# AMERICAN ACADEMY OF PEDIATRICS

# PEDIATRIC DISASTER PREPAREDNESS AND RESPONSE

# TOPICAL COLLECTION

## 2022


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# American Academy of Pediatrics
# Pediatric Disaster Preparedness and Response: Topical Collection

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# INTRODUCTION

Disaster planning should address the needs of all populations for all potential hazards, yet as a health care system and a nation, we remain suboptimally prepared for disasters. This assessment particularly holds true regarding readiness for the needs of children. All components within the chain of care for those affected by disasters can benefit from additional knowledge and guidance to improve pediatric preparedness. These entities include health care providers, clinics (private practice, hospital-run, state, and federal), emergency medical services and interhospital transport, hospitals, urgent care centers, schools and child care settings, shelters, local communities, states, and regions. Children are often an afterthought in disaster planning; children may not even be mentioned in some disaster plans or exercises, or they may be considered only in a separate plan annex. Even when mentioned, plan elements addressing the care of children may not have been reviewed by pediatric subject matter experts.

To close the remaining gaps and to ensure the health of children during public health emergencies or disasters, the American Academy of Pediatrics (AAP), with its Disaster Preparedness Advisory Council, offers policy recommendations in several critical policy documents:

- *Ensuring the Health of Children in Disasters*
- *Providing Psychosocial Support to Children and Families in the Aftermath of Disasters and Crises*
- *Medical Countermeasures for Children in Public Health Emergencies, Disasters, or Terrorism*
- *Chemical-Biological Terrorism and its Impact on Children*

Although designed for use by pediatricians and other health care providers who would likely care for children in a disaster, this topical collection could also be useful for first responders; shelter, school, and child care personnel; volunteers; emergency planners; and policy makers who aspire to be prepared to meet the unique needs of children in times of crisis/disaster and to train the next generations of professionals.

To be fully prepared for disasters, the best strategy is an all-hazards approach. A comprehensive preparedness plan should cover all potential sources and types of disasters, both natural and man-made causes, including pandemics. A preparedness plan for one event shares many of the same elements that can be used for other events. Some crises, such as large building fires and mass casualty shootings, are not specifically highlighted in this resource. Injuries from fires and gunfire are unfortunately common in the emergency medical setting; they become a crisis when the number of those injured exceeds the local capacity to provide care (and that threshold varies greatly from one community to another). The concepts and practical advice to address surge needs in other crises are equally relevant for the context of large scale building fires and mass casualty shootings. So even though there are not chapter headings specifically for all possible crises, the totality of this resource, which adopts an all-hazards approach, should include guidance relevant to all potential crisis events.

A well-conceived all-hazards plan should include consideration of steps to take in the various phases of the disaster response cycle: mitigation, preparedness, response, and recovery (short- and long-term). The Federal Emergency Management Agency (FEMA) describes these terms in its glossary (https://emilms.fema.gov/IS700aNEW/glossary.htm#R). Disaster planning in many settings has typically focused on response, yet preparing for recovery is equally important, as this helps the health care system or community to effectively return to a state of normal. The behavioral and mental health impact of a disaster can represent the event's greatest and longest-lasting manifestation, and recovery may be limited if this is not well planned for. The ultimate goal of a well-developed and practiced plan is a health care system that supports community resiliency. The Office of the Assistant Secretary for Preparedness and Response (ASPR) extends these concepts by describing *community health resilience*, which refers to the ability of a community to use its assets to strengthen public health and health care systems and to improve the community's physical, behavioral, and social health to withstand, adapt to, and recover from adversity. Community health resilience is a subset of community resilience, but it encompasses a broad area given the interrelated nature of health with other domains of resilience (www.phe.gov/Preparedness/planning/abc/Pages/community-resilience.aspx).

Every location where children visit should have a disaster plan that includes consideration of their specific needs. Such settings include but are not limited to: hospitals, clinics, schools, child care facilities, camps, faith-based institutions, shelters, and community locations (eg, libraries, shopping malls, theaters, amusement parks, sports facilities, concert venues). Anywhere that children congregate is a potential site for them to become the intended or incidental victims of violence, a terrorist attack, a natural disaster, or a pandemic. According to the results of the National Pediatric Readiness Survey, less than half of US hospital emergency departments have disaster plans that include specific considerations for children (www.ncbi.nlm.nih.gov/pubmed/25867088). All hospitals should be prepared to provide day-to-day pediatric emergency care and, likewise, should be prepared to care for children of all ages during a catastrophe.

This topical collection is an update of select material and information included in *Pediatric Terrorism and Disaster Preparedness and Response: A Resource for Pediatricians* (https://archive.ahrq.gov/research/pedprep/). The updated material contains new and pertinent information. There has been significant progress made in the field of disaster readiness including advances and new information regarding the care of children. Although the aim is to include all significant information, the goal has been to make the material readily accessible and practical. References and links are offered for those seeking further details and background. This version is more succinct to improve and increase accessibility, and the material provides links to where the interested reader can find more information.

The first edition of the *Pediatric Terrorism and Disaster Preparedness and Response: A Resource for Pediatricians* manual was developed with funding from the Agency for Healthcare Research and Quality, and this topical collection is funded by generous donations to the AAP Friends of Children fund. Two of the first edition's editors, George Foltin, MD, FAAP, and David Schonfeld, MD, FAAP, have returned as coeditors of this material. The untimely passing of Michael Shannon, MD, MPH, FAAP, in 2009 was a terrible loss to the fields of pediatric emergency medicine, toxicology, and disaster medicine. We will be forever grateful for the

enormous contributions he made as a subject matter expert, clinician, educator, researcher, mentor, leader and child advocate. Appropriately, one of Dr. Shannon's mentees, Sarita Chung, MD, FAAP, serves as the third coeditor for this edition. Steven E. Krug, MD, FAAP, as the current chairperson of the AAP Disaster Preparedness Advisory Council, has joined this editorial team.

This resource endeavors to inform and guide pediatricians as well as planners, responders, care providers, and volunteers to be better prepared to deal with children affected by disasters. Additional information can be found on the comprehensive Children and Disasters Web site managed by the AAP (www.aap.org/disasters).

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# TRIBUTE TO MICHAEL SHANNON, MD, MPH, FAAP

By Sarita Chung, MD, FAAP

A Reflection on Dr Michael Shannon (1953–2009)

As we approach the 10th anniversary of Michael Shannon's passing it remains difficult for me to recall this painful event. In 2009, I was a junior attending with a young family pursuing an interest in this new area loosely referred to as "disaster medicine." I remember feeling lucky and honored to be practicing emergency medicine at Boston Children's Hospital—but even more privileged to have Dr Michael Shannon as my mentor. We had just received an EMSC grant to analyze and create a family reunification system using leading edge computer science algorithms for photo identification.

For those who may not have known him, it is hard to separate the visceral impact of Michael's magnetic, physical presence from his leadership style. With his perfect dancers' posture, ready smile, and colorful bow ties, he always seemed to energize and motivate those around him with warm words of encouragement as well as setting the highest standards through his own personal example. But in his physical absence, it remains telling that Michael Shannon's true legacy lies in the quality, prescience, and lasting impact of his ideas and advocacy. Among many, many examples that validate this point is the evolution of this important book: *Pediatric Terrorism and Disaster Preparedness,* a book for which Michael was one of the three original editors and for which I am deeply honored and humbled to join George Foltin and David Schonfeld as a coeditor.

Many critical ideas put forth in this book today are continuations of concepts that Michael helped develop and for which he passionately and articulately advocated. One such example—the critical importance of integrating the needs of children throughout all phases of a disaster cycle—is now more commonly understood by federal, state, and local governments. By extension, the need for hospitals to implement pediatric-specific disaster plans that include carefully considered protocols for decontamination, triage, and family reunification remains particularly urgent as the number of mass casualty events continues to rise. Michael was one of the strongest voices of advocacy for the research and development of effective pediatric countermeasures to better protect children from biological, chemical, and radiological events.

Michael was also a role model for life. He impressed upon me and my colleagues that while practicing academic medicine at the highest level was important, other aspects of life also needed to take priority. Michael was devoted to his family. He always found ways to be available for his children's activities and performances and would occasionally leave national meetings or events to fly home, so he could have dinner with his family. His love of dancing showed the importance of sustaining interests and passions outside of medicine. And when everything simply got too complicated with overscheduling, Michael taught me the importance of flexibility—on a few occasions, impromptu meetings at the gym turned into brief work sessions (with exercise). Whether for a complex academic question or a simple parenting tip like how to better coax a fussy infant to sleep, Michael's door was always open.

As I now play my own role in the tradition of teaching and mentoring each new group of PEM Fellows and junior staff, I seek to emulate Michael in all the ways I possibly can (though perhaps not as a dancer!). While I will always carry with me the sad memory of his passing, the weight of this sadness dissipates with time and slowly but gradually, transforms into a feeling of deep and sustaining gratitude to have been taught by a mentor as gifted, visionary, and big-hearted as Michael Shannon.

Sarita Chung, MD, FAAP

# CHAPTER ONE:
# HOW CHILDREN ARE DIFFERENT

As all pediatric care providers know, one cannot treat children as small adults. Children have many unique anatomic, physiologic, immunologic, developmental, and psychologic considerations that potentially affect their vulnerability to injury and response in a disaster. Pediatricians can and should ensure that the needs of children are met in triage, diagnosis, and management in times of catastrophic occurrences.

## ANATOMIC DIFFERENCES

### Size

A smaller body has smaller circulating blood volume and less fluid reserve. Volumes of blood loss that would be easily handled by an adult can produce hemorrhagic shock in children. Therefore, infections that might cause mild symptoms of vomiting and diarrhea in adults could lead to hypovolemic dehydration and shock in infants, small children, or children and youth with special health care needs. These are urgent emergency situations that can very quickly lead to organ failure or death.

A child's smaller mass means greater force applied per unit of body area. The energy imparted from flying objects, falls, or other blunt or blast trauma is transmitted to a body with less fat, less elastic connective tissue, and closer proximity of chest and abdominal organs. The result is a higher frequency of multiple-organ injury.

A child's small size makes him or her more vulnerable to exposure and toxicity from agents that are heavier than air such as sarin gas and chlorine. These agents accumulate close to the ground in the breathing zone of infants, toddlers, and children.

### Structure

Head injury is common in children. The head is a larger, heavier portion of a child's body compared with the head of an adult. A child's head is supported by a short neck that lacks well-developed musculature. The calvarium (skullcap) is thin and vulnerable to penetrating injury, thus allowing greater transmission of force to the growing brain of a child.

The pediatric cervical spine is subject to distracting forces that are more likely to disrupt the upper cervical vertebra and ligaments; however, interpretation of diagnostic imaging is potentially confusing, and children can have spinal cord injury without radiographic abnormality.

The child's skeleton is more pliable than that of adults, and it is incompletely calcified with active growth centers that are more susceptible to fracture. Orthopedic injuries with subtle symptoms and physical findings are easily missed, especially in preverbal children.

Internal organ damage can occur without overlying bony fracture. It is common to have serious cardiac or lung injuries without having incurred rib fractures. The thoracic cage of a child does not provide as much protection of upper abdominal organs as that of an adult. Hepatic or splenic

injuries from blunt trauma can go unrecognized and produce significant blood loss leading to hypovolemic shock.

The mediastinum is very mobile in children. Subsequently, a tension pneumothorax can become quickly life-threatening when the mediastinum is forced to the opposite side compromising venous return and cardiac function.

### Body Surface Area

The ratio of body surface area (BSA) to mass is highest at birth and gradually diminishes as the child matures. The distribution of BSA also differs between children and adults. Children have a higher percentage of BSA devoted to the head relative to the lower extremities, and this must be taken into account when determining the percentage of BSA involved for burn injuries and in situations of hypothermia treatment or prevention.

## PHYSIOLOGIC DIFFERENCES

Children can compensate and maintain heart rate during the early phases of hypovolemic shock, which creates a false impression of normalcy resulting in resuscitation with too little fluid administration. This can be followed by a swift deterioration with little warning.

Pediatric care providers must be able to quickly interpret whether a child's vital signs are normal or abnormal for age. Temperature is an often forgotten but important vital sign in injured children. The child's ability to control body temperature is affected not only by BSA-to-mass ratio but also by thin skin and lack of substantial subcutaneous tissue. These factors increase evaporative heat loss and caloric expenditure. Considerations of methods to maintain and restore normal body temperature are critical to the resuscitation of children. Supportive methods can include thermal blankets and *warmed* resuscitation rooms, intravenous fluids, and inhaled gases.

Children have a higher minute ventilation than adults, which means that over the same period of time, they are exposed to relatively larger doses of aerosolized biological and chemical agents than are adults. The result is that children suffer the effects of these agents much more rapidly. Children are also more likely to absorb more of the substance from the lungs before it is cleared or diffused through ventilation.

## IMMUNOLOGIC DIFFERENCES

Children have immature immunologic systems, placing them at higher risk of infection. Immunologically, children have less herd immunity from infections and a unique susceptibility to many infectious agents.

## DEVELOPMENTAL DIFFERENCES

Children rely on parents or other adult caregivers for food, clothing, and shelter. In disasters, these caregivers can be injured, killed in the incident, or not present. Children, especially infants and toddlers:

- Are limited in their verbal ability to communicate their wants and needs;
- Do not always have the motor skills needed to escape from the site of the incident;
- May be limited in their ability to figure out how to flee from danger or to follow directions from others; or

- May not even recognize a threat, and because of their curious nature, may move toward a risky situation.

## PSYCHOLOGICAL DIFFERENCES

The psychological effects of disaster on children are neither uniform nor universal in nature (see the section on mental health).

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# CHAPTER TWO:
# DISASTER PLANNING FOR PEDIATRICIANS

The United States has established a robust emergency medical support infrastructure to respond to disasters at local, state, regional, and federal government levels. Populations with specific emergency medical needs in disasters—such as neonatal, adolescent, or other pediatric populations—have limited support that is quickly available and specifically designed to meet their urgent life-sustaining needs. Despite greater awareness, resources dedicated to pediatric populations continue to be inadequate for most emergency medical response activities related to disasters, even though victims often include children. Children and youth with special health care needs will require extra planning efforts in advance of a disaster. Parents know their child best and can greatly benefit from their pediatrician's help with planning before an emergency or disaster.

A disaster is an event or situation that overwhelms available resources and results in injury, death, and/or destruction of property.

## TYPES OF DISASTERS

There are different types of disasters; some occur without warning, and with others there is time for preparation. Examples include:

- Biological, chemical, explosive, nuclear or radiation threat/attack
- Drought
- Earthquake
- Extreme temperatures (heat or cold)
- Fire
- Flood
- Hurricane
- Infectious disease outbreak or pandemic
- Landslide
- Terrorism/violence
- Tornado
- Tsunami
- Volcano
- Wildfires
- Winter storms

## DISASTER SUPPORT MECHANISMS

The disaster declaration process involves the state (through the governor) asking the President of the United States to approve a major disaster declaration (www.fema.gov/disaster-declaration-process). The FEMA tracks disasters by year, type, and location (www.fema.gov/disasters/). Public health emergencies, which typically relate to infectious diseases or other situations that put the public's health at risk, are managed by the Secretary of the US Department of Health and Human Services (HHS) (www.phe.gov/Preparedness/legal/Pages/phedeclaration.aspx).

The National Response Framework (NRF) guides how the nation responds to disasters and emergencies (www.fema.gov/media-library/assets/documents/117791) and is based on the National Incident Management System (www.fema.gov/national-incident-management-system).

The National Disaster Medical System or NDMS (www.phe.gov/Preparedness/responders/ndms/ndms-teams/Pages/default.aspx) deploys pre-credentialed Disaster Medical Assistance Teams (DMATs) and other professionals to assist with disaster medical response at a national level. Other opportunities for pediatricians include signing up for Emergency System for Advance Registration of Volunteer Health Professionals (ESAR-VHP)[www.phe.gov/esarvhp/Pages/about.aspx] or Medical Reserve Corps (MRC) teams (https://mrc.hhs.gov/HomePage) in advance of a disaster.

A common instinct after a disaster is for pediatricians or other medical professionals to want to travel to a disaster-affected area and help by providing medical relief services. However, for various reasons, including the need to protect victims and volunteers and pre-credential medical professionals, this is rarely possible or advisable. Pediatricians and others who do travel to help in a disaster may find themselves taking resources from disaster victims, especially in austere areas. The AAP recommends that pediatricians sign up in advance through the DMAT, ESAR-VHP, and MRC options referenced above. It is also sometimes possible for pediatricians to assist in disaster response via the American Red Cross (www.redcross.org/take-a-class/disaster-training) or National Voluntary Agencies Active in Disasters (www.nvoad.org/voad-members/national-members/). State connections are also available (www.nvoad.org/voad-members/stateterritory-members/).

The AAP does not send teams to disaster-affected areas or endorse/approve any particular means of traveling to or volunteering in disaster-affected areas, yet the organization hopes to continue to keep its members informed of relevant opportunities. The security and safety of members continues to be a high priority, and members are urged to educate themselves about the reality of travel details, security issues, liability insurance, living conditions, and other details regarding the provision of medical care in austere conditions. The CDC offers travel health notices (wwwnc.cdc.gov/travel/notices). It is important that health care professionals carry copies of licenses and board certifications when traveling and become knowledgeable about documentation needed when taking medicines into a foreign country.

