants.
- Wash the skin and hair thoroughly with a mild soap or detergent. Begin with the head and work downwards, avoiding the eyes and mouth.
- Rinse for at least 3-5 minutes. For persistent contamination, repeat the washing process.
- Ensure contaminated water runoff is collected and disposed of properly to prevent environmental contamination.

Procedures for Technical Decontamination

- Transfer patients to a designated decontamination site if gross decontamination is insufficient. Use specialized equipment such as decontamination showers and chemical neutralizers if necessary.
- For radiological contamination, use radiation detectors to monitor and confirm the removal of radioactive particles.
- Continue to monitor and provide supportive care as needed after decontamination.

Post-Decontamination Monitoring

- Monitor patients for delayed symptoms or adverse reactions to decontamination procedures, such as hypothermia or skin irritation.
- Provide dry, clean clothing and blankets to prevent hypothermia and ensure patient comfort.

Decontamination Procedures for Healthcare Providers

Personal Protective Equipment

Ensure all healthcare providers wear appropriate PPE, including gloves, gowns, masks, and eye protection. For high-risk exposures, use fully encapsulating suits and self-contained breathing apparatus (SCBA).

- Inspect PPE for integrity before and after use. Replace any damaged or contaminated equipment immediately.

Buddy System and Monitoring

- Implement a buddy system where healthcare providers work in pairs to monitor each other for signs of contamination or PPE failure.
- Use detection equipment to regularly check for contamination on the PPE of healthcare providers, especially during extended exposure periods.

Doffing (Removal) Procedures

- Doffing PPE must be done systematically to avoid self-contamination. Follow these steps:
  -Remove gloves first, avoiding contact with the outside surfaces.
  -Remove the gown by folding it inward, containing any contaminants inside.
  -Remove the mask and goggles without touching the front.
  -Dispose of PPE in designated hazardous waste containers.

Decontamination of Healthcare Providers

- After doffing PPE, healthcare providers should undergo personal decontamination. This involves washing exposed skin with mild soap and water.
- Use radiation detectors to ensure no residual contamination if radiological agents are involved.
- For persistent contamination, use technical decontamination procedures, including decontamination showers and specialized cleansing agents. Ensure thorough decontamination of all equipment used by healthcare providers.

Decontamination Facility Setup

Decontamination Zones

- Hot Zone: Area of highest contamination. Access is restricted to personnel in full PPE.
- Warm Zone: Area where decontamination occurs. Staff should wear PPE but of a lower level than in the Hot Zone. Use this area for initial patient decontamination.
- Cold Zone: Clean area where decontaminated individuals receive medical care. PPE is not required here.

Decontamination Stations

- Set up separate stations for ambulatory and non-ambulatory patients. Use stretchers and lifting devices for those unable to walk.
- Ensure that water supply, containment systems for runoff, and waste disposal facilities are in place and clearly marked.

Waste Management

- Collect and dispose of all contaminated clothing, PPE, and decontamination waste in accordance with hazardous materials regulations. Clearly label all waste containers to prevent accidental exposure.

Psychological Considerations

Communication

- Explain the decontamination process to patients and healthcare providers to reduce anxiety. Use clear, simple language and provide reassurance about the safety and necessity of the procedures.

Support Services

- Offer psychological support to patients and responders who may be experiencing stress, fear, or trauma related to the incident and decontamination process.

7. Triage Priority: Addressing the Principles of Triage Priority According to CBRN Characteristics Including Mechanism of Action

Triage is an essential process in managing mass casualty situations, particularly when dealing with CBRN events. It is not merely a technical task but a lifesaving activity that involves making rapid, often heart-wrenching decisions under extreme pressure. The primary goal is to ensure that limited resources, whether personnel, medical supplies, or time, are allocated where they can do the best, maximizing the chances of survival and minimizing loss of life. This section delves into the principles that guide triage in these complex scenarios, focusing on how understanding each agent's mechanism of action can directly influence the prioritization of care.

Principles of Triage Priority in CBRN Incidents

Immediate Life Threat vs. Delayed Effect

- Chemical Agents: Often cause immediate, visible symptoms such as respiratory distress, seizures, or burns. Rapid triage is essential to administer antidotes and supportive care quickly.

- Biological Agents: May have delayed onset of symptoms, making initial triage challenging. Focus on identifying symptomatic individuals and those with known exposure.

- Radiological and Nuclear Agents: Radiation exposure can cause immediate life-threatening conditions like Acute Radiation Syndrome (ARS) or delayed effects such as cancer. Triage is based on dose estimation and immediate symptoms.

Mechanism of Action and Triage Implications

Chemical Agents: Include nerve agents, blister agents, choking agents, and blood agents. Triage focuses on the speed and severity of symptoms:

- Nerve Agents (e.g., Sarin, VX): Cause rapid onset of symptoms like muscle twitching, convulsions, and respiratory failure. Prioritize individuals with severe symptoms for immediate treatment with antidotes such as atropine and pralidoxime.
- Blister Agents (e.g., Mustard Gas): Causes delayed skin and mucosal damage. Triage focuses on those with severe burns or respiratory complications due to inhalation.
- Choking Agents (e.g., Chlorine, Phosgene): Cause pulmonary edema. Priority is given to those with severe respiratory distress.
- Blood Agents (e.g., Cyanide): Disrupt cellular respiration, leading to rapid loss of consciousness and death. Immediate administration of antidotes like hydroxocobalamin is critical.
- Opioid Agents: Include synthetic opioids and natural opiates, which bind to opioid receptors to relieve pain but carry a high risk of dependency and respiratory depression. Triage emphasizes the level of consciousness and respiratory function:

  - Synthetic Opioids (e.g., Fentanyl, Carfentanil): Potent agents with a rapid onset that can cause severe respiratory depression and sedation. Immediate administration of naloxone is prioritized for individuals with reduced respiratory rate or unconsciousness.
  - Natural Opiates (e.g., Morphine, Codeine): Cause analgesia but can lead to slower respiratory depression. Triage prioritizes those with signs of overdose, including pinpoint pupils, shallow breathing, and unconsciousness.
  - Mixed Agonist-Antagonists (e.g., Buprenorphine): Provide pain relief with a ceiling effect on respiratory depression, but

overdose cases still require careful monitoring and naloxone administration as needed.

Biological Agents: Include bacteria, viruses, and toxins. Triage must consider the incubation period, mode of transmission, and potential for secondary spread:

- Highly Contagious Agents (e.g., Smallpox, Plague): Isolate and prioritize symptomatic patients for quarantine and supportive care. Focus on preventing secondary transmission.
- Non-Contagious Agents (e.g., Anthrax, Botulinum Toxin): Prioritize those showing severe symptoms such as respiratory distress or neurological impairment. Use prophylactic measures for exposed but asymptomatic individuals.

Radiological and Nuclear Agents: Involve external and internal contamination risks:

- External Contamination (e.g., Fallout from a Dirty Bomb): Triage based on contamination levels measured by radiation detectors. Focus on decontamination and managing immediate symptoms of radiation sickness.
- Internal Contamination (e.g., Inhaled or Ingested Radionuclides): Use biological dose estimation to prioritize treatment. Administer decorporation agents like potassium iodide or Prussian blue based on the type of radionuclide involved.

Triage Categories in CBRN Incidents

<u>Immediate (Red Tag)</u>

- Patients with life-threatening but treatable conditions. Requires immediate intervention.
- Examples: Severe respiratory distress from nerve agent exposure, acute respiratory failure due to chlorine inhalation, or severe trauma combined with radiation exposure.

<u>Delayed (Yellow Tag)</u>

- Patients with serious but non-life-threatening conditions. Treatment can be delayed without significant risk.
- Examples: Moderate burns from blister agents, mild to moderate symptoms of radiation exposure without immediate life-threatening effects.

<u>Minimal (Green Tag)</u>

- Patients with minor injuries or mild symptoms. They do not require immediate medical intervention.
- Examples: Mild skin irritation from chemical agents, minor trauma, or psychological distress.

<u>Expectant (Black Tag)</u>

- Patients with severe, life-threatening injuries are unlikely to survive given the resources available.
- Examples: Massive exposure to nerve agents with unmanageable respiratory failure, severe burns covering large body areas, or severe radiation sickness with high doses.

Triage Protocols for Specific CBRN Incidents

Chemical Incident Triage

Use the SALT Triage (Sort, Assess, Lifesaving Interventions, Treatment/Transport) method with modifications for chemical exposures:

- Sort by visible signs of chemical exposure (e.g., drooling, convulsions).
- Assess breathing, airway patency, and circulatory status.
- Lifesaving Interventions: Administer antidotes immediately if available (e.g., atropine for nerve agents).
- Transport: Move to a decontamination area before hospital transfer.

Chemical triage by Dr Cone 2008 (Cone, D. C., MacMillan, D. S., Parwani, V., & Van Gelder, C. (2008). Pilot Test of a Proposed Chemical/Biological/Radiation/ Nuclear-Capable Mass Casualty Triage System. Prehospital Emergency Care, 12(2), 236–240. https://doi.org/10.1080/10903120801907620)

1. Primary Assessment

Assess Life-Threatening Injuries: Immediately identify life-threatening injuries or conditions using a rapid primary assessment.

- Establish Zones: Divide the incident scene into hot, warm, and cold zones to contain contamination and ensure safe medical intervention. Only appropriately equipped personnel should enter hot zones.
- Decontamination Priority: Patients with visible contamination should undergo decontamination in the warm zone before entering treatment areas.

2. Triage Categories

- T1 (Red - Immediate): Patients with injuries or symptoms that pose an immediate threat to life, requiring urgent intervention. CBRN-specific symptoms (e.g., respiratory distress, seizures, significant burns) should be carefully noted.
- T2 (Yellow - Delayed): Patients with serious but non-life-threatening injuries who can tolerate delayed treatment. Symptoms may include moderate trauma or suspected exposure to non-lethal CBRN agents without immediate systemic effects.
- T3 (Green - Minimal): Patients with minor injuries who require minimal intervention and can safely be treated after critical patients are stabilized.
- T4 (Black - Expectant): Patients with minimal likelihood of survival given available resources. Provide comfort measures as feasible.

3. Chemical/Trauma Algorithm

- Symptom-Based Classification: Utilize symptom-based identification of chemical agents, especially for agents with rapid toxidromes (e.g., organophosphate exposure presenting with muscle twitching, respiratory distress). Verify symptoms against chemical agents and assign triage levels based on clinical presentation. (Ex. Toxidrome (+), T3 -> T2 and administer antidote if indicated)

- Avoid Under-Triage: Over-triage can stretch resources, but under-triage in CBRN incidents poses greater risk by delaying necessary care. For CBRN-exposed patients, prioritize immediate treatment for any patients showing signs of severe exposure, even if traumatic injuries appear less critical.

4. Decision-Making and Role Assignments

- Assign Roles Based on Training Level: The highest-trained personnel (e.g., paramedics) should ideally manage triage, but in larger incidents, treatment responsibilities may be delegated. EMT-Basics or trained assistants can support by handling less critical cases (T3) and assisting in patient decontamination.
- Triage Documentation: Use standardized triage tags and electronic records (if available) to document patient condition, assigned triage category, and any specific symptoms related to Chemical exposure.

Biological Incident Triage

Implement the Infectious Disease Triage Protocols, focusing on isolation and infection control:

- Symptom-Based Triage: Classify based on symptoms such as fever, cough, rash, or neurological signs.
- Exposure History: Prioritize those with known exposure history for isolation and prophylaxis.
- Mass Prophylaxis Distribution: Administer vaccines or antibiotics to those exposed or at high risk.

Radiological and Nuclear Incident Triage

Use the RTR (Radiation, Triage, Treatment, and Transport) model:

- Radiation: Measure radiation levels using detectors.
- Triage: Classify based on symptoms and dose estimation.
- Treatment: Provide supportive care, decorporation agents, or blood transfusions as needed.
- Transport: Stabilize and transport to facilities equipped to handle radiation emergencies.

Special Considerations in CBRN Triage

Contamination Control

- Avoid transporting contaminated patients to clean zones. Use decontamination protocols before moving patients to hospitals or medical facilities.

Psychological Support

- Address the psychological impact on both patients and responders. Fear and anxiety can complicate triage, especially in large-scale CBRN incidents. Provide mental health support as part of the triage process.

Resource Allocation

- In resource-limited settings, prioritize interventions that can save the most lives. Use crisis standards of care when necessary to allocate scarce resources effectively.

Dynamic Reassessment

- Continuously reassess patients as symptoms can evolve rapidly in CBRN exposures. Adjust triage categories as necessary based on changing clinical conditions.

8. Evacuation and Patient Transport: Methods for Safely Evacuating and Transporting Patients from Contaminated Areas

Evacuating and transporting patients during Chemical, Biological, Radiological, and Nuclear incidents is a complex task that requires detailed planning, coordination, and strict adherence to safety protocols. Beyond simply moving individuals, the goal is twofold: to prevent further exposure to hazardous agents and ensure patients reach safe zones or medical facilities promptly.

Effective evacuations involve assessing contamination levels, using specialized equipment like sealed stretchers, and performing triage to prioritize care. Close coordination with medical teams, HAZMAT units, and emergency services is crucial for clear communication and safe route planning, while responders must remain vigilant about their own protection with proper use of PPE.

This section outlines best practices for patient evacuation, emphasizing preparedness, communication, and adaptability. It equips responders to manage the complexities of CBRN evacuations while ensuring that patients receive timely, safe care without exposing others to further risks.

General Principles of Evacuation and Patient Transport

Safety First

- Ensure the safety of both patients and healthcare providers. All personnel involved in the evacuation and transport process should wear appropriate Personal Protective Equipment based on the level of contamination.
- Decontaminate patients, whenever possible, before evacuation to prevent secondary contamination of vehicles, personnel, and healthcare facilities.

Establish Clear Evacuation Zones

Set up clearly defined *Hot, Warm, and Cold* zones around the incident site:

- *Hot Zone:* Area of highest contamination; access restricted to essential personnel in full PPE.
- *Warm Zone:* Area for decontamination and initial triage; limited access with lower-level PPE.
- *Cold Zone:* Safe area for transport and medical treatment; no PPE required.

Prioritize Patients Based on Triage

- Use a CBRN-specific triage system to prioritize patients for evacuation and transport based on the severity of their condition and the likelihood of survival.
- Patients categorized as "Immediate" (Red Tag) should be evacuated first, followed by those classified as "Delayed" (Yellow Tag) and "Minimal" (Green Tag).

Evacuation Methods

On-Site Decontamination Before Evacuation

- Perform gross decontamination on-site to remove most contaminants. Use dry decontamination (e.g., brushing off particles) if water is not available, followed by wet decontamination when possible.

- For radiological incidents, use radiation detectors to assess contamination levels before and after decontamination.

Shelter-in-Place vs. Evacuation

- *Shelter-in-Place:* Advise shelter-in-place if evacuation poses a higher risk of exposure, especially in the case of airborne biological or chemical agents. Instruct residents to seal windows, turn off ventilation systems, and stay indoors until further notice.
- *Evacuation:* Implement evacuation when the safety of remaining in place cannot be guaranteed. This is usually necessary in cases of extensive contamination or threat of secondary exposure, such as a chemical spill or radiation plume.

Evacuation Routes and Assembly Points

- Designate safe evacuation routes away from contamination zones. Avoid routes that pass through downwind areas of chemical or radiological contamination.
- Establish assembly points in the Cold Zone where decontaminated patients can be further assessed and prepared for transport to medical facilities.

Special Considerations for Vulnerable Populations

- Assign additional resources for the evacuation of vulnerable populations such as children, the elderly, and those with mobility issues. Use specialized transport if necessary (e.g., ambulances with wheelchair access).
- Provide language assistance and clear communication to ensure all affected individuals understand evacuation procedures.

Patient Transport Methods

Decontamination of Transport Vehicles

- Before transporting, ensure that vehicles are either decontaminated or outfitted with protective liners to prevent secondary contamination.
- Use dedicated vehicles for the transport of contaminated patients. Decontaminate these vehicles thoroughly after use to prevent cross-contamination.

Patient Handling During Transport

- Healthcare providers should continue to wear appropriate PPE while handling and transporting patients.
- Place contaminated patients in sealed, disposable body bags or wrap them in impermeable sheets to contain any residual contamination during transport.
- For radiological incidents, use lead-lined blankets or shields if available to reduce radiation exposure during transport.

Types of Transport Vehicles

- *Ambulances:* Use for critical patients who require continuous medical care during transport. Ensure these are equipped with the necessary medical supplies and isolation measures.
- *Buses or Vans:* Suitable for transporting multiple non-critical patients who have been decontaminated. These should be equipped with ventilation systems to prevent the buildup of contaminants.
- *Air Transport:* Use air ambulances for rapid evacuation of critical patients over long distances. Aircraft should be equipped with HEPA filtration systems and isolation capabilities.

Transport Coordination and Communication

- Establish communication between the evacuation site and receiving medical facilities to ensure they are prepared for incoming patients.
- Use secure communication channels to coordinate the movement of patients, especially in scenarios involving radiological or biological agents where contamination tracking is crucial.

Receiving Patients at Medical Facilities

Pre-Arrival Notification

- Notify receiving facilities in advance of the nature of the incident, number of patients, and types of contamination. This allows them to prepare decontamination areas and allocate resources accordingly.

Dedicated Decontamination Areas

- Designate specific areas within medical facilities for the arrival and decontamination of CBRN-exposed patients. These areas should be isolated from the main hospital to prevent cross-contamination.
- Equip these areas with showers, PPE, and decontamination supplies. Ensure staff in these areas are trained in handling CBRN patients.

Secondary Triage and Treatment

- Conduct a secondary triage upon arrival to reassess patients' conditions post-evacuation. This may include additional decontamination or advanced medical care as required.
- Provide psychological support for patients and staff involved in the incident, as CBRN events can have significant mental health impacts.

Challenges and Consideration

Logistical Constraints

- Limited availability of transport vehicles and decontamination resources can complicate evacuation efforts. Prioritize the use of available resources based on triage assessments.

Environmental Factors

- Weather conditions, terrain, and infrastructure damage can impact the speed and safety of evacuation and transport. Plan for alternative routes and methods as necessary.

Legal and Ethical Considerations

- Decisions to evacuate or shelter-in-place must be made with consideration for public safety and ethical principles. Ensure that vulnerable populations receive adequate protection and resources during evacuation.

9. Psychological First Aid: Methods for Addressing the Psychological Impact on Both Victims and Healthcare Providers During CBRN Incidents

CBRN incidents can cause significant psychological harm to both victims and healthcare providers. Fear, trauma, and exposure to hazardous agents may lead to acute stress, anxiety, and long-term conditions like Post-Traumatic Stress Disorder (PTSD). Healthcare workers, facing high-pressure environments, are also at risk of psychological strain.