## DISASTER PHASES: PEDIATRICIAN INVOLVEMENT

The exact terminology for disaster phases differs, and the terms used seem to change frequently. For example, FEMA references: prevention, protection, mitigation, response, and recovery.

For the purposes of this resources, the AAP will reference 4 basic phases related to a disaster:

1. Mitigation
2. Preparedness
3. Response
4. Recovery (short- and long-term)

**Mitigation Phase**

During mitigation, actions are taken to eliminate or reduce the probability of a disaster or reduce the impact of unavoidable disasters (www.fema.gov/what-mitigation). Mitigation preparedness measures include building codes, vulnerability analyses, tax incentives and disincentives, zoning and land use management, building-use regulations, safety codes, sharing of resources among states, vaccination, preventive health care, and public education.

Information resources, data, and services important in mitigation activities include: geographic information systems-based risk assessment, claims history data, facility/resource identification, land use/zoning, building code information, and modeling/prediction tools for trend and risk analysis.

The pediatrician's role in mitigation is typically what is done on a day-to-day basis (eg, immunizations, vaccine storage, preventive health care, health education, and outreach to community and public health specific to routine health and safety efforts). A key resource is the AAP policy "Pediatricians and Public Health: Optimizing the Health and Well-being of the Nation's Children" (http://pediatrics.aappublications.org/content/early/2018/01/18/peds.2017-3848).

**Preparedness Phase**

Although disasters cannot usually be predicted, sometimes it is possible to control their impact through prevention and planning efforts. Preparedness is probably the most important phase of response in emergency management (www.dhs.gov/topic/plan-and-prepare-disasters). During the preparedness phase, governments, organizations, and individuals conduct risk assessments to recognize which disasters are most likely to occur in particular geographical areas, and then they develop plans to save lives, minimize disaster damage, enhance disaster response, and facilitate short- and long-term recovery. Preparedness efforts include developing written disaster plans; evacuation planning; emergency exercises and training; emergency communications and warning systems; public information and education; and development of resource inventories, personnel contact lists, and mutual aid agreements.

Pediatricians can participate in disaster preparedness in many ways. They can:

- Advise local disaster planners and hospital and health system administrators on the considerations of children and families
- Advocate for children's needs
- Educate disaster response teams on pediatric issues
- Join disaster or health care coalitions
- Participate in and help to plan exercises and drills
- Support partners in disaster planning:
  - Child care facilities and schools
  - Emergency medical services (EMS) and EMS for Children (EMSC)
  - Law enforcement (offer guidance on the impact scenarios would have on children)
  - Public health
- Help families with preparedness planning
- Participate in medical surveillance efforts to alert public health officials of suspicious trends
- Seek education on disaster topics

- Initiate or get involved in disaster preparedness initiatives
- Form a communications network to enhance messaging/information sharing in a disaster
- Advise others on how best to educate and create awareness in school personnel and among parents without causing panic
- Develop a written plan for their practice setting (office practice, hospital, urgent care center)
- Prepare their own family disaster plan

A critical way for pediatricians to make a difference in pediatric disaster preparedness is to advocate for the needs of children by speaking directly to hospital administrators. This is especially important in general or community hospitals, where most planning will likely relate to adults. In addition, in a disaster, hospital personnel will prioritize the needs of their own family/children, and this could affect their ability to work. So, taking steps to meet with hospital administrators and discuss disaster preparedness is a win-win for everyone. (Also see Chapter 4: Mental Health Issues.)

Additional details on the role of the pediatrician in disaster preparedness are included in the AAP policy "Ensuring the Health of Children in Disasters" (http://pediatrics.aappublications.org/content/136/5/e1407). Also see the AAP Family Readiness Kit, which pediatricians can provide to families (www.aap.org/en-us/Documents/disasters_family_readiness_kit.pdf).

Relationship building during the preparedness process is critical. The leaders involved in community disaster planning should routinely meet with each other to develop familiarity and to facilitate communication during a crisis. Communication is a key element for success. If leaders can communicate successfully during routine circumstances, it will be more likely that they will communicate effectively during times of crisis.

Pediatricians might find that community connections to other groups that are involved in disaster planning and response can supplement their efforts. Some may not be relevant to most office-based pediatricians (in terms of applying this resource to their setting); however, it is advisable for pediatricians to be aware that others in their community might be involved in these efforts.

***Citizen Corps:*** The Citizen Corps program brings together local government, business, and community leaders who work to prepare their communities for disasters and to make them more resilient. It includes a national network of more than 1200 state, local, and tribal Citizen Corps Councils. The Citizen Corps is coordinated by FEMA. In this capacity, FEMA works closely with other federal entities, state, and local governments; first responders and emergency managers; the volunteer community; and the Corporation for National and Community Service (www.ready.gov/citizen-corps).

***Community Emergency Response Team:*** The Community Emergency Response Team (CERT) program educates people about disaster preparedness and trains them in basic disaster response skills, such as fire safety, light search and rescue, and disaster medical operations. Using their training, CERT members can assist others in their neighborhood or workplace following an event

and can take a more active role in preparing their community. The program is administered by FEMA (www.ready.gov/community-emergency-response-team).

***Medical Reserve Corps:*** The Medical Reserve Corps (MRC) is a national network of locally organized volunteers who are integrated into the community's disaster response plan. The MRC network includes about 190,000 volunteers in 900 community-based units in the United States and its territories. These volunteers include medical and public health professionals, as well as other community members without health care backgrounds. The MRC units prepare for and respond to disasters as well as other emergencies affecting public health. This program is an ideal way for office-based pediatrician to become more active in local disaster response (https://mrc.hhs.gov/pageviewfldr/About).

***National Volunteer Organizations Active in Disasters:*** The National Volunteer Organizations Active in Disasters (NVOAD) is a forum where organizations share knowledge and resources throughout the disaster cycle to help disaster survivors and their communities. The NVOAD uses cooperation, coordination, communication, and collaboration as guiding principles for how it operates, and the partner organizations work to better serve communities and the nation (www.nvoad.org/).

Once preparedness plans are developed, these written plans should be reviewed, tested, and refined on a regular basis. For a plan to work efficiently and effectively during a crisis, it must be well-rehearsed. Plans that have been tested on a regular basis enable the responders to know and understand their roles. Careful review and personal communication with all involved in both incident management and potential disaster response can always help to identify more opportunities for improvement. Because disasters are dynamic events, plans must be flexible so that they can be adapted to an incident as it evolves. People involved in the planning process should stay current regarding new trends, technologies, and intelligence information that becomes available. For pediatricians, this can mean signing up in advance to monitor messaging and updates from federal agencies such as the ASPR, Centers for Disease Control and Prevention (CDC), FEMA, and local and state public health agencies.

**Response Phase**

The next phase is the response to the actual event. Response activities provide emergency assistance for casualties, reduce the probability of secondary damage, and enhance recovery. Response activities can include activating public warning systems, declaring disasters, mobilizing emergency personnel and equipment, providing emergency medical assistance, activating and managing emergency operation centers, evacuating the public, mobilizing security forces, and providing search and rescue operations.

Response to a mass casualty incident (MCI) begins at the scene by the first responders. An integral role of the first responder is coordination with agencies able to recognize characteristics of MCIs secondary to explosive devices or to biological, chemical, or radiological agents, such that ongoing risk is minimized. First responders collect casualties, triage survivors, institute treatment (including decontamination), and transport victims to hospital emergency departments or other treatment areas. In blast trauma, first responders should convey field information to hospital personnel so that management of casualties can be

facilitated. This information should include the sorts of injuries that are expected, initial estimates of the number of casualties, and any additional risks to personnel from toxic substances. Involvement of hazardous substances such as chemical or biological agents, fires, collapsed structures, or the possibility of a radiation dispersal device (dirty bomb) should initiate specific response protocols.

Disaster events can change quickly, so personnel should be able to adapt plans to deal with the incident as needed. The Incident Command System (www.fema.gov/incident-command-system-resources) is a core component of any disaster response. There should be an incident commander—a qualified, visible leader—who can take charge of the response and direct the responders. The incident commander must be able to think quickly, make rapid assessments, and switch direction as needed. The incident commander should be surrounded by competent, knowledgeable, and trusted people. The people who support the incident commander will be called on to provide complete and accurate information to the incident commander so that he or she has the tools needed to make rapid, informed decisions. The National Incident Management System, or NIMS (www.fema.gov/national-incident-management-system), provides a common, nationwide approach to enable the whole community to work together to manage all threats and hazards. The NIMS applies to all incidents, regardless of cause, size, location, or complexity.

The individual pediatrician may be involved in disaster response in various ways:

- Continue to care for patients, even when business is disrupted
- Direct families and colleagues to disaster assistance resources
- Assess and help to address pediatric needs in shelters
- Ask families how they are coping
- Join in the medical response through participation in national or state opportunities
- Support family reunification
- Monitor public health messages
- Tend to professional self-care

Pediatricians must make their own professional self-care a priority to effectively help those children and their families who are affected by disasters. Providing psychological support or "psychological first aid" will be a critical consideration for pediatricians after a disaster. (Also see Chapter 4 Mental Health Issues.)

**Recovery Phase**

The recovery phase evolves as steps are taken to mitigate the impact of the disaster event. The objective of recovery is to support the affected area to return to normal as quickly as possible and for recovery activities continue until all systems have been returned to normal or better. Depending on the scope of the incident, the recovery period can range from hours to years. During recovery, damage assessments are made, financial needs are identified, and timelines and plans to support disaster recovery are developed and implemented.

Short- and long-term recovery measures include returning vital life-support systems to minimum operating standards; reconstruction; temporary housing; ongoing medical care; and public information, health and safety education, and counseling. One aspect of long-term recovery involves assessing the infrastructure, how it held up during the incident, what the cost of the

response was, and how that cost can be recovered. Recovery efforts in economic support include paying out insurance/loans and grants to cover damage, providing disaster unemployment insurance, and performing economic impact studies. Information resources and services related to recovery include data collection related to rebuilding, claims processing, and documentation of lessons learned.

During disaster recovery, pediatricians can:

- Connect with their AAP chapter
- Continue self-care and support colleagues and families affected by the disaster
- Restore access to medical care
- Serve as a pediatric advisor or child advocate, especially for disaster recovery Children and Youth Task Forces, often initiated by HHS after a disaster
- Support clean-up and continuation of child care facilities, schools, and safe play areas for children

During long-term recovery, participants review and critique the response, evaluating how the overall plan worked in a real event. This allows them to determine what needs to be done to update the plan and educate responders and to make changes necessary to improve the original response plan and prevent a recurrence.

The AAP offers resource and support to AAP chapters (www.aap.org/disasters/chapters), including a Chapter Preparedness Checklist, a Chapter Planning Template, and access to AAP Disaster Recovery Funds and AAP Chapter Contacts.

## FEDERAL AGENCIES INVOLVED IN DISASTER EFFORTS

The federal agencies that have primary responsibility for addressing children's needs in disasters include the HHS ASPR, the CDC, the Department of Homeland Security/FEMA, and the Administration for Children and Families/Office of Human Services Emergency Preparedness and Response. Details on these agencies and select activities follow.

### Administration for Children and Families/Office of Human Services Emergency Preparedness and Response

(www.acf.hhs.gov/ohsepr)

The Administration for Children and Families is a division of HHS that promotes the economic and social well-being of children, families, individuals and communities with leadership and resources for compassionate, effective delivery of human services. The Office of Human Services Emergency Preparedness and Response promotes resilience for individuals, families, and communities affected by disasters and public health emergencies by providing expertise in human services policy, planning, operations, and partnerships.

### Centers for Disease Control and Prevention

(www.cdc.gov/)

The CDC strives to protect America from health, safety, and security threats by conducting critical science efforts, providing health information, and responding to diseases or threats as they occur. Within the CDC, the Emergency Operations Center (EOC) operates 24 hours a day, 7 days a week to provide emergency consultation and assistance to state and local health

agencies, clinicians, and citizens. The EOC can be reached at 770-488-7100. The Clinician Information Line (877-554-4625) is available to clinicians 24 hours a day to provide guidance on the management of patients. The CDC EOC can also refer pediatricians to agent-specific subject matter experts. The CDC National Center on Birth Defects and Developmental Disabilities works in partnership with the CDC Office of Public Health Preparedness and Response to support the CDC Children's Preparedness Unit (www.cdc.gov/childrenindisasters/). The CDC also oversees the CDC Public Health Emergency Preparedness (PHEP) cooperative agreement program (www.cdc.gov/phpr/readiness/phep.htm). This program offers funding to enable health departments to strengthen their capabilities to respond to various threats, such as infectious diseases, natural disasters, and biological, chemical, nuclear, and radiological events. Preparedness activities funded by the PHEP cooperative agreement are "emergency ready" as well as flexible and adaptable. The CDC mission, role, and pledge emphasizes its role in nurturing state and local public health (www.cdc.gov/about/organization/mission.htm). The need for a strong connection between pediatricians and public health officials is emphasized in the AAP Pediatric Preparedness Resource Kit (www.aap.org/disasters/resourcekit).

**Department of Homeland Security**
(www.dhs.gov/)
The Department of Homeland Security strives to keep Americans safe and secure the nation from many threats related to areas such as aviation, border security, cyber security, and emergency response. Mission areas include preventing terrorism and enhancing security, managing the US borders, administering immigration laws, securing cyberspace, and ensuring disaster resilience.

**Office of the Assistant Secretary for Preparedness and Response**
(www.phe.gov/preparedness/pages/default.aspx)
The mission of the HHS ASPR is to save lives and protect the nation from current threats to health security. The ASPR leads the nation's medical and public health preparedness for, response to, and recovery from disasters and public health emergencies at the federal level. The ASPR collaborates with academia; biotechnology firms; communities; hospitals; health care coalitions; as well as state, local, tribal, and territorial governments and other partners across the country to improve readiness and response capabilities. The ASPR continuously identifies and addresses gaps in coordinating patient care and transportation in disasters, especially specific to coalitions and states. The ASPR is working to implement a Regional Disaster Health Response System, and pediatrics is a critical component of this effort. The ASPR also offers support in this area through the federally funded Hospital Preparedness Program, which is now focused on Health Care Coalition Preparedness efforts (www.phe.gov/preparedness/planning/hpp/pages/default.aspx).

***Technical Resources, Assistance Center, and Information Exchange (TRACIE):*** The ASPR offers technical assistant and support through TRACIE, which was created to meet the information and technical assistance needs of regional ASPR staff; health care coalitions, entities, and providers; emergency managers; public health practitioners; and others working in disaster medicine, health care system preparedness, and public health emergency preparedness. Pediatricians and others can visit https://asprtracie.hhs.gov/ or reach TRACIE staff via telephone (844-587-2243) or e-mail (askasprtracie@hhs.gov).

***Federal Advisory Councils:*** The ASPR and other areas of HHS oversee various federal advisory councils that provide guidance and recommendations to the assistant secretaries.

*National Commission on Children and Disasters:* The National Commission on Children and Disasters (which was sunset in 2015) identified many recommendations to improve disaster preparedness and response in its 2010 Report to the President and Congress (https://cybercemetery.unt.edu/archive/nccd/20110427002908/http:/www.childrenanddisasters.acf.hhs.gov/index.html).

*National Advisory Committee on Children and Disasters:* The National Advisory Committee on Children and Disasters (NACCD) was established after the National Commission on Children and Disasters was sunset to provide advice and consultation to the HHS Secretary and/or ASPR on issues related to the medical and public health needs of children as they relate to disasters. (www.phe.gov/Preparedness/legal/boards/naccd/Pages/default.aspx). The mission of the NACCD is to:

- Provide advice and consultation
- Evaluate and provide input with respect to the medical and public needs of children as they relate to preparation for, response to, and recovery from all-hazards emergencies
- Provide advice and consultation with respect to state emergency preparedness and response activities for children, including related drills and exercises pursuant to the preparedness goals
- Provide advice and recommendations to the HHS Secretary with respect to children and the medical and public health grants and cooperative agreements

The NACCD also issued recommendations specific to children in several reports (www.phe.gov/Preparedness/legal/boards/naccd/Pages/recommendations.aspx).

*National Preparedness and Response Science Board:* The National Preparedness and Response Science Board (NPRSB) provides expert advice and guidance to the Assistant Secretary of HHS and the Assistant Secretary for Preparedness and Response on scientific, technical, and other matters related to public health emergency preparedness and response (www.phe.gov/Preparedness/legal/boards/nprsb/Pages/default.aspx).

## FEDERAL AND STATE COORDINATION

Communication and information sharing are key parts of successful disaster management, both before and during an actual event. Although each area of the country handles emergency responses in somewhat different ways, all emergency response agencies use some form of an incident management system, generally NIMS. When a disaster happens, each state serves as the primary point of contact with the federal government. Communications typically occur through the governor (www.phe.gov/Preparedness/responders/soc/Pages/coordination.aspx). The best way for pediatricians to get involved in regional efforts is to join existing disaster-related health care coalitions. The ASPR offers state points of contact (www.phe.gov/Preparedness/planning/hpp/Pages/find-hc-coalition.aspx).

**Emergency Medical Services**

Emergency Medical Services, or EMS, in the United States is a coordinated system of disaster response and emergency medical care that involves multiple people and agencies. The availability and capabilities of EMS in the United States have undergone explosive growth throughout its history. Congress passed the Highway Safety Act of 1966, establishing the National Highway Traffic Safety Administration (NHTSA). The agency's purpose was to help states start coordinated EMS programs. When Congress passed the Emergency Medical Services Systems Act of 1973, this established the regional basis for coordination of emergency medical care throughout the United States.

In its series on the *Future of Emergency Care* (2007), the Institute of Medicine (IOM) reported deficiencies in the quality of prehospital pediatric emergency care resulting from the infrequent encounters with critical pediatric patients coupled with inadequate initial and continuing pediatric education (www.nationalacademies.org/hmd/Activities/Quality/emergencycare.aspx). These deficiencies resulted in prehospital care providers expressing discomfort when rendering care to children, especially infants. On the basis of these findings, the IOM recommended that "every pediatric- and emergency care-related health professional credentialing and certification body should define pediatric emergency care competencies and require practitioners to receive the level of initial and continuing education necessary to achieve and maintain those competencies."

The draft *EMS Agenda 2050* (www.ems.gov/projects/ems-agenda-2050.html) concluded:

- Patients' age should not affect the quality of care they receive.
- EMS initial and continuing education and simulation should ensure providers are as comfortable treating infants and children as they are treating adults.
- Systems should develop evidence-based protocols and have equipment appropriate for every age range in the patient spectrum.
- Medical research should include safe ways of assessing the treatment of, and equipment used, for patients of all ages from neonates to the elderly.
- Industry should be incentivized to develop equipment that can be adjusted to the age and size of patients to safely assess, treat, and transport patients of any age.

A comprehensive EMS system is ready for all emergencies and disasters (www.ems.gov/whatisems.html).

**Emergency Medical Services for Children**

In 1984, Congress first appropriated funds to support the EMSC program. The EMSC program did not promote the development of a separate EMS system for children, but instead EMSC focused on enhancing the pediatric capability of existing EMS systems. During the past 25 years, the scope and complexity of care rendered by prehospital EMS providers have expanded greatly. The NHTSA oversees EMS, and a relevant history of the evolution of these activities is available online (www.ems.gov/OEMShistory.html). The AAP offers information on the evolution of the EMSC program (www.aap.org/en-us/Documents/EMSC_Historical_Perspective2125.pdf). The AAP offers many policy documents with recommendations on pediatric emergency care (http://pediatrics.aappublications.org/collection/committee-pediatric-emergency-medicine). Of special significance are the "Joint Policy Statement—Pediatric Readiness in the Emergency

Department" (http://pediatrics.aappublications.org/content/142/5/e20182459) and "Emergency Information Forms and Emergency Preparedness for Children With Special Health Care Needs" (http://pediatrics.aappublications.org/content/125/4/829).

The EMSC Innovation and Improvement Center (IIC) was initiated in 2015 to offer support to state EMSC projects and to improve outcomes for children in emergency situations by using improvement science as the basis for collaborative efforts to address known gaps in the US health care system. The EMSC IIC offers a comprehensive Web site (https://emscimprovement.center/) with targeted resources on disaster planning (https://emscimprovement.center/categories/disaster/).

The AAP encourages AAP chapter leaders to get involved in pediatric disaster preparedness discussions through connections with public health as well as EMSC, CDC PHEP, and ASPR HPP program contacts. The AAP has identified pediatricians to serve as Chapter contacts for disaster preparedness in all states (www.aap.org/disasters/chaptercontacts).

**Hospital Preparedness**

The Hospital Preparedness Program is supplemented by other initiatives. The National Pediatric Readiness Project (https://emscimprovement.center/projects/pediatricreadiness/) was established to ensure that all US hospital emergency departments have the essential guidelines and resources in place to provide effective emergency care to children. Of the 4146 emergency departments that participated in the 2013 National Pediatric Readiness assessment, only 47% responded that they have a disaster preparedness plan in place that addressed the unique needs of children. The AAP, in partnership with the EMSC IIC, has developed checklists, toolkits, and other resources to improve pediatric readiness within hospitals. A follow-up data collection and assessment will begin in 2019.

In MCIs, including those involving release of biological or chemical agents, both children and adults are likely to be significantly affected. Children would probably be disproportionately affected by such an incident, so pediatricians should assist in planning coordinated responses for local hospitals that may have limited pediatric resources. Health care facilities could also be a primary or secondary target. At the very least, facilities will be overwhelmed by a massive number of anxious and worried individuals.

The problems associated with terrorist incidents differ from those usually faced by hospital disaster alert systems. In the typical scenario, most victims are triaged in the field and then carefully distributed among available resources to avoid a single facility from being overwhelmed. In a terrorist attack or after a sudden unexpected mass casualty event, facilities will be particularly vulnerable to inundation with many victims who have not been triaged or transported by EMS. Arrivals without full notification could interfere with attempts to isolate contaminated victims and ensure protection of health care personnel. In addition, terrorist events will be further complicated by the issues of security and forensics.

Hospital emergency department personnel become involved both before and after the arrival of victims. For example, emergency departments must be able to accommodate large numbers of patients, inpatient units must be prepared to surge, operating rooms must move patients through

more quickly, and nonmedical areas must be prepared to set up to care for the less serious patients presenting themselves. Activities prior to arrival include processing current patients in the emergency department to prepare for new arrivals, checking all equipment, activating additional personnel, assigning team leaders, and possibly assigning liaisons to government agencies. Information and recommendations are contained within the AAP policy statement, "Chemical-Biological Terrorism and its Impact on Children" (http://pediatrics.aappublications.org/content/118/3/1267).

Hospital preparedness planning is often based on a gap analysis or risk or hazard vulnerability assessments.

***Risk Assessment:*** The objective of conducting a hospital risk assessment is to estimate the likelihood that an incident will have an impact on the hospital. Considerations in risk assessment include the following:

- Size of the incident and the hospital's ability to respond
- Whether the incident has the *potential* to generate large number of causalities
- Whether effects are immediate or may be delayed
- What types of specialized equipment, procedures (decontamination), and medications, all adapted to pediatric needs, will be required for the response
- Awareness that hospitals may be targets of secondary attacks to amplify effect

Situations with both high probability and the potential for high impact (eg, an earthquake in California or a tornado in the Midwest) should receive more attention in preparedness planning than either situations of low probability with the potential for high impact (eg, industrial plant chemical leak) or situations of high probability and the potential for low impact (eg, community outbreak of infectious gastroenteritis).

***Hazard Vulnerability Analysis:*** The Hazard Vulnerability Analysis (HVA) is an aspect of risk analysis that considers the hospital's capabilities regarding the traditional elements of risk. This analysis allows a comparison between the potential risk factor (hazard) and the hospital's ability to cope. The action plan resulting from this type of risk analysis should be directed toward those hazards against which the hospital is less able to cope (ie, vulnerabilities). Areas of vulnerability may include issues such as an attack on hospital information systems, inadequate ventilation systems (negative pressure, contained exhaust) for decontamination procedures in toxic exposures, power and water supplies, or hospital staff untrained in the proper use of personal protective equipment (PPE).

The key benefit of HVA is the ability to prioritize planning for the hospital in any given situation. The key to effective HVA is a good, frequently updated inventory of the resources and capabilities (within both the hospital and the community) that are available for dealing with a particular hazard-related emergency.

The ASPR TRACIE offers relevant tools and resources specific to risk assessment and HVA (https://asprtracie.hhs.gov/technical-resources/3/Hazard-Vulnerability-Risk-Assessment/1).

## COALITION BUILDING

There has been increasing recognition of the importance of coalitions as the cornerstone for meaningful preparedness in this country. Examples of this recognition are mandatory inclusions of coalition building for federal funding and in federal, state and local planning documents. Pediatric Disaster Coalitions, incorporated into overall disaster planning and management, can be an effective mechanism to match resources to needs during catastrophic events. They can thereby improve outcomes for pediatric victims and their families. These coalitions have grown from grassroots efforts of 2 to 3 health care providers and agencies planning together to more formal structured entities that include the full gamut of pediatric disaster response. The AAP offers information on establishing pediatric advisory councils or children's preparedness coalitions (www.aap.org/disasters/EstablishingPreparednessCoalitions) and disaster-related coalitions (www.aap.org/disasters/coalitions).

The National Pediatric Disaster Coalition was established in 2016 to engage multidisciplinary organizations and subject matter experts to harness collaborative ideas and technologies that promote the best outcomes for children in disasters (www.npdcoalition.org/).

## REGIONAL COORDINATION OF HEALTH CARE SYSTEM RESPONSE

Emergency incidents require coordination of the health care system within the local community and region. Coordination with community stakeholders includes liaison and planning with various local, state, and national agencies/organizations. The ASPR has identified regional coordinators (www.phe.gov/Preparedness/responders/rec/Pages/default.aspx).

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# CHAPTER THREE:
# PREPAREDNESS PLANNING IN SPECIFIC PRACTICE SETTINGS

## PLANNING

Historically, planning for disasters, terrorist incidents, and public health crises has focused on hospitals and emergency departments. In recent years, there has been a growing realization that preparedness needs to reflect the whole community, and public health preparedness needs to address the entire continuum of health care delivery. Office-based pediatricians are recognized as having a vital role in planning for and responding to disasters. In the immediate aftermath of a catastrophic event, complications of baseline chronic medical needs are one of the primary reasons for people seeking medical care. As response transitions to recovery, disaster-related screening, support and intervention, and follow-up increasingly falls to the medical home and other ambulatory settings.

All pediatricians should be engaged in disaster planning. This includes personal/family preparedness and encouraging patients to prepare. Pediatricians should attend to the continuity of practice operations to provide services in time of need and stay abreast of disaster and public health developments to be active participants in community planning efforts. Many health care professionals will find this challenging to achieve. Pediatricians may not know where to find preparedness resources, what activities to start first, or how to engage with public health and other disaster response organizations. Conversely, existing response organizations may not know how to reach and engage community pediatricians, or how to utilize their expertise. Efforts need to be bidirectional, and one party should not wait for the other to make the first step. As the saying goes, “a disaster is not the time to start exchanging business cards”—connections and collaboration are best established well in advance of a crisis event. Simple “getting to know you” introductions over coffee, for example, are one way to establish professional relationships, whereby the pediatrician and the community or public health representative learn each other’s potential roles, responsibilities, resources, challenges, and interests.

The ideal disaster response starts with the vision of the community meeting all needs of all children. If the community accepts this goal, it will quickly realize that a broad coalition of many medical, mental health, social service, and educational providers is required. This has been reflected in the changing role of the HHS ASPR Hospital Preparedness Program (HPP). As the name implies, the program initially awarded funding to hospitals to improve their ability to respond to disasters and public health emergencies. The HPP has since evolved with a current focus on community-based health care coalitions (www.phe.gov/preparedness/planning/hpp/pages/default.aspx).

Many pediatricians work in small to mid-size group practices, and they will need to collaborate with their competitors to achieve preparedness planning and work with physicians in other pediatric subspecialties. Nonpediatric physicians and care providers also should be engaged in disaster planning discussions, because a mass casualty event involving children will likely require their assistance. Pediatricians will need to be steadfast advocates for the needs of children in the face of other competing priorities.

Community partners who care for children can and should participate in the preparedness effort (eg, schools, child care facilities, after-school programs, camps, and scouting programs). A list of the various agencies and groups that may be relevant or could have resources include:

**Local Resources**

- AAP District and State Chapter offices
- Behavioral health services and organizations
- Camps (eg, before-/after-school programs, specialty)
- Child care programs
- Community-based organizations
- Emergency management organizations
- Emergency medical services
- Faith-based groups (eg, churches, mosques, synagogues)
- Fire department
- Head Start programs
- Health care coalitions
- Health care facilities
- Infrastructure companies (eg, communications, sanitation, utilities)
- Law enforcement
- Local government
- Medical Reserve Corps/other community volunteer groups
- Nongovernmental organizations (eg, amateur radio operators, American Red Cross Chapter, voluntary organizations)
- Public health agencies
- Public recreation (eg, amusement parks, parks, sports stadiums, museums, YMCA, zoos)
- Schools (colleges/universities, private, public)
- Service groups (eg, Kiwanis, parent-teacher associations/organizations, Rotary, Salvation Army)
- Shelters
- Social works services
- State hospital associations
- Support service providers
    - Blood banks
    - Clinical laboratories
    - Pharmacies
    - Poison Control
    - Radiology

**National Resources**

- American Academy of Pediatrics
- American Academy of Urgent Care Medicine
- American Red Cross
- US Department of Education
- US Department of Health and Human Services
    - Centers for Disease Control and Prevention

  - Centers for Medicare and Medicaid Services
  - Health Resources and Services Administration
  - Office of the Assistant Secretary for Preparedness and Response
- US Department of Homeland Security/FEMA
- US Department of Transportation
- US Department of Veterans Affairs Medical Centers
- US Occupational Safety Health Administration
- Urgent Care Association of America

It is recognized that this list of partners is lengthy; no one expects any one individual or entity to connect with all of these groups. Pediatricians should remember to view the community as a resource. Because governmental emergency response capabilities are limited, community resources play an important role in a community's response to and recovery from disasters. For example, in previous disaster situations, members of a community have joined together to help in search and rescue efforts and deliver first aid to victims. Community programs that provide disaster response training have the potential to assist government efforts in many ways, including:

- Improving response time and effectiveness
- Providing culturally sensitive information
- Promoting the medical home
- Connecting with key community leaders
- Improving recovery and promoting resiliency

## CONSIDERATIONS IN VARIOUS PRACTICE SETTINGS

Disaster planning involves an all-hazards approach, and when planning for the office practice (practice) response, this method should also be followed. But all-hazards planning does not mean that every practice preparedness plan is identical. Although basic planning frameworks can and should be shared, each practice is unique, requiring special thought and considerations when developing the plan, and this is most obvious when considering the different practice settings in which pediatricians work. Pediatricians provide care in a wide variety of settings, including:

- Primary care practices
- Multispecialty groups
- Federally qualified health centers
- Freestanding ambulatory centers
- Hospital-based ambulatory centers
- Urgent care centers
- Hospital emergency departments
- Hospital inpatient units, neonatal intensive care units, and regular/term nurseries

The setting obviously has a tremendous effect on how preparations should be made. For example, finding an alternate practice facility for a solo or small practice will be much different than for a hospital-owned practice that is off-site from the main campus. These differences in practice settings will be discussed in more detail as different planning areas are covered.

## OFFICE OR PRACTICE-BASED PEDIATRICIANS

According to the AAP policy statement "Ensuring the Health of Children in Disasters," all pediatricians, including primary care pediatricians, pediatric medical subspecialists, and pediatric surgical specialists, have key roles to play in preparing and treating families in cases of disasters. Pediatricians are the experts in providing developmentally and physiologically appropriate care to children. In the chaos of a disaster and its aftermath, it is important for pediatricians to ensure that their patient's medical needs are appropriately met. A majority of the medical care that children receive occurs in the outpatient setting, and this does not change during a disaster. There are ways that office- or practice-based pediatricians can maintain the continuity of their practices in times of disasters and in the often-overlooked recovery stage that may last for months. Having a written office preparedness plan is critical. Integrating the office's response within the federal, state, regional, and community response is essential.

### Internal Operations of the Practice: Office Readiness

The underlying principle of pediatric disaster preparedness is to ensure that the medical and psychological needs of children are met during and after disaster events. Proper planning can help a practice provide the necessary care to their patients. Pediatric providers are the experts in managing children's health. Maintaining outpatient capabilities will offer children and families access to their typical sources of pediatric care and will help to reduce surges in demand for emergency care, allowing hospital emergency departments to focus resources on what they do best, taking care of the seriously ill and injured. In addition, recovery after a disaster can take months if not years. Maintaining a functioning outpatient practice facility helps restore stability and access to the medical home for needed preventative services. The AAP has captured relevant information in its Preparedness Checklist for Pediatric Practices (www.aap.org/disasters/checklist).

### Basic Office Readiness

All disaster plans start with a hazard vulnerability assessment. This assessment identifies and prioritizes potential disasters and risks that could occur to a health care facility or the community. Conducting an office hazard vulnerability assessment should be one of the first steps in writing an office-based disaster preparedness plan. Geography, climate, population size and makeup, and surrounding industry all will factor into the assessment. The likelihood of certain disasters will affect the offices' preparations. For example, if the office is more likely to experience a flood, then important equipment and records will need to be stored in higher levels of the facility, whereas if a tornado is more likely, then basement storage may be a better option.

### Facilities

Disasters can occur suddenly with little or no warning, or they may be anticipated for days in advance. In either case, during a disaster proper facility planning can mitigate, and in some cases, prevent damage to the building structure. Facility management during a disaster will be greatly affected by the type of facility in which the practice is housed and who owns the property. A solo or small practice housed in a single-occupancy structure may have primary responsibility for mitigation efforts. In a larger building, facility management may be the responsibility of a maintenance group or team. Even in these larger facilities, the staff of an office-based practice may be able to assist in mitigation efforts. Communicating with the

building manager and coordinating these efforts can mean the difference in whether a practice continues its operations or not.