Psychological First Aid (PFA) is essential for reducing immediate and long-term distress by offering emotional support and practical assistance. For victims, it provides reassurance and access to resources, while for healthcare providers, peer support and stress management are key to preventing burnout.

This section outlines how to effectively deliver PFA, focusing on early intervention, empathy, and practical support to foster resilience and recovery in CBRN situations.

Principles of Psychological First Aid

Safety and Comfort

- Ensure that the physical environment is safe and secure for both victims and responders. This includes moving individuals to a contamination-free zone and addressing basic needs such as food, water, and shelter.
- Provide reassurance through calm and empathetic communication, helping to reduce fear and anxiety related to the incident.

Stabilization

- Help individuals who are emotionally overwhelmed to regain a sense of calm and control. Use grounding techniques, such as deep breathing exercises, to help reduce acute stress responses.
- Offer practical support to address immediate concerns, such as finding loved ones or securing personal belongings, to alleviate feelings of helplessness.

Connectedness

- Facilitate contact with family, friends, or community support systems. Social support is a crucial factor in recovery from traumatic events.
- Encourage group discussions among healthcare providers to share experiences and support each other, reducing the sense of isolation.

Self-Efficacy

- Empower individuals by providing clear and accurate information about the situation, the steps being taken to ensure safety, and the resources available to them.
- Encourage healthcare providers to take active roles in their own self-care, including taking breaks, seeking peer support, and utilizing mental health resources.

Hope and Resilience

- Reinforce the strengths and coping abilities of individuals, highlighting their ability to get through difficult situations.
- Promote positive coping strategies, such as focusing on things within their control and engaging in activities that provide a sense of normalcy.

PFA Methods for Victims

Initial Contact and Engagement:

- Approach individuals in a calm and non-intrusive manner. Introduce yourself and your role and ask permission before providing assistance.
- Assess the individual's immediate needs and concerns. Use active listening to validate their feelings and experiences without judgment.

Providing Practical Assistance

- Address basic needs first: offer water, food, blankets, and a safe space to rest. Help with practical tasks, such as finding information about loved ones or connecting with emergency services.
- For individuals separated from family or friends, facilitate contact if possible. This helps to reduce feelings of isolation and distress.

Emotional Support and Information

- Provide clear, concise information about what is happening and what steps are being taken to ensure safety.
- Avoid giving false assurances. Instead, focus on what is being done to help and what the individual can do to stay safe.

Supporting Specific Populations

- Children: Use age-appropriate language and provide comfort through familiar objects or routines. Involve caregivers in providing support.
- Elderly and Individuals with Disabilities: Be mindful of physical limitations and communication needs. Offer additional assistance with mobility or medical equipment if needed.
- Non-English Speakers: Provide interpretation services or language support to ensure that information is accessible and clear.

Referral to Mental Health Services

- Identify individuals who may need additional mental health support, such as those exhibiting severe distress, confusion, or disorientation.
- Provide information about available mental health resources and, if appropriate, facilitate referrals to professional counselors or psychologists.

PFA Methods for Healthcare Providers

Pre-Incident Preparation

- Train healthcare providers in recognizing signs of acute stress reactions in themselves and others. Encourage the use of self-care strategies and peer support before, during, and after the incident.
- Establish a mental health support team that can be mobilized to provide PFA to responders during and after the incident.

On-Site Support

- Implement a “buddy system” where healthcare providers work in pairs to monitor each other for signs of stress or burnout.
- Provide regular briefings with clear and concise information to reduce uncertainty and confusion. Allow time for questions and concerns to be addressed.
- Encourage short breaks and rotation of duties to reduce fatigue and prevent burnout. Ensure that basic needs such as hydration, nutrition, and rest are met.

Emotional Support

- Create safe spaces for healthcare providers to express their emotions and share their experiences. Use debriefing sessions to process the events and their personal impact .
- Validate their experiences and acknowledge the challenges they face. Avoid minimizing their feelings or offering clichés such as “stay strong”.

Long-Term Mental Health Support

- Provide access to ongoing mental health services, including counseling and peer support groups. Offer confidential, one-on-one sessions with mental health professionals as needed.
- Monitor for signs of delayed stress reactions, such as PTSD or depression, and encourage early intervention and treatment.

Self-Care and Resilience Building

- Promote self-care practices such as mindfulness, relaxation techniques, and physical exercise. Encourage healthcare providers to maintain a healthy work-life balance.
- Facilitate training in stress management and resilience-building techniques to enhance coping skills for future incidents.

Special Considerations for CBRN Incidents

Stigma and Fear

- CBRN incidents often involve fear of contamination and stigma associated with exposure. Address these concerns directly by providing information about risks and safety measures.
- Use clear communication to dispel myths and reduce fear related to the spread of contamination or infectious diseases.

Uncertainty and Prolonged Impact

- The unpredictable nature of CBRN incidents can lead to prolonged anxiety and stress. Provide regular updates and maintain transparency about the situation and recovery efforts.
- Prepare individuals for potential long-term effects, such as monitoring for radiological contamination or managing chronic health conditions related to biological exposure.

Cultural Sensitivity

- Be mindful of cultural differences in expressing distress and seeking help. Adapt PFA interventions to be culturally appropriate and respectful of individuals' beliefs and practices.

10. Recap – Safe Behavior: Summary of Key Safety Practices for Healthcare Professionals Responding to CBRN Incidents

Healthcare professionals responding to Chemical, Biological, Radiological, and Nuclear incidents face significant risks from exposure to hazardous agents. To ensure safety, it is essential to strictly follow protocols and adopt safe behaviors throughout the response.

Key safety practices include the proper use of Personal Protective Equipment (PPE), ensuring maximum protection from harmful substances. Decontamination procedures are also vital to prevent the spread of contaminants, requiring careful handling of affected materials and maintaining isolation zones. Situational awareness is crucial, allowing responders to adapt to changing conditions and evolving risks.

This recap emphasizes the importance of PPE, decontamination, and situational awareness to protect healthcare professionals and ensure safe, effective operations in CBRN environments.

Use of Personal Protective Equipment

Select Appropriate PPE Based on the Hazard

- *Level A PPE:* For the highest level of protection, including fully encapsulating suits and self-contained breathing apparatus (SCBA). Use in environments with unknown or highly hazardous chemical agents.
- *Level B PPE:* Chemical-resistant suits with SCBA, suitable for situations where respiratory protection is required, but the risk of skin exposure is lower.
- *Level C PPE:* Air-purifying respirators and chemical-resistant clothing. Appropriate when contaminants are known, and concentrations are low.
- *Level D PPE:* Standard work uniform with minimal protection. Only used in areas without CBRN risks.

Proper Donning and Doffing Procedures

- *Donning:* Follow a systematic process to ensure all PPE components fit securely and are sealed properly. Perform this in a contamination-free area.
- *Doffing:* Carefully remove PPE to avoid self-contamination. Use a step-by-step approach to peel away contaminated layers and dispose of them in designated hazardous waste containers.

Regular Training and Fit Testing

- Participate in regular PPE training and fit testing for respirators to ensure proper usage and an effective seal. Familiarize yourself with emergency procedures for PPE failure.

Decontamination Procedures

Perform Decontamination Before Medical Treatment

- Prioritize decontamination to prevent secondary contamination of healthcare facilities and personnel. Remove contaminated clothing and rinse exposed skin with water or mild soap.
- Use designated decontamination areas with proper containment and waste disposal systems to prevent environmental contamination.

Differentiate Between Dry and Wet Decontamination

- *Dry Decontamination:* Use dry materials such as cloths or powders to remove contaminants when water is not available or when the use of water is contraindicated.
- *Wet Decontamination:* Use water, with or without mild detergents, to remove soluble chemicals and biological agents from the skin and hair. Ensure water runoff is properly contained.

Decontamination of Equipment and Vehicles

- Decontaminate all medical equipment, transport vehicles, and other items that meet contaminated patients. Use appropriate cleaning agents and follow established protocols.

Situational Awareness and Risk Assessment

Maintain Situational Awareness

- Continuously assess the environment for potential hazards, including changing weather conditions, wind direction, and the spread of contaminants.

- Use real-time data from detection equipment to monitor the presence and concentration of hazardous agents. Adjust safety measures based on these findings.

Effective Communication
- Establish clear communication channels within the response team and with other agencies involved in the incident. Use standardized codes and protocols to convey information efficiently.
- Regularly update all team members on the status of the incident, potential hazards, and any changes in safety protocols.

Follow the Incident Command System
Adhere to the ICS structure for organized response and clear command lines. This ensures coordinated actions and avoids confusion during high stress situations.

Safe Handling of Contaminated Patients and Materials

Triage and Treatment Protocols
- Use CBRN-specific triage protocols to classify patients based on the severity of exposure and symptoms. Isolate and prioritize those with severe symptoms or high-risk contamination.
- Handle contaminated patients with care, using barriers such as impermeable sheets to prevent the spread of contaminants. Provide immediate life-saving interventions as needed while minimizing contact.

Safe Disposal of Contaminated Materials
- Dispose of contaminated PPE, medical waste, and clothing in clearly labeled hazardous waste containers. Follow local regulations for the disposal and transport of hazardous waste.
- Avoid using standard disposal procedures for CBRN-contaminated materials to prevent cross-contamination.