Whether a large multistory structure or single-occupancy building, there are a few general considerations that every practice needs to consider and include in their facility plans.

| Preparedness: Facility Considerations | |
|---|---|
| **POWER** | What is the power source?<br>Is there a generator available?<br>Where are circuit breakers located?<br>Where is the gas shutoff? |
| **WATER** | Where are water shutoff valves?<br>What are sources of water? |
| **FIRE** | Where are fire extinguishers located?<br>Is there a sprinkler system?<br>What is the plan for evacuation? |
| **HEATING/COOLING** | How will the temperature be controlled? |
| **VACCINE STORAGE** | What is the vaccine storage plan? Vaccines in refrigerated storage areas need special monitoring and attention to protect these supplies during disasters. |

When developing mitigation planning, one should always remember that mitigation is secondary to the safety of patients and staff. It is the responsibility of all practices to have a facility evacuation plan in place. There should be periodic drills to review and practice these plans.

Damage to the facility, parking lot, or roads may make access to or use of the practice's building impossible for an indeterminate amount of time. Office practices should prepare to relocate in these instances. Practice type will make a difference in planning for being unable to access the office. Hospital-owned practices and larger multisite practices may have alternate locations available in which to move the office practice immediately. Electronic health records can be maintained with minimal, if any, disruption in these cases. For the solo or small practice, relocation may be much more difficult. Options include sharing or renting space with another local practice, area hospital, county health department, or other health clinics. There may be rental office space available in the community. There are mobile medical units that can be rented or purchased. Remember that if the disaster is widespread, other businesses will be vying for office space also. Considering these options in advance of a disaster is essential.

**Equipment**

Most of the equipment in a pediatric office is relatively inexpensive, however, some equipment can be costly to replace. The office preparedness plan should make a notation of any such equipment and make preparations to store it in the safest location possible should there be sufficient warning of an impending disaster. The most important equipment for continuity of the practice can be kept in an office disaster kit. Having an office disaster kit located both on-site and off-site will help ensure that the practice will be able to continue operations as quickly as

possible. The core contents of this kit are listed below. A more extensive list is included in the AAP Preparedness Checklist for Pediatric Practices.

| Items to Include in Office Disaster Kit |
|---|
| Stethoscope |
| Otoscope/ophthalmoscope (with specula) |
| Tongue depressors |
| Blood pressure cuffs |
| Tape measure |
| Gloves |
| Disposable personal and protective equipment (PPE) gowns |
| Masks |
| Thermometer/covers |
| Small scale |
| Prescription pads/clinic note pads |

Consider what other equipment may be required to provide services at another location. These could include items such as portable suction, mobile generators, batteries, chargers, two-way radios, medications, nebulizers, bag-valve-masks, and suture kits. You may want to include these supplies in additional kits to which you have access.

**Records**

Copies of important records, including patient medical records and additional patient information, need to be stored off-site. The advent of electronic health record systems and the use of the cloud and Web-based storage sites has made such storage much easier for providers. For smaller or independent practices, any information or records that would assist the practice in continuing to function should be maintained off-site. These include financial and other information, such as bank statements, loan documents, tax returns, and corporation documents. Insurance and malpractice insurance information, hospital identification badge(s), lease agreements, state medical licenses, Drug Enforcement Administration documents, and related contact numbers are also important and need to be readily available. Keeping lists of repair service numbers along with vendor contact information will accelerate the recovery process. Although these may not be as important to larger multisite and hospital-affiliated practices, pediatricians and their staff still need to be aware of what their larger institutions have planned and how they can access the information they need.

**Communication Systems**

Having reliable communication during and immediately after a disaster is paramount for saving lives. Reliable communication shares knowledge and provides information to first responders, support systems, medical services, and the public. Unfortunately, one of the first breakdowns during a disaster is the communications infrastructure. The success of an office's business continuity plan will center on the communications protocols that have been set in place. These protocols should include a chain of command, contact information for the staff, and specific responsibilities of each staff member.

## Chain of Command

As mentioned, the Incident Command System and the chain of command is a key feature of effective disaster response. The office preparedness plan should institute a similar organizational structure. Knowing who is in charge and specific delineation of duties for staff members will result in a more reliable response. This information should be reviewed with staff members on a routine basis. This is especially important as office personnel may change frequently. Practices that are within larger organizational structures will need to coordinate the chain of command with the organization's broader preparedness plan.

## Contact List

The office preparedness plan should include methods to notify staff and provide accurate information on the situation. A confidential list of contact information for the staff should be kept in a number of secure locations accessible by members in the chain of command. This information should include telephone numbers, text messaging information, and Web-based contact details (e-mail addresses or social media accounts). During a disaster, telephone communication is usually disrupted. However, text messages can often be made even in these conditions. The Internet is another source of communication that may still function during disasters. Satellite telephones and radios are other, although somewhat limited, options to consider. A "calling tree" can be used to provide rapid notification and ensure that everyone is accounted for and receives important information.

## Staff Responsibilities

The office staff have professional responsibilities of which they need to be aware. Availability during disasters is one of these duties. Unfortunately, these professional responsibilities may conflict with responsibilities that these staff members have for their own families. Each staff member should be encouraged to prepare and share his or her own family preparedness plan. Frank discussion of expectations with the staff prior to an event is important to alleviate concerns and to anticipate problems. This will also prevent any misunderstandings about staff roles and responsibilities. Duties for consideration include mitigation activities to the structure, evacuation and safety of patients, notifying fire or police officials, rescheduling patient appointments, communication to patients and the public, and proper maintenance and storage of vaccines. Periodic exercises can ensure that staff members know their responsibilities and also become familiar with those of other staff members.

## Vaccines

Vaccines are fragile biological products that are very sensitive to light and temperature. If vaccines are not carefully stored and protected from these elements, then they can lose potency. Vaccines are also very expensive to purchase or replace. Office practices can have thousands of dollars in vaccine inventory. Proper storage and monitoring of vaccines requires special refrigerator and freezer units to maintain specific temperatures. These units require power to maintain the appropriate conditions. Power outages must be addressed immediately to maintain the cold chain and prevent spoilage of the vaccines. In disasters, power outages do occur, and therefore a plan to maintain vaccine storage and handling needs to be in place.

Every office preparedness plan should emphasize that once an outage occurs, the doors to the units where the vaccines are stored must be kept closed. This will buy some time (approximately 2 hours) while the vaccine recovery plan is instituted. Primary and secondary persons with 24-hour access responsible for instituting the vaccine recovery plan should be determined. The office may consider having a generator to use in the case of power outages, but this is not a guarantee that vaccines will be safely maintained. A person needs to be sure that the generator is functioning properly and that the temperatures in the refrigerators are maintained at an appropriate level. If the office has no generator and the outage is anticipated to last more than 2 hours, consideration should be given to transporting the vaccines to another facility. Transfer of vaccines must be made to a facility with proper storage equipment and back-up power. These arrangements should be made with a facility in advance of any power outage or disaster. These plans need to be revisited frequently to prevent misunderstandings and to ensure acceptance of the vaccines. Once the decision is made to transfer the vaccines, the receiving facility needs to be contacted. Vaccines must be transferred with proper coolers, packing, and monitoring of temperatures. The AAP offers updated information on vaccine storage and handling (www.aap.org/vaccinestorage). More specific information on the transport of vaccines during emergencies is available from the CDC (www.cdc.gov/vaccines/recs/storage/downloads/emergency-transport.pdf).

**Infectious Disease and Other Surveillance**

Public health surveillance is a key function of the office-based pediatrician during times of epidemics or acts of bioterrorism. Community-based pediatricians may be the first point of contact for a victim of a biological, chemical, or radiological incident or an emerging infection or outbreak. Pediatricians should have a general knowledge of bioterrorism agents. Early identification will significantly mitigate the impact of these agents to the community. Referral procedures including required information to report to public health agencies should be part of the preparedness plan. In addition, the office preparedness plan must include proper protocols for isolation and infection control in the office. Correct use of PPE and waste management and patient transfer protocols are topics to be addressed in the plan. Community pediatricians can improve disaster response by recognizing that referring patients to emergency departments can increase the burden on an already overwhelmed setting, so they should do whatever is reasonable to treat patients in their practice setting. State Departments of Health (www.cdc.gov/mmwr/international/relres.html) along with the CDC can be excellent sources of information. Anyone can call or e-mail the CDC via CDC-INFO (www.cdc.gov/cdc-info/). Physicians should identify themselves as such. Anyone with a question about a child should also clarify this when contacting the CDC.

**Triage, Screening, and Prioritization**

Emergency personnel generally have little experience in managing the health care of children, especially infants and toddlers. Pediatricians are the experts in caring for children of all ages. As such, office-based pediatricians can serve important roles in their communities by stepping outside of their role in the office and assisting hospitals and emergency services in planning to care for children. Community pediatricians can help with triage, screening, and prioritization of children who are injured or become ill in an emergency. Appropriate triage and prioritization is especially important when resources are scarce, such as in the periods during and immediately following a disaster. In the aftermath of disasters, large numbers of patients may seek care at

primary care medical offices, so triage skills will be needed to determine whether these patients need hospital care or can be managed in the office setting. Pediatricians and others (including child life specialists) can help hospitals and other entities develop plans to care for children who have been separated from their parents. (See the AAP Family Separation and Reunification in Disasters resources www.aap.org/disasters/reunification.) Also, all disasters result in psychological stress. Pediatricians should be familiar with the normal developmental responses to stress and be able to screen for more serious problems and provide effective support for the vast majority of children. Having an appropriate referral system of mental health providers who can manage children in these special situations can be part of the preparedness plan.

**Practice Readiness and Staff Development**

Staff education and exercises are important to allow the office to function efficiently in a disaster. Staff education programs can be developed by the office staff or through connections with another organization. Besides the information that is included in the office preparedness plan, these programs should include basic information on the incident command system, community response, and the role of the practice in this response.

**Insurance**

After a disaster, it can take some time before the office practice or the community is able to return to business as usual. Insurance coverage is vital to maintain your business and ensure continuity of the practice. In major disasters, prepare for income to be significantly diminished for an extended period of time. Business interruption insurance policies can help, but to prepare effectively, the practice needs to determine how much revenue it can afford to lose and establish a line of credit with a bank. Also, staff should look very closely at the details of any insurance policy. Many standard policies may not cover certain disaster situations such as flooding. Inventory documentation will be required. Digital images or a video of the office contents is quick and useful for this documentation. Remember to update these recordings frequently. Separate vaccine insurance should be considered, because vaccines are likely the most expensive inventory in an office. Finally, an annual review of all policies should be performed.

**External Operations: Communications and Coordination with Other Agencies**

***Communication Systems:*** Communication and coordination among community agencies is essential to provide efficient and consistent care to the community during disasters. Unfortunately, in many communities, the schools, hospitals, medical agencies, and businesses may all have separate preparedness plans but little coordination or communication during the planning process. The local Office of Emergency Management can serve as a conduit for coordination of various local, state, and federal agencies. The office-based pediatrician is a resource to the community that is often overlooked. One of the challenges to the office-based pediatrician is becoming integrated into these community-wide plans. A good place to start is by contacting local and state departments of health and local hospitals. Pediatricians in larger health systems can contact their system’s preparedness director or team. Office-based pediatricians should also coordinate their planning with local school districts. Once it is known there is an interest, these groups may readily incorporate the pediatrician and the office practice into their response plans. The office-based pediatrician can become involved with community partners either actively or by offering to help with the education of its volunteers.

The office-based pediatrician plays a central role in providing accurate, timely information to patients and their families prior to, during, and after disasters. Pediatricians are considered trusted sources of information by patients and families, and they are expected to be knowledgeable in the areas of their concern.

***Anticipatory Guidance:*** Family preparedness should be part of the anticipatory guidance provided during well-child care visits. The AAP offers a Family Readiness Kit (www.aap.org/disasters/kit) and a comprehensive Web site for families (www.healthychildren.org). HealthyChildren.org provides valuable information concerning not only family disaster plans, but also tips about discussing disasters with children and ways to reduce the fear and anxiety associated with the event (www.healthychildren.org/English/safety-prevention/at-home/Pages/Getting-Your-Family-Prepared-for-a-Disaster.aspx).

***Communicating With Patients During Events:*** As mentioned, communication systems, especially telephone lines, are likely to be disrupted during disaster situations. Not only does this affect communications with office staff, but it also affects the practice's ability to provide accurate and timely information to the families of patients. Web sites and social media sites can be used to notify patients and families of transportation disruptions, contact information, and changes in office location and operation times. These communication avenues can be used to provide information about health concerns and relief efforts to the public, during the disaster and the immediate aftermath. The office preparedness plan should include details on which methods of communication will be used and how staff will respond to general questions and also provide responses to questions concerning individual patients. During these events, families may receive both good and bad information from a number of sources that can include the Internet, the media, and even public officials. The practice must make sure that it is providing accurate information and should strive to align its communications with messaging from other sources. Misinformation can result in panic, overreaction, and misuse of community resources and emergency services. One member of the office staff should be responsible for ensuring disseminated information is correct, and that all members of the staff are giving consistent messages. It is also important that the practice relays information that is consistent with the messages the public receives from state and local public health agencies and emergency management personnel. Contact information for these organizations' informational/public relations services should be included in the office preparedness plan.

## HOSPITAL-BASED PEDIATRICIANS

In mass-casualty incidents (including those involving chemical and biological agents), casualties among children and adults could be significant. Because children are likely to become victims in many disaster events, pediatricians should assist in preparedness planning to ensure the coordinated responses of local hospitals. In addition to patients, health care facilities may be overwhelmed by massive numbers of anxious individuals and families. Whether or not a hospital routinely cares for children, all hospitals must be prepared to care for children in a disaster. Pediatricians working in or supporting hospitals can play a vital role in ensuring appropriate care of the pediatric disaster victim by participating in all levels of disaster preparedness planning.

**Emergency Department Readiness**

The AAP offers several critical policy statements and resources specific to EMS and hospital preparedness and pediatric emergency medicine (www.aap.org/en-us/Documents/Current_COPEM_Policy_Statements_2018.pdf). Pediatricians should review these policy statements, with a priority of becoming familiar with the "Joint Policy Statement—Pediatric Readiness in the Emergency Department" (http://pediatrics.aappublications.org/content/142/5/e20182459) and the National Pediatric Readiness Project (https://emscimprovement.center/projects/pediatricreadiness/about/what-is-the-national-pediatric-readiness-project/) before proceeding to take steps to improve preparedness.

The prehospital disaster system is designed to triage victims in the field and carefully distribute them among available facilities to match patient needs with resources and keep a single facility from being overwhelmed. However, in many crisis situations, facilities are vulnerable to inundation with patients who arrive in large numbers without EMS transport and before entry triage. Often, these are the first patients to arrive at hospitals after mass-casualty events. Pediatricians working in or supporting hospitals should interact with hospital emergency management leaders to ensure adequate training and preparation of supplies and treatment areas in the emergency department. Pediatricians in hospitals can be key facilitators between emergency department services, critical care services, and regular inpatient services. Institutions should be ready to triage large numbers of pediatric patients, however, limited pediatric resources may necessitate pediatric triage even when adult needs can be adequately met. Hospitals and emergency departments should establish pediatric transfer and transport protocols with other facilities. Coordination with the local community should involve primary/prehospital/infrastructure response (with liaison planning to state and federal agencies) and community/citizen response.

**Inpatient Service Readiness**

Anticipating surge capacity for inpatient care is vital in preparedness planning. A tiered approach to pediatric care in disasters may be most efficient. This type of approach concentrates care for the most critically ill or injured children at hospitals with greater pediatric capabilities, and it uses nonpediatric care areas to provide care to children who are less ill.

Consider:

- Increasing surge capacity within hospitals that normally provide services for children (eg, by instituting rapid discharge protocols, using areas that are not typically part of intensive care units [ICUs] to increase ICU capacity [eg, postanesthesia care unit, procedure areas]). This process can also increase inpatient capacity and leverage available staff.
- Increasing pediatric capabilities at hospitals that do not normally provide services to children (implement recommendations within the "Joint Policy Statement—Guidelines for Care of Children in the Emergency Department").
- Increasing the number of inpatient beds within a community. This can be accomplished by converting available space into ward units (eg, cafeterias, meeting spaces) or making arrangements to use space in nearby hospitals. Areas such as local hotels or school gymnasiums can be converted into low-acuity medical facilities with some planning.
- Preparing in advance for emergency mass critical care for both neonatal and pediatric ICUs.

- Contingency plans for acquiring or maintaining essential services, such as water, electricity, portable oxygen, garbage/trash removal, Internet, medical records, etc.
- Planning for stockpiling or readily acquiring medical supplies such as antibiotics, antitoxins, and vaccines (in dosages and formulations appropriate for pediatric patients). In addition, pediatric-specific supplies and equipment in a full range of sizes to accommodate pediatric patients should be available.
- Networking with community resources to have plans in place for supervision of or caregiving for orphaned and unaccompanied children.