Personal Health and Psychological Resilience

Monitor for Signs of Exposure
- Regularly check yourself and your team for symptoms of exposure, such as respiratory distress, skin irritation, or neurological changes. Use detection equipment to verify contamination levels.
- Report any suspected exposures immediately and seek medical evaluation and treatment as necessary.

Practice Self-Care and Stress Management
- Take regular breaks, hydrate, and maintain adequate nutrition to prevent fatigue. Use stress management techniques such as deep breathing, meditation, or physical exercise to reduce stress.
- Utilize peer support and mental health resources to cope with the psychological demands of responding to a CBRN incident.

Maintain Long-Term Health Monitoring
- Participate in long-term health monitoring programs if you have been exposed to CBRN agents. Regular medical check-ups can help detect any delayed health effects.

Coordination and Collaboration

Engage with Multi-Agency Partners

- Work closely with local, regional, and national agencies involved in the response. Share information and resources to enhance the effectiveness of the incident management.
- Coordinate with public health officials, environmental agencies, and law enforcement to address all aspects of the incident, including public safety, environmental contamination, and security.

Public Communication and Education

- Provide clear information to the public about the nature of the CBRN incident and the steps they can take to protect themselves. Address misinformation and fears proactively.
- Educate the community on basic protective measures and emergency preparedness for future incidents.

11. Contact Information and Resources: Essential Contacts and Additional Resources for Healthcare Providers Involved in CBRN Responses

Effective response to Chemical, Biological, Radiological, and Nuclear (CBRN) incidents depends on quick access to reliable information, expert consultation, and coordination with specialized agencies. Healthcare providers need essential contact information readily available to seek guidance, request assistance, and mobilize critical resources during a CBRN event.

Coordination with agencies like public health authorities, HAZMAT teams, and emergency management organizations is crucial for a comprehensive response. Providers may also consult specialists, such as toxicologists or radiological experts, and rely on real-time data and treatment guidelines to make informed decisions. Effective communication with law enforcement, fire departments, and military units ensures streamlined operations and resource allocation.

This section offers a list of essential contacts and resources to enhance healthcare providers' preparedness and response capabilities during CBRN incidents.

Essential Contacts for CBRN Response

Agency for Toxic Substances and Disease Registry

- *Function:* The Agency for Toxic Substances and Disease Registry (ATSDR), based in Atlanta, Georgia, is a federal public health agency of the U.S. Department of Health and Human Services. ATSDR protects communities from harmful health effects related to exposure to natural and man-made hazardous substances by responding to environmental health emergencies; investigating emerging environmental health threats; conducting research on the health impacts of hazardous waste sites; and building capabilities of and providing actionable guidance to state and local health partners.
- *Contact:* 1+-800-232-4636
- *Use:* (https://www.atsdr.cdc.gov/docs/Across_the_US_ATSDR_FactSheet_508.pdf)

National Poison Control Center

- *Function:* Provides expert guidance on the management of chemical exposures and toxicology.
- *Contact:*
  - U.S. Number: 1-800-222-1222
  - International: Contact your local or national poison control center.
- *Use:* For advice on the identification and treatment of chemical exposures, including antidote recommendations.

Centers for Disease Control and Prevention (CDC)

- *Function:* Offers guidance on the management of biological threats, infectious disease outbreaks, and public health emergencies.
- *Contact:*
  - Emergency Operations Center: +1-770-488-7100 (available 24/7)
  - Website: CDC Emergency Preparedness and Response (https://emergency.cdc.gov/)
- *Use:* For information on disease control, biological agent identification, infection control, and vaccination protocols.

Radiation Emergency Assistance Center/Training Site (REAC/TS)

- *Function:* Provides expertise in radiation emergency medical management, training, and consultation.
- *Contact:*
  - Emergency Line: +1-865-576-1005 (available 24/7)
  - Website: REAC/TS (https://orise.orau.gov/reacts/)
- *Use:* For guidance on radiation exposure management, treatment protocols for Acute Radiation Syndrome, and radiation decontamination procedures.

World Health Organization (WHO)

- *Function:* Offers global guidance on health emergencies, including CBRN incidents, and coordinates international response efforts.
- *Contact:*
  - Health Emergencies Program: +41-22-7912111 (Geneva, Switzerland)
  - Website: (https://www.who.int/our-work/health-emergencies)
- *Use:* For global health guidance, disease surveillance information, and international response coordination.

United Nations Office for the Coordination of Humanitarian Affairs (OCHA)

- *Function:* Coordinates international humanitarian response to large-scale emergencies, including CBRN events.
- *Contact:*
  - Emergency Desk: +41-22-917-1234 (Geneva, Switzerland)
  - Website: (https://www.unocha.org/)
- *Use:* For international coordination, resource mobilization, and assistance in complex emergencies.

International Atomic Energy Agency (IAEA)

- *Function:* Provides support and guidance on radiological and nuclear safety and emergency preparedness.
- *Contact:*
  - Emergency Preparedness and Response Section: +43-1-2600-0 (Vienna, Austria)
  - Website: IAEA Emergency Preparedness (https://www.iaea.org/topics/preparedness)
- *Use:* For guidance on radiological safety, incident classification, and international nuclear incident response.

Key Online Resources for Healthcare Providers

Chemical Hazards Emergency Medical Management (CHEMM)

- *Description:* A comprehensive resource by the U.S. Department of Health and Human Services (HHS) for healthcare providers managing chemical exposures.
- *Website:* (https://chemm.hhs.gov/)
- *Use:* For information on chemical agents, toxicity profiles, and treatment protocols.

Radiation Emergency Medical Management (REMM)

- *Description:* Provides guidance on the medical management of radiological and nuclear incidents.
- *Website:* REMM (https://remm.hhs.gov/)
- *Use:* For information on radiation exposure assessment, medical countermeasures, and radiation emergency protocols.

Global Health Cluster (GHC)

- *Description:* A partnership of health organizations led by the WHO, providing guidance and resources for health emergencies.

- *Website*: Global Health Cluster (https://healthcluster.who.int/)
- *Use:* For guidance on international health responses, coordination tools, and best practices in complex emergencies.

Public Health Agency of Canada (PHAC) – Emergency Preparedness and Response

- *Description:* Provides resources for CBRN preparedness and response, including guidelines for healthcare providers.
- *Website:* PHAC Emergency Preparedness (https://www.canada.ca/en/public-health.html)
- *Use:* For guidelines on CBRN response, infection control, and public health measures in Canada.

Emergency Response Guidebook (ERG)

- *Description:* A guide for first responders during the initial phase of a dangerous goods/hazardous materials incident.
- *Website:* ERG (https://www.phmsa.dot.gov/training/hazmat/erg/emergency-response-guidebook-erg)
- *Use:* For information on the identification and initial response to hazardous materials incidents.

Recommended Training and Educational Resources

WHO Open WHO Platform

- *Description:* Free online courses on emergency health response, including CBRN preparedness and response.
- *Website:* OpenWHO (https://openwho.org/)
- *Use:* For self-paced learning on topics such as chemical safety, radiological response, and infectious disease management.

FEMA Independent Study Program

- *Description:* Offers courses on emergency management, disaster response, and CBRN incident handling.
- *Website:* FEMA Independent Study (https://training.fema.gov/is/searchis.aspx?search=public%20assistance&all=true)
  Use: For comprehensive training in emergency management and response operations.

IAEA eLearning Platform

- *Description:* Provides training resources on radiological safety, emergency preparedness, and response.
- *Website:* IAEA eLearning (https://www.iaea.org/services/education-and-training/online-learning)
- *Use:* For in-depth training on radiation protection, emergency planning, and response to nuclear incidents.

OPCW e-Learning Platform

- *Description:* Offers specialized online courses on chemical safety, the Chemical Weapons Convention, and emergency response to chemical incidents.
- *Website:* OPCW e-Learning (https://learn.opcw.org)
- Use: For training on chemical safety, international regulations, and emergency responses to chemical warfare agents and hazardous chemical incidents.

Conclusion

Effectively responding to CBRN (Chemical, Biological, Radiological, and Nuclear) mass casualty incidents requires a well-coordinated, multi-agency approach that prioritizes safety, preparedness, and rapid response. Healthcare professionals must be equipped with knowledge and resources to navigate the complexities of these environments, which include both immediate threats to life and long-term health risks. Key strategies such as the use of personal protective equipment (PPE), decontamination procedures, situational awareness, and psychological support are essential to protect both responders and victims during these high-risk scenarios.

Through detailed planning, comprehensive training, and continuous adaptation to evolving threats, responders can minimize exposure to hazardous agents, ensure the safe evacuation of victims, and provide timely medical care. This handbook serves as a practical guide to equip healthcare providers with the tools and protocols necessary for managing CBRN incidents, emphasizing the importance of preparedness, coordination, and resilience in the face of unprecedented challenges.

Glossary

Acute Radiation Syndrome (Radiation Sickness): A serious illness caused by high doses of radiation, leading to symptoms like nausea, vomiting, and damage to internal organs.

Biological Threats: Hazards caused by harmful biological agents like bacteria, viruses, or toxins that can cause diseases or outbreaks. Examples include anthrax and smallpox.

Blister Agents: Chemicals that cause severe skin, eye, and respiratory irritation, leading to painful blisters and long-term injuries.

CBRN: Chemical, Biological, Radiological, and Nuclear. Refers to hazardous materials or incidents involving these substances, posing serious health and safety risks.

Chemical Threats: Hazards caused by toxic chemicals such as nerve agents, blister agents, or toxic industrial chemicals that can cause poisoning and other immediate health effects.