**Hospital Infrastructure Needs**

***Emergency Operations Plans:*** Hospital emergency operations plans need to include plans for caring for children, even in hospitals that primarily care for adults. In addition, the plans must be sufficiently thorough and detailed to provide meaningful guidance in an emergency. Pediatricians can work with hospital emergency preparedness leaders to ensure that these plans contain guidance for:

- Age-appropriate decontamination of children
- Moving between conventional, contingency, and crisis responses to a surge of pediatric patients
- Rapidly increasing pediatric critical care capacity by 20% above baseline capacity in a conventional response, by 100% in a contingency response, and by 200% in a crisis response
- Stabilizing and caring for critically ill or injured children in nonpediatric hospitals when access to pediatric hospitals is limited
- Accessing pediatric experts (including experts in burn care, critical care, infectious diseases, and toxicology) to support hospitals that do not employ or have experts on active staff
- Limiting spread of infection to patients, staff, and family members through robust infection-control practices
- Consideration of parental presence protocols
- Reunification planning (which includes tracking and identifying pediatric patients, caring for unaccompanied minors in pediatric safe areas, and reuniting separated families)
- Providing appropriate psychosocial support to children and families
- Developing a consistent approach to patient triage in situations with limited resources
- Ensuring that guidelines for crisis care incorporate children and are ethically sound
- Encouraging health care personal to have personal preparedness plans so that expectations are clear for times when health care workers provide services versus when they tend to personal needs
- Using pediatric interfacility transfer agreements to appropriately transfer children to higher or more specialized levels of care when needed

***Exercises and Drills:*** Hospital and community-wide exercises are essential to preparedness planning. These drills need to be detailed enough to test emergency plans, and scenarios and goals should align with the hospitals' hazard vulnerability analyses and test areas where there are gaps, areas of concern, or unknown preparedness (eg, the ability to evacuate a neonatal ICU during a power outage). Drills should include not only initial triage and decontamination but also continuing care in inpatient areas, including ICUs. Every disaster drill should include pediatric patients; this is especially important for hospitals that do not normally provide care to children. See additional information in the Pediatric Preparedness Exercises section.

***Staff Training:*** Staff training should, at a minimum, include:

- Decontamination of younger children, including the use of warm water and chaperones
- Emergency stabilization of children in nonpediatric emergency departments
- Provision of critical care to children in nonpediatric ICUs
- Appropriate infection control practices, specific to the care of children and their families
- Personal emergency preparedness
- Orientation to the Incident Command System for those who will staff or interact with the hospital's EOC
- Understanding of "Access and Functional Needs" or the mechanism by which FEMA addresses at-risk individuals who might need additional assistance in a disaster (www.phe.gov/Preparedness/planning/abc/Pages/afn-guidance.aspx)
- Strategies for coping with family demands, developmental concerns, behavioral health, and provider self-care

## PEDIATRICIANS IN AMBULATORY OR URGENT CARE SETTINGS

Community-based (nonhospital) health centers with capabilities in pediatric urgent care can play an important role in a disaster. Urgent care, including pediatric urgent care, is a rapidly evolving presence in the community and, with the necessary resources and training, could serve as sites to care for certain ill or injured children in a disaster. Pediatric urgent care centers are prepared to efficiently care for children with higher acuity injuries and illness when hospital emergency departments are unable to handle surge capacity. These centers can evaluate and reassure families that become concerned in the aftermath of a disaster (ie, the "worried well"), and are prepared to evaluate and treat a more severely ill or injured child. Many sites have laboratory and imaging services available as well as the ability to splint, suture, provide intravenous fluids, and perform minor procedures. In this capacity, many urgent care centers can offload patients from the emergency department, allowing the emergency department to more effectively care for the most critically ill or injured children. However, limitations must also be considered as capabilities will likely vary from site to site. Most recommendations for office practices (see above) apply to these settings.

### Communication

Effective communication in a disaster is crucial and plans must be established prior to an event. This includes both internal communication (within an urgent care center or among multiple sites within an urgent care system) and communication with external community resources and organizations.

Establishing relationships in advance and understanding the capabilities and expectations of outside resources and vice versa is critical to a successful effort. A written memorandum of understanding with these outside agencies will clearly define roles and expectations in advance of a disaster. Communication should be ongoing and bidirectional throughout an event.

Multiple means of communication and a backup plan may be necessary given risk for power outages and overwhelmed systems (such as telephone service). In the event of a power failure, cellular telephone communication may still be possible, but communication via e-mail systems

would likely not be accessible right away. Portable cellular telephone chargers should be available.

The following options for communication should be considered:

- Telephone landlines
- Cellular telephones (voice calls and text messaging)
- Internet (facility Web site and social media)
- Two-way radio
- Satellite telephones
- Runners
- Posting of written notices in places where constituents might see these

Both electronic and paper lists of all key contacts should be readily accessible to staff members. A designated person within the urgent care center or system should know how to access and disseminate information from the local public health departments and the CDC, particularly when and Health Alert Network (HAN) messaging occurs.

Internal communication is also important for both activation of an emergency plan and ongoing communication during a disaster. Group e-mails or texts are efficient means of conveying information regarding plans and updates and are simple ways to receive a response. Intranet, if available, is also an easy way to communicate. Direct telephone landline communication is not as efficient as sending group messages but is still an option for one-on-one communication, although telephone landlines may be the first means of communication to break down. Group conference calls for daily updates can work well, once connectivity is available. Electronic (cellular telephone, hard drive, USB flash drive) and paper lists with staff contact information (telephone numbers, e-mail addresses, emergency contacts) should be available for all staff members and updated on a regular basis. Staff members should know key contacts in advance as well as their preferred means of communication.

Ongoing information to the community regarding hours of operation (extended hours or early closing) can be communicated via social media, telephone voice message, Web site postings, e-mail blasts, and posting of printed materials. Communication with primary care providers in the community may facilitate referral of their patients if their offices are inoperable or if higher level of care is needed. Again, these relationships are best established before a disaster occurs. Larger facilities may have a department responsible for regular and crisis communications.

Resources are available to assist businesses with many of these functions (www.ready.gov/business).

**All-Hazards Approach**

An all-hazards approach is most effective when creating a disaster management plan for an urgent care center. The disaster plan should account for response to both natural and manmade disasters, including those caused by chemical, biological, radiological, nuclear, and high-yield explosive (CBRNE) events. Additionally, all possible hazards that could affect the region including natural disasters (weather-related or environmental), man-made disasters

(transportation events, fires, structural collapse, terrorist attacks, weapons of mass destruction) and epidemics/pandemics should be considered and planned for accordingly.

Urgent care centers will vary in their ability to respond to injuries and illnesses caused by a disaster but should be aware of the potential for presentation of victims from a variety of disaster situations. An urgent care center may be the first place a victim presents, and early identification is critical to mitigate damage. For example, a person contaminated with a chemical or ill with a highly infective agent may present to an urgent care center unknowingly, and the etiology must be rapidly identified. Screening for potential infectious diseases by assessing symptoms and travel history early in the visit is helpful. Each facility should assess capabilities, understand limitations, screen patients, and have a plan in place for avoiding contamination or rapidly transferring patients who require care beyond the capabilities of the urgent care center.

**Leadership**

Leadership during an event should follow the National Incident Management System (NIMS) guidelines (www.fema.gov/national-incident-management-system), allowing for consistency across multiple organizations. The Incident Command System [ICS] (www.fema.gov/incident-command-system-resources) is an important component of any disaster response, and ICS staff should include an incident commander along with a public information officer, safety officer, and liaison officer. In a smaller urgent care setting, a single person may be responsible for multiple roles. Sections include operations (doers), planning (thinkers), logistics (getters), finance and administration (payers). Leadership will be responsible for distributing job action sheets to staff with instructions allowing for just-in-time preparation.

**Logistics and Operations**

Assessing the operational capabilities of an urgent care center and recognizing the necessary supplies for an incident prior to the event is critical. Urgent care centers will likely have varying capabilities for handling pediatric patients with pediatric urgent care centers being most capable of caring for acutely ill or injured pediatric patients. With proper planning and practice, however, most facilities should be able to provide initial care and stabilization of urgent needs in pediatric patients and have a plan in place to transfer patients to the facility where they are most likely to receive the care they need. A pediatric urgent care center may need to anticipate ramping up the level of care provided as hospital emergency departments reach surge capacity. For example, patients with burns or fractures that might normally be transferred out might need to remain in the urgent care center for treatment. Transportation options and resources may be limited. Again, potential capabilities should be determined prior to an event along with establishment of clinical guidelines for managing these patients.

Rapid triage assessment using medical personnel trained in recognizing acutely ill or injured children should be in place. Triage space should be near the entrance to the facility to allow for screening for potentially contagious infectious diseases by asking key questions about symptoms and travel. Urgent care centers may not have the capacity for decontamination. However, patients needing decontamination may present to the facility, and therefore, there should be protocols for handling these situations. Patients who might require decontamination need to wait outside the facility in a designated area so as not to contaminate others. The agency responsible for decontamination should be notified. A written plan for staff protocols should be in place.

The number of patients that might arrive at an urgent care center in a disaster can be difficult to predict. It is important to determine surge capacity for the facility. Can patient treatment areas be expanded by using chairs or cots? Can hours of operation be extended? Can staffing be increased? How can patients be moved through the facility most efficiently (one-way flow is often most efficient)?

Staffing during a disaster is likely to be difficult to manage. Of utmost consideration is staff safety and well-being. Additional staffing will be needed to accommodate extended hours and surge capacity. However, staff may be ill or injured or unable to travel safely to work. Staff members may also have ill or injured family members that need care at home or children that cannot be left alone. These issues provide additional stress for staff making it more difficult for them to perform their job effectively and efficiently. Having someone available to care for staff dependents at the urgent care center could relieve this burden and allow staff to come to work.

Consider using staff from other facilities within the organization. Another location may have staff willing to travel to the affected site. For staff working long hours, food, water, and a place for rest should be available. Providing staff with necessary support and rest time is critical for keeping the team functioning optimally. All of these issues, including plans for paying staff (ie, amounts, overtime) for their work should be discussed in advance. It is also important to predetermine the policy for paying staff if they are unable to get to work or if the facility needs to shut down. A sick leave or paid time off policy should be considered.

The most effective way to prepare staff for a disaster is to have exercises and simulations at regular intervals. Staff should know where to find procedures and plans for an event, have readily accessible contact information, be able to rapidly locate equipment, and understand expected roles.

**Supplies and Medical Records**

Supplies necessary to handle surge capacity and higher acuity of ill or injured children need to be maintained. Supplies should also be readily accessible, clearly labeled, checked on a regular basis, rotated, and checked for expiration dates. Supplies and equipment should be kept in a safe area free from possible damage yet readily accessible. Relationships should be established in advance with vendors who can rapidly replenish supplies in an ongoing disaster. In addition to medical supplies, food and water should be available for sheltering in place for up to 72 to 96 hours. A pediatric crash cart with airway equipment, emergency medications, and intravenous (IV)/intraosseous access should also be maintained. Readily available supplies include the following:

- Alcohol wipes
- Bandages, gauze, elastic wrap bandages
- Batteries
- Calculator
- Cold packs
- Exam equipment (stethoscope, otoscope/ophthalmoscope, tongue depressors, thermometer, blood pressure cuff, etc)
- Flashlight

- Hand sanitizer
- Medications/fluids (eg, acetaminophen, ibuprofen, albuterol, oral/intramuscular/topical antibiotics, ondansetron, diphenhydramine, steroids, epinephrine 1:1000, 1% lidocaine)
- Nebulizers (including battery operated), metered-dose inhalers and spacers
- Needles, syringes
- Oral rehydration solution (liquid and powder)
- Oxygen tanks
- Personal protective equipment (including masks, gowns, gloves, face shields)
- Radio
- Reference book
- Splinting material
- Suture material
- Trauma scissors

Keeping an urgent care disaster kit on hand that can be grabbed quickly to assist with emergencies outside the facility or taken to another center if the urgent care center cannot remain open because of structural damage or power failure is also part of an emergency preparation plan. The kit should be stocked with most of the items noted above. Be aware of what supplies require refrigeration in case of a power outage. Some urgent care centers may have access to a power generator that would allow for the facility to remain operational.

Because most facilities have electronic health records, loss of electricity or computer/Internet access can present a real problem. Flow for downtime should be determined in advance and paper forms for registration, evaluation, and discharge should be readily available. Knowing the downtime flow for registration, charting, and tracking patients will allow for minimal interruption in patient care. The downtime recovery process should include a procedure for billing and integrating paper charts into the electronic medical record.

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# CHAPTER FOUR:
# MENTAL HEALTH ISSUES

## MENTAL HEALTH AND THE ROLE OF THE PEDIATRICIAN

Schools and pediatricians have generally become the de facto mental health providers for children. Children are most likely to receive treatment from primary care physicians for symptoms associated with mental disorders, and most psychotropic drug prescriptions for children and adolescents are prescribed by primary care physicians. In a disaster or terrorist event, the need for mental health services will be far greater and the resources even less adequate. Pediatricians and other health professionals that care for children will play many critical roles in identifying and addressing the mental health needs of children and families in a disaster or terrorist event.

For many, if not most, children affected by a critical event, pediatricians and other health care providers for children will be the first responders. Therefore, pediatricians need to be able to identify psychological symptoms, perform timely and effective triage of mental health complaints, initiate brief supportive interventions, and make appropriate referrals when necessary. Many children (and their parents) with emotional reactions to a disaster (manmade or otherwise) will not identify their problems as psychological in nature. Pediatricians will have to be vigilant for somatization and help children, and their families, recognize and address the underlying psychological cause of these physical complaints. Because children's adjustment depends to a great extent on their parents' own ability to cope with the situation, pediatricians should also attempt to identify parents who are having difficulties adjusting to the event and encourage them to seek support for themselves. Pediatricians can also help families identify and access appropriate supportive or counseling services, and they can help support families who are reluctant to seek mental health services because of misunderstandings related to the nature of the treatment or associated stigma.

## PEDIATRIC TRAUMA-RELATED DISORDERS

Children are not immune to the emotional and behavioral consequences of disasters and terrorism. Their reactions depend on their own inherent characteristics and experiences, their developmental level, and family and social influences as well as the nature and magnitude of the event and their exposure to it.

Exposure to disasters and terrorism can be direct, interpersonal, or indirect. Children who are physically present during an incident are directly exposed. Interpersonal exposure occurs when relatives or close associates are directly affected. Indirect exposure occurs through secondary negative consequences of an event, such as chaos and disruption in daily activities. Children who are far away from an incident may be remotely affected with fear and generalized distress as they perceive the societal impact of these experiences.

Exposure to media coverage may play a role in the child's reaction to an event. Studies have documented an association between viewing television coverage of terrorist incidents and post-traumatic stress reactions, but these associations do not establish a causal relationship. Aroused children may be drawn to the information provided by the media, and it is possible

that other factors are responsible for the link between exposure to media coverage and these emotional states.

**Reaction to Disasters and Terrorism**

There are a wide range of adjustment reactions that may generally be seen in children after a disaster or act of terrorism, as outlined in **Table 4.1: Common Symptoms of Adjustment Reactions in Children after a Disaster or Act of Terrorism.** Children may develop psychiatric symptoms and disorders—including post-traumatic stress disorder (PTSD), anxiety, depression, and behavioral problems—after exposure to disasters or terrorist incidents. Grief in these situations can be compounded by the traumatic circumstances associated with the loss.

| **Table 4.1: Common Symptoms of Adjustment Reactions in Children after a Disaster or Act of Terrorism** |
|---|
| Sleep problems: difficulty falling or staying asleep, frequent night awakenings or difficulty awakening in the morning, nightmares, or other sleep disruptions |
| Eating problems: loss of appetite or increased eating |
| Sadness or depression: may result in a reluctance to engage in previously enjoyed activities or a withdrawal from peers and adults |
| Anxiety, worries, or fears: children may be concerned about a repetition of the traumatic event (eg, become afraid during storms after surviving a tornado) or show an increase in unrelated fears (eg, become more fearful of the dark even if the disaster occurred during daylight); this may present as separation anxiety or school avoidance |
| Difficulties in concentration: the ability to learn and retain new information or to otherwise progress academically |
| Substance abuse: the new onset or exacerbation of alcohol, tobacco, or other substance use may be seen in children and adults after a disaster |
| Risk-taking behavior: increased sexual behavior or other reactive risk-taking can occur, especially among older children and adolescents |
| Somatization: children with adjustment difficulties may present instead with physical symptoms suggesting a physical condition |
| Developmental or social regression: children (and adults) may become less patient or tolerant of change or become irritable and disruptive |
| Post-traumatic reactions and disorders: see Table 2: Symptoms of Post-traumatic Stress Disorder) |

***Risk Factors for Adjustment Difficulties:*** The following factors are associated with an increased risk of post-traumatic symptoms and other adjustment difficulties:

- The children themselves, or others close to them, are direct victims, especially if injury is involved (or the death of significant others).
- Children directly witness the event, especially if there was exposure to horrific scenes (indirect exposure through the media to these scenes is also associated with increased risk).
- Children perceive during the event that their life is in jeopardy (even if the perception is inaccurate).
- Event results in separation from parents or other caregivers.