Decontamination: The process of removing or neutralizing hazardous substances from people, equipment, and the environment to prevent further contamination.

Decontamination Corridor: A controlled area established during a CBRN incident where decontamination processes are carried out to prevent the spread of hazardous substances.

Evacuation Zones: Designated areas used to manage contamination during CBRN incidents, including zones of high contamination for response activities and safe areas for treatment.

Gross Decontamination: The initial phase of decontamination involving the quick removal of the bulk of contaminants.

HAZMAT: Hazardous materials response teams trained to deal with the containment, control, and decontamination of hazardous substances during incidents.

Inhalation Exposure: The entry of hazardous agents into the body through the respiratory system, which can cause immediate and severe health problems.

Mass Casualty Incident (MCI): An emergency situation where the number of casualties overwhelms the available healthcare resources, requiring specialized management and triage protocols.

Nerve Agents: Toxic chemicals that disrupt the nervous system, causing loss of muscle control, respiratory failure, and death.

Nuclear Threats: Involves the use of nuclear materials, either through weapons or accidents, leading to massive destruction, radiation exposure, and environmental contamination.

PPE (Personal Protective Equipment): Specialized gear worn by responders to protect against hazardous agents, including masks, gloves, suits, and respirators.

Prophylaxis: Preventative treatment administered to individuals exposed to biological or chemical agents to prevent the onset of illness.

Psychological First Aid (PFA): A method of providing immediate emotional and practical support to victims and responders after a traumatic incident to reduce stress and prevent long-term psychological issues.

Psychological Resilience: The ability of healthcare professionals and responders to cope with the psychological stress of working in high-risk environments, such as CBRN incidents.

Radiological Threats: Hazards caused by exposure to radioactive materials that can lead to radiation sickness and long-term health effects like cancer.

Shelter-in-Place: A protective action advising people to remain indoors and take protective measures to avoid exposure to hazardous agents.

Situational Awareness: The ongoing assessment of the environment and conditions during an incident to ensure the safety of responders and patients, and to make informed decisions.

Technical Decontamination: A thorough process following gross decontamination, involving specialized equipment and procedures to ensure complete removal of hazardous materials.

Triage: The process of assessing and prioritizing patients for treatment based on the severity of their condition, particularly in mass casualty incidents.

Bibliography

Chapter 1

1. Mugavero, R. (2024). Safety and emergency guidelines for active bystanders in natural, technological, and intentional incidents. European Centre for Disaster Medicine (CEMEC). AIEP Publisher. ISBN: 9788860862501
2. Alkuhaly, M., & Mugavero, R. (2024). Safety procedures for healthcare professionals in conflict zones: Landmines & ERW awareness. European Centre for Disaster Medicine (CEMEC). AIEP Publisher. ISBN: 9788860862464
3. Mugavero, R. (2024). Global security, civil protection and defence, emerging risk scenarios and public health. Public Health Journals, (11), 7–17. ISBN 9791281648005
4. Bland, S. (2017). 030 Training the all-hazards approach along a continuum of care – counter-chemical, biological, radiological and nuclear (CBRN) medical training. *BMJ Simulation & Technology Enhanced Learning*, 3, A24-A25. https://doi.org/10.1136/bmjstel-2017-aspihconf.52.
5. Calder, A., & Bland, S. (2015). Chemical, biological, radiological and nuclear considerations in a major incident. *Surgery (Oxford, Oxfordshire)*, 33, 442-448. https://doi.org/10.1016/j.mpsur.2015.07.006.
6. Calder, A., & Bland, S. (2018). CBRN considerations in a major incident. *Surgery (Oxford).* https://doi.org/10.1016/J.MPSUR.2018.05.002.
7. Farhat, H., Gangaram, P., Castle, N., Khenissi, M., Bounouh, S., Pullian, N., Khnissi, M., Gargouri, I., Khadhraoui, M., Laughton, J., & Alinier, G. (2021). Hazardous materials and CBRN incidents: Fundamentals of pre-hospital readiness in the State of Qatar. *Journal of Emergency Medicine, Trauma and Acute Care.* https://doi.org/10.5339/jemtac.2021.qhc.35.
8. Herciu, A. (2019). RISKS AND THREATS IN THE CURRENT OPERATIONAL ENVIRONMENT. *Volume 8*.
9. Marques, M., Carapau, R., Rodrigues, A., Lobo, V., Gouveia-Carvalho, J., Antunes, W., Gonçalves, T., Duarte, F., & Veríssimo, B. (2017). GammaEx project: A solution for CBRN remote sensing using unmanned aerial vehicles in maritime environments. *OCEANS 2017 – Anchorage*, 1-6.
10. Marques, M., Teles, D. C., Rodrigues, A. V., Lobo, V., Gouveia-Carvalho, J., Antunes, W., Gonçalves, T., Baptista, A., & Duarte, F. (2018). Chemical and radiological detection using UAV's with ATEX compliance: Proof of concept in port and maritime incident-based scenarios. *OCEANS 2018 MTS/IEEE Charleston*, 1-5. https://doi.org/10.1109/OCEANS.2018.8604601.
11. Plamboeck, A., Sahovic, D., & Bazarschi, J. (2015). Enhancing First Responder CBRN Capabilities. *Volume 15*, 60-65.
12. Smith, M., & Weir, A. (2022). CBRNE3 medicine in the austere environment: the challenges. *BMJ Military Health.* https://doi.org/10.1136/military-2022-002259

Chapter 2

1. Armand, P., Patryl, L., Lamaison, G., Soulhac, L., Deguillaume, L., Chaumerliac, N., & Monfort, M. (2013). H15-33: CERES™ CBRN - A unified modelling and decision support system to assess the dispersal and health impact of hazardous releases in urban or open-field environments. *172-177*.
2. Bright, R. (2007). Office of the Assistant Secretary for Preparedness and Response; HHS Public Health Emergency Medical Countermeasures Enterprise implementation plan for chemical, biological, radiological and nuclear threats. Notice. *Federal Register, 72(77),* 20117-28.
3. Jindal, A., & Roy, K. (2014). Bio-threat preparedness: Need for a paradigm shift. *Medical Journal, Armed Forces India, 70(2),* 170-174. https://doi.org/10.1016/j.mjafi.2013.05.007.
4. Konieczny, M. (2024). Cooperation and interoperability between public security services and medical service in the aspect of CBRN threats in the territory of the Republic of Poland. *Acta Iuris Stetinensis.* https://doi.org/10.18276/ais.2024.47-01.
5. Mani, Z., Plummer, V., Kuhn, L., Khorram-Manesh, A., Tin, D., & Goniewicz, K. (2024). Public Health Responses to CBRN Terrorism in the Middle East and North Africa. *Disaster Medicine and Public Health Preparedness, 18.* https://doi.org/10.1017/dmp.2024.73.
6. Meyerhoff, A. (2009). Challenges to CBRN Medical Countermeasures Development. *1-21.* https://doi.org/10.1002/9780470087923.HHS171.
7. Niemeyer, D. (2004). A composite CBRN surveillance and testing service. *5416.* https://doi.org/10.1117/12.543022.
8. Reddy, D. (2024). Progress and Challenges in Developing Medical Countermeasures for Chemical, Biological, Radiological, and Nuclear Threat Agents. *The Journal of Pharmacology and Experimental Therapeutics, 388,* 260-267. https://doi.org/10.1124/jpet.123.002040.
9. Sandström, B. E., Eriksson, H., Norlander, L., Thorstensson, M., & Cassel, G. (2014). Training of public health personnel in handling CBRN emergencies: a table-top exercise card concept. *Environment International, 72,* 164-169. https://doi.org/10.1016/j.envint.2014.03.009.
10. Singh, V., Romaine, P., Newman, V., & Seed, T. (2016). Medical countermeasures for unwanted CBRN exposures: part II radiological and nuclear threats with review of recent countermeasure patents. *Expert Opinion on Therapeutic Patents, 26,* 1399-1408. https://doi.org/10.1080/13543776.2016.1231805.

Chapter 3

1. Brinker, A., Gray, S., & Schumacher, J. (2007). Influence of air-purifying respirators on the simulated first response emergency treatment of CBRN victims. *Resuscitation, 74(2),* 310-316. https://doi.org/10.1016/J.RESUSCITATION.2007.01.017.
2. Castle, N. (2010). Care after chemical, biological, radiation or nuclear events. *Emergency Nurse: The Journal of the RCN Accident and Emergency Nursing Association, 18(7),* 26-36. https://doi.org/10.7748/EN2010.11.18.7.26.C8086.
3. Castle, N., Bowen, J., & Spencer, N. (2010). Does wearing CBRN-PPE adversely affect the ability for clinicians to accurately, safely, and speedily draw up drugs? *Clinical Toxicology, 48,* 522-527. https://doi.org/10.3109/15563650.2010.491483.
4. Castle, N., Owen, R., Hann, M., Clark, S., Reeves, D., & Gurney, I. (2009). Impact of chemical, biological, radiation, and nuclear personal protective equipment on the performance of low-

and high-dexterity airway and vascular access skills. *Resuscitation, 80(11),* 1290-1295. https://doi.org/10.1016/j.resuscitation.2009.08.001.

5. Gikiewicz, M., & Bralewska, K. (2021). Personal protective equipment for rescuers involved in CBRN incidents. Case study for selected hazard scenarios. *Zeszyty Naukowe SGSP.* https://doi.org/10.5604/01.3001.0015.6470.
6. Wiyor, H., Coburn, J., & Siegel, K. (2019). Impact of clinician personal protective equipment on medical device use during public health emergency: A review. *Disaster Medicine and Public Health Preparedness, 14,* 273-283. https://doi.org/10.1017/dmp.2019.52.

Chapter 4

1. Bland, S. (2009). Chemical, Biological and Radiation Casualties: Critical Care Considerations. *Journal of the Royal Army Medical Corps, 155,* 160-171. https://doi.org/10.1136/jramc-155-02-17.
2. Bland, S. (2017). 030 Training the all-hazards approach along a continuum of care – counter-chemical, biological, radiological and nuclear (CBRN) medical training. *BMJ Simulation & Technology Enhanced Learning, 3,* A24-A25. https://doi.org/10.1136/bmjstel-2017-aspihconf.52.
3. Brinker, A., Gray, S., & Schumacher, J. (2007). Influence of air-purifying respirators on the simulated first response emergency treatment of CBRN victims. *Resuscitation, 74(2),* 310-316. https://doi.org/10.1016/J.RESUSCITATION.2007.01.017.
4. Calder, A., & Bland, S. (2018). CBRN considerations in a major incident. *Surgery (Oxford).* https://doi.org/10.1016/J.MPSUR.2018.05.002.
5. Castle, N. (2010). Care after chemical, biological, radiation or nuclear events. *Emergency Nurse: The Journal of the RCN Accident and Emergency Nursing Association, 18(7),* 26-36. https://doi.org/10.7748/EN2010.11.18.7.26.C8086.
6. Castle, N., Bowen, J., & Spencer, N. (2010). Does wearing CBRN-PPE adversely affect the ability for clinicians to accurately, safely, and speedily draw up drugs? *Clinical Toxicology, 48,* 522-527. https://doi.org/10.3109/15563650.2010.491483.
7. Gouweloos, J., Dückers, M., te Brake, H., Kleber, R., & Drogendijk, A. (2014). Psychosocial care to affected citizens and communities in case of CBRN incidents: A systematic review. *Environment International, 72,* 46-65. https://doi.org/10.1016/j.envint.2014.02.009.
8. Mcisaac, J. (2023). Combined Trauma and CBRN Exposure. *Prehospital and Disaster Medicine, 38,* s129. https://doi.org/10.1017/S1049023X23003400.
9. Singh, V., Romaine, P., Newman, V., & Seed, T. (2016). Medical countermeasures for unwanted CBRN exposures: Part II radiological and nuclear threats with review of recent countermeasure patents. *Expert Opinion on Therapeutic Patents, 26,* 1399-1408. https://doi.org/10.1080/13543776.2016.1231805.
10. Sprague, R., Ladd, M., & Ashurst, J. (2020). EMS Resuscitation During Contamination While Wearing PPE.

Chapter 5

1. Angeley, D., & Lockhart, M. (2006). CBRN planning and response: collecting, analyzing, and using actionable knowledge. *6249.* https://doi.org/10.1117/12.666315.

2. Bader, J., Nemhauser, J., Chang, F., Mashayekhi, B., Sczcur, M., Knebel, A., Hrdina, C., & Coleman, N. (2008). Radiation Event Medical Management (REMM): Website Guidance for Health Care Providers. *Prehospital Emergency Care, 12,* 1-11. https://doi.org/10.1080/10903120701710595.
3. Bland, S. (2009). Chemical, Biological and Radiation Casualties: Critical Care Considerations. *Journal of the Royal Army Medical Corps, 155,* 160-171. https://doi.org/10.1136/jramc-155-02-17.
4. Berben, S. A. A., Vloet, L. C. M., Lischer, F., Pieters, M., & de Cock, J. (2021). Medical Coordination Rescue Members' and Ambulance Nurses' Perspectives on a New Model for Mass Casualty and Disaster Management and a Novel Terror Attack Mitigation Approach in the Netherlands: A Qualitative Study. *Prehospital and Disaster Medicine, 36(5),* 519-525. https://doi.org/10.1017/S1049023X21000790.
5. Gautam, S., Sharma, N., Sharma, R., & Basu, M. (2017). Human Patient Simulator based CBRN Casualty Management Training. *Life Science Journal, 2,* 80-84. https://doi.org/10.14429/DLSJ.2.11073.
6. Kaszeta, D. (2012). CBRN and HAZMAT Incidents at Major Public Events. *DOI:* https://doi.org/10.1002/9781118529713.
7. Long, F., Bateman, G., & Majumdar, A. (2020). The impact of fire and rescue service first responders on participant behaviour during chemical, biological, radiological and nuclear (CBRN)/Hazmat incidents. *International Journal of Embedded Systems, 9,* 283-298. https://doi.org/10.1108/ijes-06-2019-0027.
8. Marsella, S., & Sciarretta, N. (2018). CBRN Events and Mass Evacuation Planning. *Pages 353-363.* https://doi.org/10.1007/978-3-319-91791-7_41.
9. Markel, G., Krivoy, A., Rotman, E., Schein, O., Shrot, S., Brosh-Nissimov, T., Dushnitsky, T., & Eisenkraft, A. (2008). Medical management of toxicological mass casualty events. *The Israel Medical Association Journal, 10(11),* 761-766.
10. Pelaccia, T. (2008). Preparing health care students for mass casualty events. *Medical Education, 42.* https://doi.org/10.1111/j.1365-2923.2008.03200.x.
11. Plamboeck, A., Sahovic, D., & Bazarschi, J. (2015). Enhancing First Responder CBRN Capabilities. *15,* 60-65.
12. Ramesh, A., & Kumar, S. (2010). Triage, monitoring, and treatment of mass casualty events involving chemical, biological, radiological, or nuclear agents. *Journal of Pharmacy and Bioallied Sciences, 2,* 239-247. https://doi.org/10.4103/0975-7406.68506.
13. Tariverdi, M., Miller-Hooks, E., & Kirsch, T. (2018). Strategies for Improved Hospital Response to Mass Casualty Incidents. *Disaster Medicine and Public Health Preparedness, 12,* 778-790. https://doi.org/10.1017/dmp.2018.4.
14. Timbie, J. (2013). Systematic review of strategies to manage and allocate scarce resources during mass casualty events. *Annals of Emergency Medicine, 61(6),* 677-689.e101. https://doi.org/10.1016/j.annemergmed.2013.02.005.

Chapter 6

1. Chilcott, R. P., Larner, J., & Matar, H. (2019). UK's initial operational response and specialist operational response to CBRN and HazMat incidents: A primer on decontamination protocols for healthcare professionals. *Emergency Medicine Journal, 36*(2), 117-123. https://doi.org/10.1136/emermed-2018-207562.

2. Cox, B. (2016). Hospital Decontamination: What Nurses Need to Know. *The Nursing Clinics of North America, 51*(4), 663-674. https://doi.org/10.1016/j.cnur.2016.07.010.
3. Dragolici, C., & Dragolici, F. (2014). Introduction in Means and Methods Used in Chemical, Biological, Radiological, and Nuclear Decontamination. *Romanian Journal of Physics, 59*, 920-929.
4. Hancox, G., Hignett, S., Kintzios, S., Pillin, H., Plass, M., & Silmari, J. (2016). Mapping Emergency Responders' Current Procedures in the Event of a CBRNe Incident. Loughborough University. Conference contribution. https://hdl.handle.net/2134/23490.
5. Hick, J., Penn, P., Hanfling, D., Lappé, M., O'Laughlin, D., & Burstein, J. (2003). Establishing and Training Health Care Facility Decontamination Teams. *Annals of Emergency Medicine, 42*(3), 381-390. https://doi.org/10.1016/S0196-0644(03)00442-6.
6. Kippnich, M., Schorscher, N., Sattler, H., Kippnich, U., Meybohm, P., & Wurmb, T. (2021). Managing CBRN Mass Casualty Incidents at Hospitals-Find a Simple Solution for a Complex Problem: A Pilot Study. *Journal of Emergency Management, 20*(1), 23-29. https://doi.org/10.21203/RS.3.RS-263244/V1.
7. Kumar, V., Goel, R., Chawla, R., Silambarasan, M., & Sharma, R. (2010). Chemical, Biological, Radiological, and Nuclear Decontamination: Recent Trends and Future Perspective. *Journal of Pharmacy and Bioallied Sciences, 2*, 220-238. https://doi.org/10.4103/0975-7406.68505.
8. Lillie, S., Kelly, J., Mattis, J., & Rayburn, B. (2006). CBRN Decontamination: Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination. https://doi.org/10.21236/ada523781.
9. Monteith, R., & Pearce, L. (2015). Self-care Decontamination within a Chemical Exposure Mass-Casualty Incident. *Prehospital and Disaster Medicine, 30*, 288-296. https://doi.org/10.1017/S1049023X15004677.
10. Örün, S., Türkeri, B., Doğtaş, Z., & Aköz, A. (2022). CBRN Incident Awareness of Healthcare Professionals Working in Public and University Hospitals. *Eurasian Journal of Toxicology, 4*(1), 3-10. https://doi.org/10.51262/ejtox.1073410.
11. Razak, S., Hignett, S., & Barnes, J. (2018). Emergency Department Response to Chemical, Biological, Radiological, Nuclear, and Explosive Events: A Systematic Review. *Prehospital and Disaster Medicine, 33*, 543-549. https://doi.org/10.1017/S1049023X18000900.
12. Romney, D. (2020). Chemical, Biological, Radiological, or Nuclear Event (CBRNE): Prehospital and Hospital Management. *569-582*. https://doi.org/10.1007/978-3-030-40655-4_42.
13. Rybka, A., Gavel, A., Pražák, P., Meloun, J., & Pejchal, J. (2019). Decontamination of CBRN Units Contaminated by Highly Contagious Biological Agents. *Epidemiologie, Mikrobiologie, Imunologie, 68*(1), 40-45.
14. Scarfone, R., Sullivan, F., & Henretig, F. (2006). Decontamination and the Use of Personal Protective Equipment. *Pediatric Emergency Care, 22*, 453-455. https://doi.org/10.1097/01.pec.0000222797.62861.50.
15. Vasović, D., Mušicki, S., & Hristov, S. (2019). CBRN Decontamination Considered by the Concept of CBRN Security: A Serbian Case. https://doi.org/10.21175/RadProc.2018.14.
16. Zuidberg, M., Woerkom, T., Bruin, K., Stoel, R., & Puit, M. (2014). Effects of CBRN Decontaminants in Common Use by First Responders on the Recovery of Latent Fingerprints: Assessment of the Loss of Ridge Detail on Glass. *Journal of Forensic Sciences, 59*. https://doi.org/10.1111/1556-4029.12281.