- Event results in loss of personal property or other disruption in regular environment.
- Children have a history of prior traumatic experiences.
- Children have a history of prior psychopathology.
- Parents have difficulty coping with the aftermath of the event.
- Family lacks a supportive communication style.
- Community lacks the resources to support children after the event.

***Post-traumatic Stress Disorder:*** The essential feature of PTSD is the development of characteristic symptoms after exposure to a traumatic event that arouse intense fear, helplessness, or horror or that lead to disorganized or agitated behavior. Current diagnostic criteria are outlined in **Table 4.2: Symptoms of Post-Traumatic Stress Disorder.** Clinicians should note that children with other adjustment difficulties (eg, bereavement) may appear to meet these current diagnostic criteria.

**Table 4.2: Symptoms of Post-Traumatic Stress Disorder**

Exposure: The child is exposed to actual or threatened death, serious injury, or sexual violence. This exposure may be through the child's direct experience; by witnessing the traumatic event, especially when involving a caregiver; or by the child learning that the traumatic event occurred involving a close family member or friend without any direct experience or witnessing of the event by the child.

The following symptoms must occur for more than 1 month's time:

1. Intrusive symptoms:
   - The child has repeated distressing memories and/or dreams (nightmares) about the traumatic event; it is not required for children to remember the content of these distressing dreams. For some children, repetitive play activities may involve themes or aspects of the traumatic event.
   - The child may display a loss of awareness of present surroundings (dissociation) and act as if the traumatic event is reoccurring (flashbacks).
   - The child may experience intense or prolonged psychological distress and/or physiological reactions at exposure to internal or external cues that symbolize or resemble the traumatic event.
2. Avoidance
   - The child attempts to avoid distressing memories, thoughts, feelings, activities and/or places that remind him or her of the traumatic event.
3. Negative alterations in cognitions and mood
   - The child has problems remembering important aspects of the traumatic event.
   - The child maintains negative beliefs or expectations about oneself, others, or the world.
   - The child has thoughts about the cause or consequences of the traumatic event that lead to blame of self/others.
   - The child experiences negative emotional states, such as depression, and has trouble experiencing and expressing positive emotions.
   - The child shows a markedly diminished interest or participation in significant activities including play.
   - The child feels distant from others, which may lead the child to become socially withdrawn and avoid people, conversations, or interpersonal situations.
4. Increased arousal and reactivity associated with the traumatic event:
   - Irritable and angry outbursts (extreme temper tantrums)
   - Reckless or self-destructive behavior
   - Hypervigilance
   - Exaggerated startle response
   - Problems with concentration
   - Sleep disturbance

The symptoms must last for more than 1 month and must cause clinically significant distress or impaired functioning. Because of developmental influences, symptoms in young children may not correspond exactly to those in adults.

***Other Conditions:*** Other conditions, especially anxiety and affective disorders, are common after crisis events and may occur independently or together with PTSD. These conditions may precede, follow, or develop at the same time as PTSD. Establishing the temporal relationship in onset of disorders may aid in treatment. For example, PTSD stems from the primary traumatic event, whereas depression may result secondarily from persistent severe PTSD symptoms or intervening stresses. Fear and avoidance of situations reminiscent of the trauma may persist for years.

***Behavioral Reactions:*** Signs of trauma may be evident in children's behavior, mood, and interactions with others. Traumatized children may adopt behavior more appropriate of younger children. Although they may not share their concerns and they may be especially compliant in the aftermath of an incident, compliant behavior does not mean the child is unaffected. Withdrawal is a cause for concern as it may represent a symptom of PTSD, and it potentially distances the child from adults who could provide support and assistance. Girls are more likely to express anxiety and sadness; boys tend to exhibit more behavior problems.

The child's reaction will reflect his or her developmental level. Infants may experience sleep and feeding problems, irritability, and failure to achieve developmental milestones. Problems in preschool children include separation anxiety, dependence, clinginess, irritability, misbehavior, sleep disturbance, and withdrawal. Problems in school-aged children and adolescents includes those seen in younger children as well as somatic complaints, anxiety, change in academic performance, guilt, anger and hate, and preoccupation with death.

***Grief and Traumatic Grief:*** Although grief is not a mental disorder, it may require professional attention, especially if it is complicated by depression or PTSD. Traumatic deaths are of particular concern in disasters because of the implications for assessment, which should include an evaluation of the circumstances of the death and the child's exposure, and for treatment, which should address trauma symptoms as well as grief. In some ways, any death may be perceived by survivors as subjectively traumatic; however, 5 factors have been described that are likely to be present in death circumstances that are considered "traumatic deaths":

- Sudden, unanticipated deaths
- Deaths involving violence, mutilation, and destruction
- Deaths that are perceived as random and/or preventable
- Multiple deaths
- Deaths witnessed by the survivor that are associated with a significant threat to personal survival or a massive or shocking confrontation with the death and mutilation

Deaths that occur in the context of a disaster or terrorist situation often meet these criteria and pose an increased risk of traumatic grief. Referral to a pediatric mental health professional is often indicated in these situations, but this approach may also be of benefit when grief reactions are extreme, atypical, prolonged, or disrupting daily functioning.

## ASSESSMENT AND TREATMENT OF TRAUMA-RELATED DISORDERS

Assessment and treatment of trauma-related disorders in children after a disaster will vary, depending on the characteristics of the disaster and the child's exposure, the setting, and the length of time since the event.

### Early Interventions

In the acute-impact and early postimpact phases, supportive interventions should ensure the child's safety and protection from additional harm, address immediate physical needs, provide reassurance, minimize exposure to traumatic aspects of the event, validate experiences and feelings, and restore routine. Children benefit from accurate information, but it should be age-appropriate and measured, avoiding unnecessary or graphic details. If possible, pediatric mental health professionals can help other health professionals and family members with the process of death notification. Reuniting family members is a priority.

### Assessment and Screening

Assessment should include a history of the child's exposure and reactions. When children or their close family members have been directly exposed, the children may require more comprehensive assessment. Children with less direct exposure may also need attention. Children and their parents should be educated about trauma reactions and coping and may welcome opportunities to ask questions and correct misperceptions. Children may not spontaneously describe their feelings, and adults may underestimate trauma in children. Therefore, it is essential to ask children directly about their experiences. Observation and the use of projective techniques, such as play and the use of art, aid in assessment and are useful in treatment as well.

Screening to identify children at risk and those needing referral can be conducted with symptom rating scales, which typically measure the type and degree of exposure, subjective reactions, personal consequences, and PTSD symptoms, and inquire about other related symptoms such as fear and depression, grief, and functioning.

### Treatment

Treatment should be guided by the child's exposure and reactions. Cognitive behavioral therapy and psychoeducation provide structure and support and may be used in individual or group sessions after disasters.

Group sessions can be used to provide age-appropriate explanations of acute and longer-term reactions, reactions to traumatic reminders, secondary effects, anniversary reactions, and coping. Parallel parent groups provide a means to address parental reactions and concerns and to discuss effective management. These groups also provide an opportunity to teach parents how to parent their children who have been traumatized.

The family has a major role in the child's adjustment to trauma, and parents should be included in treatment. Often, more than one family member will be traumatized, although specific aspects of exposure may differ among family members. Helping parents resolve their own emotional distress can increase their perceptiveness and responsiveness to their children. Parents may also

benefit from psychoeducation about symptoms, how to manage symptoms effectively, and ways to decrease traumatic reminders and secondary stresses.

Medication is rarely indicated in children after disasters but might be used for those with severe reactions. Consultation with a child psychiatrist is recommended when medication is being considered. When used, medication should be coupled with psychotherapeutic interventions such as play therapy or cognitive behavioral approaches. Specific symptoms determine whether to use a drug, which drug to use, and how long to use it. Comorbid conditions should be considered in selecting an agent. Selective serotonin reuptake inhibitors may be effective in treating childhood PTSD and comorbid anxiety and depression.

### School-Based Interventions

Schools are an excellent setting to deliver mental health services to children and families after a disaster. They provide access to children, encourage normalcy, and minimize stigma. PTSD and associated symptoms are likely to emerge in the school setting. For example, intrusive thoughts and difficulty concentrating may interfere with academic performance and social adaptation. Therefore, school consultation about the consequences of trauma and the recovery process may be indicated. School-based interventions, which can include curricular materials and activities, should be appropriate for the setting and should not supplant efforts to identify and refer children in need of more intensive individual evaluation and treatment. Manualized group interventions based on cognitive behavioral approaches, such as CBITS (Cognitive Behavioral Intervention for Trauma in Schools), can be delivered in schools by mental health professionals and have been shown to be effective in treating symptoms of PTSD.

### Long-term and Staged Interventions

Long-term interventions may be necessary, especially for children with direct or interpersonal exposure and for those with enduring symptoms, pre-existing or comorbid conditions, prior or subsequent trauma, or family problems. New issues related to trauma may emerge as children mature. Thus, developmentally-appropriate staged interventions, which anticipate and address the course of recovery, should be considered during developmental transitions and at marker events such as anniversaries.

## DEATH NOTIFICATION AND PEDIATRIC BEREAVEMENT

### Considerations in Notifying Individuals About an Unexpected Death

At the time of a large-scale disaster or terrorist attack, it is very unlikely that pediatric health care providers will have the time and resources to deliver death notification in an optimal manner. Nonetheless, sensitivity to the issues discussed here can help minimize the short- and long-term impact on survivors.

***Before Notification:*** Consider these issues before initiating the notification process:

- Verify the identity of the deceased and identify the next of kin.
- Establish contact as soon as possible. Do not delay contact waiting for a time thought to be more convenient for the survivors (eg, if the death occurs in the middle of the night, do not wait until the following morning).

- Contact the next of kin. Phone calls can be used to contact next of kin, but death notification is preferably done in person. Alternatively, someone (eg, police) can be sent to the home of the next of kin to ask them to come to the hospital for notification purposes.
- Minimize the likelihood that you will be compelled to notify the family members of the death over the phone. If you contact the survivor(s) by phone to request they come to the hospital, try to contact the family before the death has been declared (ie, during resuscitation) or have someone else who has not been directly involved in the care call on your behalf. Someone not directly involved in the care could make a statement such as: "I know that your husband was seriously hurt in the bombing, but I don't have any further information. If you come to the hospital now, someone who has been taking care of your husband will be available to talk with you when you arrive." If family members demand information on the phone, the caller can state: "I would prefer to talk with you about this in person when you arrive at the hospital."
- Consider inviting additional family members or friends to accompany the next of kin to the hospital for notification. If a child has died, it is best to notify both parents at the same time. When any family member has died, survivors may benefit from being told with at least one other family member or friend present. Family members and friends can provide support to the next of kin and help notify other relatives and friends (instead of the entire burden being placed on one survivor).
- Before notifying the family, briefly review the basic facts, including the name of the deceased, the relationship to individual(s) that will be notified, the basic circumstances of injury and death, and the nature of medical care provided. For example, the individual was in a building when a bomb detonated and was found under rubble; CPR was performed until arrival in the emergency department, where after an attempt at resuscitation, he was pronounced dead. Identify who else will participate in the notification, and consider planning in advance for how to initiate the conversation.

***At the Hospital:*** Once the family arrives at the hospital, consider the following:

- When the family arrives at the hospital (or site where death notification will be occurring), have them escorted to a private location, if possible. Try to inform them in as private a site as possible; if there is no opportunity for a private room, make every reasonable effort to maximize privacy (eg, use a curtain or notify the family while standing behind the building instead of in front). Do not inform family members in view of the media; anticipate the presence of media or members of the public who might otherwise photograph or videotape family members and try to offer survivors the opportunity to maintain their privacy as much as possible immediately after notification.
- If possible, have the notification conducted by a physician who was involved in the care, especially if he or she knows the family or had some direct involvement. Comments such as "I was with your husband when he first arrived at the hospital. He was not conscious at the time and therefore was not feeling any pain" can be very helpful to families. Inform the patient's primary care provider whenever possible.
- Consider involving at least one other professional on the health care team, such as a social worker, chaplain, nurse, etc. If more than one family member is receiving the notification, conducting the notification with another professional is especially helpful; however, one staff person should be in charge of the discussion. Try to include at least 2 staff people for notification, even when notification is conducted in the field, but limit the number of staff to

those directly involved. It can be overwhelming for a family member to be notified by a large team.

- Just before and during the notification process, try to assess whether the survivors have any physical (eg, severe heart disease) or psychological (eg, major depression) risk factors, and assess their status after notification has been completed.

***During Notification:*** When it is time to notify the family in person, remember to:

- Introduce yourself and any other member(s) of the health care team who are participating by name and title and offer to shake hands.
- Offer seating to the survivors. Sit close to them and face them so that eye-to-eye contact can be easily maintained.
- Refer to the deceased by name and/or relationship to the survivor (eg, "Mr. Smith" or "your husband"). Avoid referring to the person as "the deceased" or "the victim." If children are included, involve professionals with training and experience in working with children in the notification process. Notification of the death of a family member is preferably provided to children by family members (such as the surviving parent) soon after the parent is informed, rather than having notification be provided by professionals unknown to the child. However, parents may wish for professionals to be present when children are told to provide support and to help answer questions.
- Remember that informing survivors of a death is a process, not an act. Pacing of the discussion is important. Do not start by stating that the individual is dead, because survivors are unlikely to hear any further information.
- Start by asking the family what they have already been told or know. Then provide a brief description of the circumstances of the injury and the relief efforts. This information helps the survivors understand the context of the death; not knowing what happened introduces a discontinuity in the history that impairs adjustment. After giving brief background information, it is useful to give a "warning notice" and then proceed fairly quickly to stating that the individual died. Ideally, the family will be present during the resuscitation efforts, and medical staff can provide the background information when the resuscitation begins and return to deliver updates that may serve as a "warning notice." For example, "The team has given several medications to try to get your husband's heart starting again, but so far there has not been any response."
- An example of a notification initiated after a death might be: "There was an explosion 2 hours ago that we believe was caused by a bomb in the building where your husband works. The explosion started a fire that spread rapidly. Firefighters arrived on the scene within several minutes, but the exits were blocked and flames spread quickly. Many individuals were unable to get out of the building before they were overwhelmed by smoke. I am sorry to say that your husband did not get out of the building in time. We believe he died as a result of the smoke from the fire. His body was recovered by a firefighter, and we identified him by the wallet that we found in his pocket. We found your phone number in the wallet. I am very sorry to have to be telling you this news."
- After notifying the survivor(s) of the death, pause to allow both the information to be processed and emotions to be expressed. Do not try to fill the silence, even though it may seem awkward. Listen more than you speak. Silence is often better than anything you can say. Stay with the family members as they are reacting to the news, even if they are not talking.

- Use clear and simple language. Avoid euphemisms such as terminated, expired, or passed away. State that the individual died or is dead.
- Do not provide unnecessary graphic details. Begin by providing basic information and allow the individual to ask questions for more details.
- Do not lie or speculate. If you do not know the answer to a question, say so. Try to get the answer if possible.
- Be conscious of nonverbal communication and cues, both those of the family as well as your own.
- Be aware of and sensitive to cultural differences. If you do not know how a particular culture deals with a death, it is fine to ask the family. Be particularly attentive to difficulty speaking or understanding English. If there is any doubt whether the family members are fluent in English, make sure to have a professional translator present unless you are fluent in the family's preferred language. Using family and friends as unofficial translators often leads to inadequate translation in the general medical setting. Such reliance on family and friends as translators for death notification is particularly burdensome to them and should be avoided.
- Consider the use of limited physical contact (eg, placing a hand on the family member's shoulder or providing a shoulder to cry on). Monitor the individual's body language and if at all in doubt whether such contact would be well received, ask first.

***Additional Considerations:*** Below are a few additional issues to keep in mind:

- Realize that the individual may initially appear to be in shock or denial. Expect additional reactions, such as sadness, anger, guilt, or blame. Acknowledge emotions and allow them to be expressed without judgment.
- Do not ignore or dismiss suicidal or homicidal statements or threats. Investigate any such statements (often this will be facilitated by the involvement of mental health professionals), and if concerns persist, take appropriate action.
- If possible, write down your name and contact information in case the family wants further information at a later time. If the situation is not appropriate for providing your name and contact information, then consider how the family may be able to obtain additional information in the future (even months later). For example: "I work as a volunteer for the Red Cross. Here is my name and the contact information for the Red Cross Chapter. If later you wish more information about what happened to your husband, you can call them at this number and they should be able to look at the records." Survivors may not be ready to think of or ask questions and may later regret not asking for critical information.
- Do not try to "cheer-up" survivors by making statements such as "I know it hurts very much right now, but I know you will feel better within a short period of time." Instead, allow them their grief. Do not encourage them to be strong or to cover up their emotions by saying "You need to be strong for your children; you don't want them to see you crying, do you?"
- Feel free to express your own feelings and to demonstrate empathy, but do not state you know exactly how family members feel. Comments such as "I realize this must be extremely difficult for you" or "I can only begin to imagine how painful this must be to hear" can demonstrate empathy. Avoid statements such as "I know exactly what you are going through" (you can't know this) or "You must be angry" (let the individual express his or her own feelings; don't tell the person how to feel) or "Both my parents died when I was your age" (don't compete with the survivor for sympathy). Provide whatever reassuring information you may be able to, such as "It appears your husband died immediately after the

explosion. It is unlikely he was even aware of what happened and did not suffer before he died." However, do not appear to use such information as an attempt to "cheer-up" family members (eg, "You should be happy, many people suffered painful burns or were trapped under rubble for an hour before they died. At least your husband didn't experience that.")
- Feel free to demonstrate that you are upset as well—it is fine to get choked-up or become tearful. If you feel, though, that you are likely to become overwhelmed (eg, sobbing or hysterical), then try to identify someone else to do the notification.