Chapter 7

1. Anbari, E., Yarmohammadian, M., & Isfahani, M. (2015). From investigation of hospital protocols and guidelines to designing a generic protocol for responding to chemical, biological, radiological, and nuclear incidents. *International Journal of Health System and Disaster Management, 3,* 195. https://doi.org/10.4103/2347-9019.162553
2. Bazyar, J., Farrokhi, M., Salari, A., & Khankeh, H. (2020). The Principles of Triage in Emergencies and Disasters: A Systematic Review. *Prehospital and Disaster Medicine, 35,* 305 - 313. https://doi.org/10.1017/S1049023X20000291
3. Bertrand, C., Lecarpentier, É., Hérodin, F., & Dorandeu, F. (2019). Triage Issues in a CBRNE Crisis: Experiences from European Projects. *The International Library of Ethics, Law and Technology.* https://doi.org/10.1007/978-3-030-11977-5_14
4. Calder, A., & Bland, S. (2018). CBRN considerations in a major incident. *Surgery (Oxford).* https://doi.org/10.1016/J.MPSUR.2018.05.002
5. Kako, M., Hammad, K., Mitani, S., & Arbon, P. (2018). Existing Approaches to Chemical, Biological, Radiological, and Nuclear (CBRN) Education and Training for Health Professionals: Findings from an Integrative Literature Review. *Prehospital and Disaster Medicine, 33,* 182 - 190. https://doi.org/10.1017/S1049023X18000043
6. Lansdowne, K., Scully, C., Galeotti, L., Schwartz, S., Marcozzi, D., & Strauss, D. (2015). Recent Advances in Medical Device Triage Technologies for Chemical, Biological, Radiological, and Nuclear Events. *Prehospital and Disaster Medicine, 30,* 320 - 323. https://doi.org/10.1017/S1049023X15004641
7. Malich, G., Coupland, R., Donnelly, S., & Baker, D. (2012). A proposal for field-level medical assistance in an international humanitarian response to chemical, biological, radiological or nuclear events. *Emergency Medicine Journal, 30,* 804 - 808. https://doi.org/10.1136/emermed-2012-201915
8. Ramesh, A., & Kumar, S. (2010). Triage, monitoring, and treatment of mass casualty events involving chemical, biological, radiological, or nuclear agents. *Journal of Pharmacy and Bioallied Sciences, 2,* 239 - 247. https://doi.org/10.4103/0975-7406.68506
9. Romney, D. (2020). Chemical, Biological, Radiological, or Nuclear Event (CBRNE): Prehospital and Hospital Management. *569-582.* https://doi.org/10.1007/978-3-030-40655-4_42
10. Singh, V., Romaine, P., Newman, V., & Seed, T. (2016). Medical countermeasures for unwanted CBRN exposures: part II radiological and nuclear threats with review of recent countermeasure patents. *Expert Opinion on Therapeutic Patents, 26,* 1399 - 1408. https://doi.org/10.1080/13543776.2016.1231805

Chapter 8

1. Anbari, E., Yarmohammadian, M., & Isfahani, M. (2015). From investigation of hospital protocols and guidelines to designing a generic protocol for responding to chemical, biological, radiological, and nuclear incidents. *International Journal of Health System and Disaster Management, 3*, 195. https://doi.org/10.4103/2347-9019.162553.
2. Be'eri E., Owen S., Beeri M., Millis S. R., & Eisenkraft A. (2018). A Chemical-Biological-Radio-Nuclear (CBRN) Filter can be Added to the Air-Outflow Port of a Ventilator to Protect a Home

Ventilated Patient From Inhalation of Toxic Industrial Compounds. *Disaster Medicine and Public Health Preparedness, 12*(6), 739–743. https://doi.org/10.1017/dmp.2018.3.
3. Blakeman, T. C., Toth, P., Rodriquez, D., & Branson, R. D. (2010). Mechanical ventilators in the hot zone: effects of a CBRN filter on patient protection and battery life. *Resuscitation, 81*(9), 1148–1151. https://doi.org/10.1016/j.resuscitation.2010.05.006.
4. Boling, B., Hardin-Pierce, M., Jensen, L., & Hassan, Z. U. (2016). Evaluation of a High-Fidelity Simulation Training Program for New Cardiothoracic Intensive Care Unit Nurses. *Seminars in Thoracic and Cardiovascular Surgery, 28*(4), 770–775. https://doi.org/10.1053/j.semtcvs.2016.11.001.
5. Burgess, J., Kirk, M., Borron, S., & Cisek, J. (1999). Emergency department hazardous materials protocol for contaminated patients. *Annals of Emergency Medicine, 34*(2), 205–212. https://doi.org/10.1016/S0196-0644(99)70230-1.
6. Cheney, P., Haddock, T., Sanchez, L., Ernst, A., & Weiss, S. (2008). Safety and compliance with an emergency medical service direct psychiatric center transport protocol. *The American Journal of Emergency Medicine, 26*(7), 750–756. https://doi.org/10.1016/j.ajem.2007.10.019.
7. Glober, N., Hamilton, J., Montelauro, N., Ulintz, A., Arkins, T., Supples, M., Liao, M., O'Donnell, D., & Faris, G. (2022). Safety of an Alternative Care Protocol for EMS Non-Transport in the COVID-19 Pandemic. *Prehospital Emergency Care, 27*, 315–320. https://doi.org/10.1080/10903127.2022.2086652.
8. Haberland, D., Silva, T., Da Silva Kneodler, T., De Almeida Guilherme, F., Borges, L., & De Oliveira, A. (2023). COMPETENCIES FOR AEROMEDICAL EVACUATION PRACTICES IN EMERGENCIES AND DISASTERS: A SCOPING REVIEW. *Texto & Contexto - Enfermagem*. https://doi.org/10.1590/1980-265X-TCE-2022-0315en.
9. Isbilir, F., Kaynak, M., & Kesemen, M. (2018). Insulated Patient Transport Capsule for Chemical, Biological, Radiological and Nuclear (CBRN) Contamination Cases. *European Mechanical Science*. https://doi.org/10.26701/ems.464243.
10. Rc, R. (1983). Transport of irradiated or radioactively contaminated patients to the hospital. *Bulletin of the New York Academy of Medicine, 59*(10), 1108–1118.
11. Schmidt, T., Atcheson, R., Federiuk, C., Mann, N., Pinney, T., Fuller, D., & Colbry, K. (2000). Evaluation of protocols allowing emergency medical technicians to determine need for treatment and transport. *Academic Emergency Medicine, 7*(6), 663–669. https://doi.org/10.1111/J.1553-2712.2000.TB02041.X.
12. Schumacher, J., Gray, S., Weidelt, L., Brinker, A., Prior, K., & Stratling, W. (2009). Comparison of powered and conventional air-purifying respirators during simulated resuscitation of casualties contaminated with hazardous substances. *Emergency Medicine Journal, 26*, 501–505. https://doi.org/10.1136/emj.2008.061531.
13. Shin, D. (2015). Prevention and Decontamination of Chemical, Biological, Radiological, and Nuclear Contaminants for the Emergency Medical Personnel during Ambulance Services. *Hanyang Medical Reviews, 35*, 146–151. https://doi.org/10.7599/HMR.2015.35.3.146.
14. Sprague, R., Ladd, M., & Ashurst, J. (2020). EMS Resuscitation During Contamination While Wearing PPE. *Prehospital Emergency Care, 27*.