***After Notification:*** Consider the following as discussions conclude:
- After you have provided the information to the family and allowed adequate time for them to process the information, you may wish to ask questions to verify comprehension.
- Offer the family the opportunity to view the body of the deceased and to spend some time with their loved one. Before allowing the family to view the body, the health care team should prepare it for viewing by others. A member of the health care team should escort the family to the viewing and remain present, at least initially. Tell them what needs to be done regarding the disposition of the body. For further information about preparation of the body for viewing, as well as additional recommendations about the death notification process, see *Death Notification: A Practical Guide to the Process* by R.M Leash (Hinesburg, VT: Upper Access, 1994).
- Help families figure out what to do next. Offer to help them notify additional family members or close friends. Check to see whether they have a means to get home safely (if they have driven to the notification, they may not feel able to drive back safely). Ask if they have someone they can be with when they return home.
- Help survivors identify potential sources of support within the community (eg, member of the clergy, their pediatrician, family members, or close friends).
- Take care of yourself. Death notification can be very stressful to health care providers. Health care providers need to explore and come to understand their own reactions to patient death and associated emotions, which may include sadness, anger, guilt, or a sense of responsibility. It is important to provide support to professionals who provide death notification, especially if related to tragic deaths or when multiple deaths are involved (as would be anticipated in a major disaster or terrorist event).

**Explaining Death to Children**

Children's understanding of death may be very different from that of adults. Children have had far less personal experience of loss and have accumulated less information about death. They can also have difficulty understanding what they have seen and what they are told unless the basic concepts related to death are explained to them. Adults will need to provide especially young children with both the basic facts about what happens to people after they die, as well as the concepts that help them to explain those facts. For example, young children may be told that after people have died, their body is buried in a cemetery or turned to ashes that can then be buried or scattered. Children can be very distressed by these facts unless they are helped to understand the concept that at the time of death, all life functions end completely and permanently—the body can no longer move, and the person is no longer able to feel pain. That is why it is okay to bury or cremate the body.

Children need to understand 4 concepts about death to comprehend what death means and to adjust to a personal loss: irreversibility, finality, inevitability, and causality **(Table 4.3: Concepts of Death and Implications of Incomplete Understanding for Adjustment to Loss).** Most children will develop an understanding of these concepts between ages 5 and 7, but this varies widely among children of the same age or developmental level, based in part on their experience and what others have taught them. When faced with a personal loss, some children 2 years or younger may demonstrate at least some comprehension of these concepts. Adults should not underestimate the ability of young children to understand what death means if it is explained to them appropriately. Therefore, it is best to ask children what they understand about death, instead of assuming a level of comprehension based on their age. As children explain what they already understand, it will be possible to identify their misunderstandings and misinformation and to correct them accordingly.

**Table 4.3: Concepts of Death and Implications of Incomplete Understanding for Adjustment to Loss**

| Concept | Example of Incomplete Understanding | Implication |
|---|---|---|
| ***Irreversibility*** | | |
| Death is seen as a permanent phenomenon from which there is no recovery or return. | Child expects the deceased to return, as if from a trip. | Failure to comprehend this concept prevents child from taking the first step in the mourning process, that of appreciating the permanence of the loss and the need to adjust ties to the deceased. |
| ***Finality (Nonfunctionality)*** | | |
| Death is seen as a state in which all life functions cease completely. | Child worries about a buried relative being in pain or trying to dig himself or herself out of the grave; child wishes to bury food with the deceased. | Can lead to preoccupation with physical suffering of the deceased and may impair readjustment; serves as the basis for many horror stories and films directed at children and youth (eg, zombies, vampires, and other "living dead"). |
| ***Inevitability (Universality)*** | | |
| Death is seen as a natural phenomenon that no living being can escape indefinitely. | Child views significant individuals (ie, self, parents) as immortal. | If child does not view death as inevitable, he or she is likely to view death as a punishment (either for actions or thoughts of the child or the deceased), leading to excessive guilt and shame. |
| ***Causality*** | | |
| A realistic understanding of the causes of death is developed. | Child who relies on magical thinking is apt to assume responsibility for death of a loved one by assuming bad thoughts or unrelated actions were causative. | Tends to lead to excessive guilt that is difficult for child to resolve. |

When providing explanations to children, use simple and direct terms. Be sure to use the words "dead" or "died" instead of euphemisms that children may find confusing. If young children are told that the person who died is in "eternal sleep," they may expect the deceased to later awaken and be afraid to go to sleep themselves. This description does little to help children understand death and may cause more confusion and distress. Religious explanations can be shared with

children of any age, but adults should appreciate that religious explanations are generally very abstract and therefore difficult for young children to comprehend. It is best to present both the facts about what happens to the physical body after death, as well as the religious beliefs that are held by the family.

Even when children are given appropriate explanations, they still may misinterpret what they have been told. For example, some children who have been told that the body is placed in a casket worry about where the head has been placed. After explanations have been given to children, it is helpful to ask them to review what they now understand about the death.

**Common Reactions Among Children Who Have Experienced a Personal Loss**

Like adults, children may be reluctant to talk about a death. They may at first be shocked by the news or fail to understand its implications. Young children have difficulty sustaining strong emotions, so they may appear upset for a brief period of time and then return to play. They may also use play or other creative activities, such as artwork or writing, to both express and work through their feelings associated with a loss. By observing play and the products of children's creative activities, we may find some clues as to what is bothering them, but it is important not to jump to conclusions about the meaning or relevance of what is observed.

Soon after notification, children often ask questions about the deceased and the meaning the death has for them personally. These questions may cause surviving family members' distress because they often are particularly poignant. Children pick up readily on the cues from others in their family that adults are made uncomfortable by these inquiries. They may conclude that such questions are unwelcome, inappropriate, or even represent misbehavior and stop asking. The silence that results is not an indication that children do not understand what has happened or have already coped. Rather, it may be a sign that they are trying to protect their parents who appear overwhelmed or that they do not feel comfortable asking questions or expressing their emotions, leaving them to deal with both alone. Therefore, it is important for adults to explicitly invite children to share their questions and feelings. Often it is helpful for an adult who is familiar with child development and who knows the child personally to provide an additional outlet for discussion. The child's pediatrician or a social worker from the child's school, for example, may be in a good position to start such a conversation.

Older children and adolescents may initially decline the assistance of adults because they are more accustomed to turning to peers for support and to address issues of concern. It is important to extend an open invitation to these young people to talk with you when they have questions or want to talk about the situation and to help them identify other adults in their lives they can turn to for support and assistance (eg, a chaplain, coach, or teacher).

Even in the setting of a natural disaster or terrorist event, children may still wonder if they were in some way responsible for the death. After a traumatic death, such guilt feelings may increase post-traumatic symptoms and complicate the grieving process. Young children, in particular, have a very limited understanding of why things occur and tend to be self-centered. As a result, they often use magical thinking to explain situations that they do not understand. This may result in extreme feelings of personal responsibility for a death that has occurred, even in situations when there is absolutely no logical reason why the child should feel responsible.

Often, such feelings of guilt are irrational. “If only I hadn’t gone to school that day, my dad would never have gone to the office and wouldn’t have been killed by the bomb,” “I was mean to my father yesterday and that’s probably why he died,” etc. Understandably, children are often reluctant to share their guilt feelings with adults; adults may not anticipate these feelings (or be burdened with their own guilt feelings). It may be helpful to reassure children of their complete lack of responsibility, even if they do not express feelings of guilt, and there is no logical reason why you might anticipate they would feel guilty.

At the time of a traumatic loss, children often think first about their own needs. Parents should be warned that this self-centeredness is not a sign that children are selfish; more likely, it is a sign that they are under considerable stress and in need of more support and assistance.

Children often regress in response to the stress of a personal loss. Children who had been successfully toilet-trained may now begin to wet their bed; children who had not had difficulty attending child care may now begin to show separation problems; children who had good social skills may now argue more or have difficulty getting along with peers. Children and adolescents may also develop somatic complaints, such as headaches, stomach aches, or generalized fatigue.

A disaster or terrorist event may uncover children’s concerns about another loss or personal crisis that has not been fully resolved. Children may react strongly to the death of someone that they did not know well or perhaps did not know at all. Or, children may be more preoccupied with their own personal crises than they are affected by the death of someone in their community.

A resource offering free multimedia training materials on how to support grieving children is available through the Coalition to Support Grieving Students at www.grievingstudents.org.

**Indications of the Need for Referral**

Not every child who has experienced the death of a family member or friend requires professional counseling, and in the setting of a major disaster or terrorist event, such resources are unlikely to be available for all those affected. It generally is helpful, however, for children who have experienced the death of a family member or friend to speak with someone outside of the immediate family who understands child development and can attend to the child’s needs (without being burdened with his or her own grief), such as their pediatrician or a school counselor or social worker. When a community disaster or crisis has occurred, it is important to help establish access to supportive services within community sites, such as schools, to provide services to larger numbers of children.

Significant stigma continues to be associated with receiving mental health services, and this stigma remains even in the setting of a major crisis event. Parents and other caregivers need to understand that even though bereavement is a normative experience, it still can be profoundly difficult. People, including children, can be helped through supportive services and, when indicated, group or individual counseling.

Children who have extreme reactions (eg, anxiety, post-traumatic symptoms, depression, or thoughts of suicide), atypical reactions (eg, appearing happy or disinterested), or prolonged reactions (eg, prolonged sleep problems or somatization) should be evaluated by their pediatrician and likely referred to a mental health professional experienced in the management of pediatric bereavement. Children who are having difficulty returning to their normal daily routines several weeks after the death or are demonstrating the new onset or worsening of problems interacting with peers should be referred. Children who are experiencing traumatic grief may require treatment of post-traumatic symptomatology before they are able to continue with normal grieving.

Soon after a death has occurred, many children may find comfort in returning to school, spending time with their friends, and taking part in the same activities that they did before the death. Allowances and adjustments should be made for a time (such as extra help with homework because of difficulty concentrating and learning) so that they can return to their day-to-day life as soon as possible. Some children may resist returning to school or resuming their regular daily activities. They may be fearful to leave other family members, worrying that they themselves—or their family members—may die in their absence or that grieving family members may need their support. These children require reassurance of the safety and well-being of surviving family members and encouragement to return to school. Other grieving family members, especially parents or guardians, should receive the support and assistance they need so children do not feel it is their responsibility.

### Attendance of Children at Funerals and Memorial Services

Children can be told in simple terms what to expect at a funeral or memorial service. If an open casket or gravesite ceremony is planned, children should be told and given explanations about what this involves. Children can be invited to participate to their level of comfort but should not be forced or coerced to attend. They should be encouraged to ask questions, which should be answered simply and honestly but without unnecessary details. At the ceremony, children should be accompanied by an adult they know and like (who is not personally grieving to the same extent as close family members) who can monitor the child's reactions, answer questions, and step out of the ceremony with the child if the child appears distressed or indicates a desire to leave. Even if children play quietly in the lobby of a funeral home, they may still have a sense of having participated in the ritual. Children who are not allowed to attend the funeral or memorial service often feel angry and hurt and lose out on the benefits of religious, family, and community support. They also may create fantasies about what occurs during funerals that are actually more frightening than the reality. It is also helpful if children can perform a small task at the funeral, such as handing out Mass cards at the entrance of the funeral home or selecting flowers to be placed near the coffin. Such tasks should be predominantly symbolic, of the child's choosing, and not overwhelming for the child.

## THERAPIES FOR PSYCHIC TRAUMA

### Crisis Response

Mass violence presents unique issues that differ from other episodes of interpersonal, community, and other forms of violence. Responding to individuals who are directly affected by the event is not enough—a multilevel strategy is required and should include victims and

witnesses, individuals with whom they are associated, and the broader community. Although crisis response providers do not have to perform all of these roles, they should work closely and collaborate with a number of individuals and agencies to ensure that the psychological impact of mass violence is addressed.

The first and foremost response to mass events is both directed and performed by the government and its agents, which are usually under the auspices of law enforcement, fire personnel, and/or emergency medical services and are typically managed by an Incident Command System (ICS). Mental health early responders should have pre-existing relationships with the ICS to perform their duties effectively. In most states and other jurisdictions, ICS staff members meet regularly to ensure efficient operation when needed. During episodes of mass violence, mental health providers need to be part of the ICS staff whenever possible. The pre-existing relationship with emergency response commanders permits more expeditious access to affected individuals and for the community's psychological needs to be considered consonant with emergency responses.

In addition, when mental health providers are members of the ICS, access to and allocation of resources for mental health crisis responders in situations of mass violence improves. Situating providers in the most useful locations, ensuring the flow of needed information and communications, and preventing well-intended but inexperienced and unlinked clinicians from arriving in masses in an attempt to provide services are essential to lessen the general confusion and chaos that accompany disasters.

A useful way of defining and understanding a response to a traumatic event is that the affected individual experiences the loss of both internal and external control. Therefore, maximizing organization and structure is a necessary prerequisite in providing mental health crisis response and early intervention. Mental health crisis models are best equipped to achieve this organization and structure when they are firmly rooted in the ICS.

**Crisis Response for Children and Families**

Unfortunately, there is limited empirical evidence for the effectiveness of any crisis response intervention. The frequently used and previously heralded Critical Incident Stress Debriefing or Management (CISD or CISM) strategies have not been demonstrated to be effective, and in some studies, they have been shown to be detrimental. Indeed, it has been recommended that compulsory debriefing of victims of trauma should cease. However, it is possible that an alternative method of early crisis intervention may be helpful for assisting people who may be recently traumatized. The following recommendations and guidelines for early intervention strategies are based on evidence from research on the risk factors for PTSD as well as some intervention research. Thus, they provide an empirical foundation for appropriate and useful approaches to assist potentially traumatized individuals.

Currently, there is no evidence that global intervention for all trauma survivors serves a function in preventing subsequent psychopathology. However, there is consensus that providing comfort, information, and support and meeting the immediate practical and emotional needs of affected individuals can help people cope with a highly stressful event. This intervention should be conceptualized as supportive and noninterventional and not as a

therapy or treatment. This suggestion recognizes that most people do not develop PTSD. Instead, they usually will experience transient stress reactions that will abate with time. The goal of early intervention is to create a supportive (but not intrusive) relationship that will result in the exposed individual being open to follow-up, further assessment, and referral to treatment when necessary. Inherent in this early intervention is the recognition that interpretation or directive interventions are not to be provided.

After ensuring that basic necessities are available and are not a pressing concern, the basic principles of intervention should be followed. These principles should ensure that no harm is being done in the intervention process and hopefully prevent or reduce symptomatology and impairment.

- Interventions should be grounded in the basic principles of child development, and providers should be experienced in working with children of different ages and levels of development.
- Mental health providers should have collaborative relationships with community providers to ensure access and community support for children and families.
- Children and families should be assessed for risk factors and symptoms, and interventions should be crafted to address the findings.
- An essential objective is to improve parental attention and family cohesion through assessment, psychoeducation, and treatment, when necessary, to parents and primary caregivers.
- Providers should make concerted efforts to prevent social disruption and displacement.
- Providers should identify, assess, and attempt to ameliorate or remove children and families from the continued threat of danger.
- Providers should have continued contact and monitor children for symptoms or impairment.

Handouts or flyers that describe trauma and if indicated bereavement, what to expect, and where to get help should be made available. Individuals should be given an array of intervention options that may best meet their needs. The goal is not to maximize emotional processing of horrific events, as in exposure therapy, but rather to respond to the acute need that arises in many to share their experience, while at the same time respecting those who do not wish to discuss what happened.

**Medication**

There is not yet clear evidence to support the use of pharmacotherapy in the treatment of post-traumatic symptoms in children. The first line of treatment for post-traumatic symptoms in children is trauma-focused cognitive behavioral treatments (CBTs), which include such interventions as graded desensitization and others. For children with severe reactions or comorbid conditions such as depression or anxiety (for whom selective serotonin reuptake inhibitors may be indicated), consultation with a child psychiatrist experienced in the treatment of PTSD would be helpful to determine whether medication should be considered an adjunct to psychotherapeutic interventions.

## SCHOOL CRISIS RESPONSE

Most children benefit from receiving supportive services in the aftermath of a disaster or terrorist attack. Pediatricians can play a vital role in advocating for, consulting for, and actively participating in school crisis response teams to ensure that such supportive services can be provided to children within schools and other community sites.

School administrators, teachers, and other school staff will be affected by the same crisis event that is affecting their students. During such times, organizing and implementing an effective crisis response can be difficult or even impossible. Therefore, it is imperative that schools begin planning for potential crisis events before they occur, both to avert disasters whenever possible and to decrease the negative impact on students and staff when disasters cannot be prevented.