Chapter 9

1. Brandt, G., Fullerton, C., Saltzgaber, L., Ursano, R., & Holloway, H. (1995). Disasters: Psychologic responses in health care providers and rescue workers. *Nordic Journal of Psychiatry, 49,* 89-94. https://doi.org/10.3109/08039489509011889.
2. Dieltjens, T., Moonens, I., Van Praet, K., De Buck, E., & Vandekerckhove, P. (2014). A Systematic Literature Search on Psychological First Aid: Lack of Evidence to Develop Guidelines. *PLoS ONE, 9.* https://doi.org/10.1371/journal.pone.0114714.
3. Everly, G., & Flynn, B. (2006). Principles and practical procedures for acute psychological first aid training for personnel without mental health experience. *International Journal of Emergency Mental Health, 8(2),* 93-100.
4. Everly, J., McCabe, P., Semon, M., Thompson, M., Links, P., & Bloomberg, J. (2014). The development of a model of psychological first aid for non-mental health trained public health personnel: the Johns Hopkins RAPID-PFA. *Journal of Public Health Management and Practice, 20(Suppl 5),* S24-29. https://doi.org/10.1097/PHH.0000000000000065.
5. Farchi, M. (2011). (A12) From a Helpless Victim to a Coping Survivor: Innovative Mental Health Intervention Methods during Emergencies and Disasters. *Prehospital and Disaster Medicine, 26,* s3-s3. https://doi.org/10.1017/S1049023X11000252.
6. Fox, J., Burkle, F., Bass, J., Pia, F., Epstein, J., & Markenson, D. (2012). The Effectiveness of Psychological First Aid as a Disaster Intervention Tool: Research Analysis of Peer-Reviewed Literature From 1990-2010. *Disaster Medicine and Public Health Preparedness, 6,* 247-252. https://doi.org/10.1001/dmp.2012.39.
7. Gautam, S., Sharma, N., Sharma, R., & Basu, M. (2017). Human Patient Simulator based CBRN Casualty Management Training. *Life Science Journal, 2,* 80-84. https://doi.org/10.14429/DLSJ.2.11073.
8. Kaplunenko, Y. (2021). Psychological First Aid: Experience of International Organizations. *Psychology and Psychosocial Interventions.* https://doi.org/10.18523/2617-2348.2020.3.36-41.
9. Magaldi, M., Perdomo, J., López-Baamonde, M., Chanzá, M., Sánchez, D., & Gomar, C. (2021). Second victim phenomenon in a surgical area: online survey. *Revista Espanola de Anestesiologia y Reanimacion.* https://doi.org/10.1016/j.redar.2020.11.009.
10. Shultz, J., & Forbes, D. (2013). Psychological First Aid. *Disaster Health, 2,* 3-12. https://doi.org/10.4161/dish.26006.
11. Sim, T., & Wang, A. (2021). Contextualization of Psychological First Aid: An Integrative Literature Review. *Journal of Nursing Scholarship.* https://doi.org/10.1111/jnu.12613.
12. Yin, M., Li, X., Li, J., Huang, X., Tao, Q., & Luo, X. (2015). Hospital-based psychological first aid provided to patients injured in the Lushan earthquake. *Hu Li Za Zhi, 62(2),* 89-95. https://doi.org/10.6224/JN.62.2.89.

Chapter 10

1. Long, F., Bateman, G., & Majumdar, A. (2020). The impact of fire and rescue service first responders on participant behaviour during chemical, biological, radiological, and nuclear (CBRN)/Hazmat incidents. *International Journal of Embedded Systems*, 9, 283-298. https://doi.org/10.1108/ijes-06-2019-0027

2. Kako, M., Hammad, K., Mitani, S., & Arbon, P. (2018). Existing approaches to CBRN education and training for health professionals: Findings from an integrative literature review. *Prehospital and Disaster Medicine*, 33, 182-190. https://doi.org/10.1017/S1049023X18000043
3. Razak, S., Hignett, S., & Barnes, J. (2018). Emergency department response to chemical, biological, radiological, nuclear, and explosive events: A systematic review. *Prehospital and Disaster Medicine*, 33, 543-549. https://doi.org/10.1017/S1049023X18000900
4. Ziegler, A. (2009). Medical care within the hot zone: An innovative concept in Vienna during the EURO08. *Prehospital and Disaster Medicine*, 24, s157. https://doi.org/10.1017/S1049023X00057113
5. Nazari, S., Sharififar, S., Ahmadi Marzaleh, M., et al. (2023). Structural elements and requirements in forming prehospital health response teams for CBRN incidents: A comparative review study. *Disaster Medicine and Public Health Preparedness*, 17. https://doi.org/10.1017/dmp.2022.259
6. Anbari, E., Yarmohammadian, M., & Isfahani, M. (2015). From investigation of hospital protocols and guidelines to designing a generic protocol for responding to chemical, biological, radiological, and nuclear incidents. *International Journal of Health System and Disaster Management*, 3, 195. https://doi.org/10.4103/2347-9019.162553
7. Gouweloos, J., Dückers, M., te Brake, H., et al. (2014). Psychosocial care to affected citizens and communities in case of CBRN incidents: A systematic review. *Environment International*, 72, 46-65. https://doi.org/10.1016/j.envint.2014.02.009
8. Wiyor, H. D., Coburn, J., & Siegel, K. (2019). Impact of clinician personal protective equipment on medical device use during public health emergency: A review. *Disaster Medicine and Public Health Preparedness*, 14, 273-283. https://doi.org/10.1017/dmp.2019.52
9. Hick, J., Hanfling, D., Burstein, J., et al. (2003). Protective equipment for health care facility decontamination personnel: Regulations, risks, and recommendations. *Annals of Emergency Medicine*, 42, 370-380. https://doi.org/10.1016/S0196-0644(03)00447-5
10. Mcisaac, J. (2023). Combined trauma and CBRN exposure. *Prehospital and Disaster Medicine*, 38, s129. https://doi.org/10.1017/S1049023X23003400
11. Gikiewicz, M., & Bralewska, K. (2021). Personal protective equipment for rescuers involved in CBRN incidents. *Zeszyty Naukowe SGSP.* https://doi.org/10.5604/01.3001.0015.6470
12. Noel, C. K., Bruce, E. D., & Ryan, B. J. (2024). Suit up: A systematic review of PPE recommended and utilized by responders to nuclear radiological disasters at nuclear power plants. *Prehospital and Disaster Medicine*, 39, 85-93. https://doi.org/10.1017/S1049023X23006672

Authors

Prof. Roberto Mugavero is the President of the European Centre for Disaster Medicine – CEMEC – a specialized centre of the Council of Europe's EUR-OPA Agreement. With a degree in Environmental Engineering, he is also the Director and a Professor at the CUFS - Centre for Security Studies at the University of San Marino Republic. He holds prominent roles at multiple institutions, including the University of Rome "Tor Vergata," the University of Rome "Sapienza," and the University of Padua in Italy; the NATO School in Oberammergau, Germany; and the NATO JCBRN CoE in Vyskov, Czech Republic. Prof. Mugavero oversees numerous master's and advanced programs, specializing in international security studies, environmental and CBRNe risk management. As a renowned expert in security and defence, he chairs the Italian research institute "Observatory on Security and CBRNe Defence – OSDIFE." Additionally, he significantly impacts global discourse through his lectures, publications, and leadership at various conferences. Beyond academia, Prof. Mugavero brings 40 years of experience as an Officer in the Italian National Fire and Rescue Service at the Ministry of Interior, where he continues to serve as a dedicated volunteer. He also actively engages in EU and international security and defence research programs. His commitment is further demonstrated through direct participation in emergency activities and exercises.

Dr. Heejun Shin is an Associate Professor of Emergency Medicine at Soonchunhyang University Bucheon Hospital. He is the Director of the SCH Disaster Medicine Center and brings extensive expertise in emergency medicine, disaster medicine, CBRNe research and education, counter-terrorism medicine, toxicology, and chemical injury. Heejun's experience includes significant roles at prestigious institutions in both South Korea and the USA. He currently serves as Adjunct Faculty in CBRNE Education at Beth Israel Deaconess Medical Center (BIDMC) in Boston and has completed a Disaster Medicine Fellowship there. He is also the founder and leader of the CBRNE Special Interest Group and a member of the Counter-Terrorism Medicine Special Interest Group. Dr. Shin is a member of the Board of Directors of the World Association for Disaster and Emergency Medicine (WADEM), where he contributes to global efforts in advancing disaster and emergency medicine. As a research fellow at Harvard Medical School, Heejun has been involved in disaster medicine education, focusing on humanitarian programs and CBRNe training. His achievements include founding and directing the BIDMC CBRNE Simulation Training Workshop for Boston EMS and paramedic students. He has also played a key role in Korean disaster response, serving as an instructor for Korean Disaster Life Support (KDLS) and as chairman of the Korean Research Society of Chemical Injury. Through his leadership at the Shin's Disaster Medicine Academy, he continues to innovate in disaster medicine education and preparedness.

Disclaimer

The information contained in this handbook is intended for general guidance and educational purposes only. While the European Centre for Disaster Medicine (CEMEC) has made every effort to ensure the accuracy and reliability of the content, this handbook is not a substitute for professional training or advice. The procedures, recommendations, and guidelines presented herein are based on current knowledge and practices as of the date of publication. However, the nature of emergencies and disasters is inherently unpredictable, and the effectiveness of the information provided may vary depending on specific circumstances.

CEMEC and the authors of this guide do not assume any liability for actions taken or not taken based on the content of this guide. Readers are encouraged to seek appropriate training, consult with professionals, and follow the instructions of local emergency services and authorities during actual incidents. Always prioritize your safety and the safety of others when responding to emergency situations.

The use of this manual is at your own risk, and CEMEC disclaims all warranties, expressed or implied, including but not limited to any implied warranties of fitness for a particular purpose.

Contacts
CEMEC - European Centre for Disaster Medicine
c/o Ospedale di San Marino Via Scialoja 1 – 47893, Cailungo – Republic of San Marino
Phone: (+) 378 0549/994535 or 0549/994600 – Fax: (+) 378 0549/903706
E-mail: cemec@iss.sm Web Site: www.cemec-sanmarino.eu

ISBN: 978-88-6086-271-4
DOI: https://doi.org/10.23810/CEMEC-4

Published by Aiep Editore, Repubblica di San Marino, September 2025