The school crisis response plan should include generic protocols for the following:

- Notification of team members, school staff, students, and parents of a crisis event
- Delivery of psychoeducational services and brief crisis-oriented counseling, such as through support rooms or short-term support groups
- Memorialization and commemoration
- Follow-up

The structure provided by a pre-existing plan can be very comforting in times of crisis and helps to ensure that key issues are considered, appropriate steps are taken, and necessary resources are in place.

In addition, the crisis response plan should include guidelines on the following:

- Crisis team membership
- Roles of crisis team members
- Protocols for delivery of crisis intervention services
- Specific guidelines for responding to unique situations, such as large-scale natural disasters or a terrorist attack
- Physical safety and security
- Rapid dissemination of accurate and appropriate information
- Attention to the emotional impact of the events and the crisis response; all areas should be addressed concurrently and in a coordinated fashion

Delivery of supportive services to children during a crisis can be demanding work for school staff and community mental health providers working within the schools. Plans should also include mechanisms to ensure that supportive services for staff are included as a key component of a crisis response.

Free resources for training and guidance for schools responding to crisis can be found at the Web site for the National Center for School Crisis and Bereavement (www.schoolcrisiscenter.org).

## ANNIVERSARY REACTIONS AND COMMEMORATIVE ACTIVITIES

As the anniversaries of stressful, critical, or traumatic events approach, many children and adults will have significant reactions. Throughout the year, reminders of the original crisis may

add to children's sense of further danger and emotional distress. Those reminders of the events may also increase the reactions of peers, parents, teachers, and other adults.

Remember:
- Memorial activities can further the process of healing and learning.
- The planning process is as important as the memorial activities themselves and should actively include children.
- Health and mental health care professionals, teachers, parents, and children all benefit from the planning process.
- Symptoms and reactions vary from child to child.
- There is no one "best way" to acknowledge an anniversary.
- Helping children deal with a difficult event is hard work; adults need to take care of themselves as well.

**Anniversaries**
At the time of the anniversary, children frequently experience a recurrence of some of the feelings associated with a loss or tragedy. These reactions vary widely, and they can be seen in both children and adults. Some children may not be interested in revisiting the events. For these children, it may be more appropriate that they are occupied with the typical concerns of childhood.

It is important to find ways within the school to recognize the anniversary of such an important event without imposing personal emotions or expectations on either students or staff.

Some children directly affected by the traumatic event may appear to be "back to normal" but may still be feeling sad, scared, anxious, or angry. Children do not always demonstrate their feelings directly, and we should pay special attention to signs of concern or distress. Children who are known to have histories or ongoing exposure to trauma or loss, even if they are not directly related to the traumatic event, may be especially vulnerable in the days and weeks surrounding the anniversary.

Heightened media coverage and publicity of memorial events may increase reactions in children. Parents should monitor and supervise their watching of television and, especially for younger children, consider limiting the amount of television exposure.

Some signs of distress to look for include the sudden appearance of or noticeable change in the following:
- Depressed or irritable mood
- Oppositional and defiant attitude
- Attention-getting or other behavioral problems
- Difficulties getting along with classmates and peer group
- Social isolation or withdrawal
- Deterioration in academic performance
- Physical complaints
- Changes in appetite
- Sleep disturbances

The extent and nature of potential difficulties may be related to many factors, including the following:

- Age and developmental level
- Personal history (eg, prior trauma, loss, or emotional difficulties)
- Support from peers, parents, and school staff

**Memorialization**

Memorialization is any activity designed to formally mark the anniversary or memory of a significant event. Memorial events can help children express and cope with their feelings that might otherwise seem overwhelming to deal with alone. By actively planning and participating in a memorial event, children can exercise some control over how they will remember the disturbing event.

Children may have needs similar to those of adults in times of crisis, but they often meet those needs in very different ways. It is important to find out from the children what they would like to remember and what they think would be the best way to acknowledge the anniversary. Children need to be part of the planning process for memorial events. A memorial planned by adults for children is likely to be more helpful to the adults and not necessarily meet the children's needs. The planning of a memorial activity can be more therapeutic than participating in the activity itself.

Remember also that different groups of children and adults will have different needs and wishes at the time of the anniversary. Memorial activities do not need to be formal or elaborate. It is best to take cues from children, considering their age and developmental level, when planning memorial activities. Discussion allows children to explore how they are feeling and to think about what might help them feel better.

Some children may wish to acknowledge the anniversary in a personally meaningful way (eg, drawing a picture, writing a poem or essay) but resist a group activity centered around the anniversary. Some children may prefer not to mark the anniversary with any formal or even informal activity. It is important to remember that those children who are grieving their own personal losses may resent or feel frustrated if the memorial event focuses only on the heroic efforts of rescue workers.

**Planning a Memorial Activity**

Memorial activities can be planned at various levels, including individual consultation with the pediatrician, with family members, in small student groups, or in larger community or school-wide committees. Children should be involved in the planning process, but it is equally important for adults to provide guidance, structure, and support.

- Consider the children's ages and developmental levels when planning activities.
- Some children may wish to involve other friends or family members in the planning process.
- Coordinate the planned events with the family and the school.
- Not all children will want to be involved in the planning process, and participation should be voluntary.

- Do not feel pressured to plan the "perfect event." Any memorial event or activity, big or small, may be a helpful means for children to understand and mark an anniversary.
- Activities within a school or individual classroom may affect other students and staff within the school as well as children's families at home. Therefore, other families should be informed about plans for memorial events within a school.
- Other adults will benefit from additional support and guidance on how to mark an anniversary in a sensitive manner.
- Awareness of school activities and plans often can help to initiate discussions at home, where children may be most comfortable talking about critical events and anniversaries.
- Parents should be invited to share any concerns related to the anniversary or relevant family experiences with the pediatrician, teachers, and school staff. Pediatricians, teachers, and school personnel should keep the lines of communication open with parents throughout the planning process. Parents should be encouraged to continue to discuss the planned activities with their children at home.
- Open discussion communicates to children that adults are available for further discussion and support.
- Look for signs of distress in students, such as agitation, acting out, or other unexpected behaviors, and help teachers, parents, and school personnel to be aware of them.

## SUPPORTING SCHOOL STAFF

Some adults may find it difficult to discuss traumatic events, especially if dealing with their own losses. Adults should seek out support from other adults and colleagues when needed. This is difficult work for everyone, and it is important for staff to think about what their own feelings are in relation to the events. Providing an opportunity for staff to talk about their own reactions may be useful to them personally and may better prepare them to meet the children's needs.

Remember that children look to adults for guidance and support during difficult times. We need to think about how our own reactions may impact children. Children's questions may sometimes take us off guard and make us confront issues we would rather not think about.

Having a plan to address these concerns in advance will help make the task easier. If the task seems too difficult, staff should share the responsibility with a colleague or invite someone else to help with the planning and process of memorialization.

## PROFESSIONAL SELF-CARE

Pediatricians and other pediatric health care providers often live in the same community as their patients and, as such, may be affected, directly or indirectly, by the crisis event themselves—their homes may have been damaged or destroyed by a natural disaster, or family members or friends may have died or been injured by a mass casualty event. In addition, family and friends they care about, as well as colleagues with whom they work, may be affected. Despite these challenges, they may be expected to function in austere conditions and/or to address increased medical and mental health needs of their patients and their families at a time when colleagues and/or staff are unavailable or overwhelmed and the infrastructure and resources for the delivery of medical care may be compromised or over capacity. Pediatricians may need to devote significant—and generally uncompensated—time helping families navigate complex systems to

obtain needed financial or psychosocial support and encouraging families to seek often stigmatized mental health services that may be limited or virtually unavailable. Pediatricians may, by default, assume the primary or sole responsibility for the delivery of mental health services to patients and families in this setting, even though many pediatricians feel that they lack adequate training and confidence in their clinical skills in this area.

Listening to the stories of family, friends, colleagues, and patients who have experienced trauma or loss can be emotionally draining and may trigger memories of the pediatrician's own prior trauma or loss and increase a sense of personal vulnerability. Vivid narratives by patients and their families may contribute to the development of vicarious traumatization of the pediatrician. Pediatricians should help initiate discussion with their patients and families but refer to mental health professionals with trauma expertise for further processing and should limit what is shared with the pediatrician accordingly. Joining with families to experience their distress can also contribute to compassion fatigue, especially when the disaster is already jointly experienced by the patient and pediatrician. This does not mean that pediatricians have a finite reserve of compassion or that compassionate care will ultimately lead to burnout; indeed, the provision of compassionate care can bring a sense of meaning to clinical work and buffer against the development of provider burnout. But pediatricians should monitor the impact on themselves of providing such psychosocial support and allow themselves to limit such support to a level that feels comfortable and manageable at the time. Pediatricians should help ensure that patients and families get the support that is needed, but they should not feel compelled or obligated to provide all such support themselves.

If patients or their families are upset or overwhelmed, it can be hard to recognize that you are helping them, even when you are. In such a context, pediatricians may question their ability to meet the needs of patients and families and fail to see the important positive impact of their actions. Taking active steps to collaborate as a health care delivery team with shared responsibility and decision making and consciously working to share stories of positive contributions within the practice can be particularly important during the recovery period.

Pediatricians should establish realistic expectations for professional workload and outcomes during the recovery period, incorporate accommodations and flexibility in hours and work conditions as necessary and to the extent possible, and work to foster increased communication and social cohesion among members of the health care team. Adults who are under stress may experience the same adjustment reactions described above for children and youth. They may experience anxiety, confusion, anger, irritability, and distrust or suspiciousness. They may feel exhausted and become less tolerant of change, unpredictability, and increases in work load—all of which may be required by the changing work conditions and community need. Individual pediatricians should monitor themselves for negative thoughts, practice ongoing stress management and self-care, and seek to establish realistic boundaries between personal and professional time, recognizing that although the need may seem (and to an extent actually be) limitless, the pediatrician's capacity to provide service to patients and families is not.

There are many challenges to professional self-care in the context of a disaster. It is difficult for pediatricians to find the time to attend to their own needs when the needs of their patients and the community are so extensive. The reality is that pediatricians will need to "make" time rather than

wait to "find" it. Professionals often assume that others are having less difficulty adjusting and may feel shame or guilt for attending to their own needs ahead of those of their patients. Pediatricians should model a willingness to accept personal and professional assistance and support and seek resources to meet such needs for themselves and others within the practice.

## RISK COMMUNICATION AND MEDIA ISSUES

Information should be communicated to the public in timely, accurate ways that do not heighten concern and fear. Communicating effectively during a crisis requires the following:

- Planning
- Preparation
- An understanding of communications protocols, messaging, and the media
- The ability to manage the flow of information

Each element is a challenge that can be met effectively, to the benefit of those receiving messages in times of crisis.

### Developing Goals and Key Messages

People often fail to communicate effectively because of a lack of clear communications goals and key messages to support them. Setting such goals and identifying support messages are tasks that should be accomplished before issuing any public comment and are especially important in a crisis.

A communications goal of "educating the public on the complexities of bioterrorism and preparing them for any eventuality" is not realistic. Informing the public of the problem and specific dangers, providing guidance on appropriate responses, and easing concerns are achievable goals. Messages in support of these goals should also be direct and speak effectively to the audience.

A risk message is a written, verbal, or visual statement containing information about risk that may or may not include advice about behaviors to reduce risk. A formal risk message is a structured written, audio, or visual package developed with the express purpose of presenting information about risk. Risk messages may aim to ease public concern or provide guidance on how to respond.

***Messages to Ease Public Concern:*** Examples of messages to ease public concern are:

- The risk is low.
- The illness is treatable.
- It is not easily contracted.
- Symptoms are easily recognized.

***Messages on How to Respond:*** Examples of messages that give guidance on how to respond include:

- Take these precautions.
- If possibly exposed, contact a physician.
- If symptomatic, contact a physician.
- Note possible symptoms in others.

If the goal is to ease concern and the message in support of that goal is "the risk to the public is low," that message should be clearly stated at the outset and returned to as often as possible.

- Raise points often enough that the audience leaves with a clear understanding of the message you wanted them to hear.
- Take opportunities to begin or end statements with a reiteration of your message.
- Do not be so repetitious with a single message that you appear to be trying to convince people of something that is not true.
- Do not repeat messages word-for-word every time you answer a question.

Exercise some control over the conversation you are having, be it an interview, press conference, or questions from an audience. Do not allow the conversation to be led down paths that are not pertinent to the goals or message—no matter how persistent the questioner might be in pursuing a line of inquiry.

***Delivering Accurate and Timely Information:*** In a risk-communication situation, there is constant tension between providing accurate information and providing information quickly. Both demands pose challenges. To wait for all information to be complete and verified before releasing it to the public can create an information vacuum that will almost certainly be filled with rumor and speculation. To release information that has not been confirmed and turns out to be inaccurate, however, runs the risk of misleading the public and undermining your credibility as a spokesperson.

- Goals and messages should be simple, straightforward, and realistic.
- Information should be delivered with brevity, clarity, and effectiveness.

Provide statistics and key information to the media in written form. In presenting information, always know how the information was gathered and how any conclusions were reached.

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# CHAPTER FIVE:
# EMERGING INFECTIOUS DISEASES

**"People are beginning to understand there is nothing in the world so remote that it can't impact you as a person."—William H. Foege, Director, US Centers for Disease Control, 1977–1983**

As the global community becomes smaller and more interconnected with the ease of international travel, the spread of emerging or re-emerging infectious diseases becomes an ever-growing threat to the medical community, and it is critical that the pediatric health care community be prepared to safely manage patients with highly infectious and highly contagious infectious diseases (also referred to as highly hazardous communicable diseases [HHCDs]). These diseases, such as Ebola virus, avian influenza, severe acute respiratory syndrome (SARS), and Middle Eastern respiratory syndrome (MERS), can be spread from human to human from a variety of ways, depending on the pathogen, and most carry with them a high mortality rate and no available vaccine or cure.

In the case of Ebola virus, the virus is spread via contact, and although the virus is considered highly infectious, it is not highly contagious. In contrast, MERS is a contagious respiratory pathogen spread via respiratory droplets and requires strict airborne precautions **(Table 5.1: Examples of Highly Hazardous Diseases Requiring Special Isolation).** Preparing for HHCDs in pediatrics must include not only hospital environments but also outpatient facilities, where a majority of pediatric care is delivered. Care of these unique patients is labor intensive and requires extensive specialized training and should occur in biocontainment facilities when possible. However, *all* institutions caring for children should be capable of mastering the tenets of infection prevention and control, biocontainment, and isolation of children with a suspected or confirmed HHCD. This section will review the basic guidelines for recognizing, isolating, and safely managing children with highly hazardous infectious diseases.

| Table 5.1: Examples of Highly Hazardous Diseases Requiring Special Isolation | |
|---|---|
| **Pathogen** | **Transmission-Based Precaution** |
| Pandemic influenzas (including avian influenza) | **Standard, Contact, Airborne** (www.cdc.gov/flu/avianflu/novel-flu-infection-control.htm) |
| Viral hemorrhagic fevers<br>• Ebola virus<br>• Marburg virus<br>• Lassa fever<br>• Crimean-Congo fever | **Standard, Contact, Airborne** (www.cdc.gov/vhf/ebola/healthcare-us/ppe/index.html) |
| Coronaviruses<br>• Severe acute respiratory syndrome (SARS-CoV)<br>• Middle Eastern respiratory syndrome (MERS-CoV) | **Standard, Contact, Airborne** (www.cdc.gov/coronavirus/mers/infection-prevention-control.html) |
| Smallpox | **Standard, Contact, Airborne** (www.cdc.gov/smallpox/clinicians/diagnosis-evaluation.html) |
| Monkeypox | **Standard, Contact, Airborne** (www.cdc.gov/poxvirus/monkeypox/clinicians/infection-control-hospital.html) |
| Multidrug-resistant tuberculosis (MDR-TB) | **Standard, Airborne** (www.cdc.gov/tb/publications/factsheets/prevention/ichcs.htm) |

## MAJOR PRINCIPLES IN PEDIATRIC BIOCONTAINMENT

Infectious diseases remain among the leading causes of morbidity and mortality worldwide, especially in resource-limited countries. Reasons for this continued threat include the emergence of new infectious diseases as well as re-emergence of known infectious diseases after significant decline in the population. Examples of pathogens appropriate for special isolation are included in **Table 5.1: Examples of Highly Hazardous Diseases Requiring Special Isolation.** When preparing for these HHCDs, there are special issues facing children and their families that must be carefully considered. These issues include processes to screen and identify patients, appropriately isolate patients of concern, arrange for the optimum level of care for these unique patients, and communicate with and include family members in care delivery **(Table 5.2: Preparedness Steps for a Child with a Suspected EID: Identify, Isolate, and Inform).**

**Table 5.2: Preparedness Steps for a Child With a Suspected EID: Identify, Isolate, and Inform**

| Preparedness Steps | Possible Challenges | Potential Solutions |
|---|---|---|
| ***Identify***<br><br>Relevant signs and symptoms and travel history | • Cocirculating and seasonal infections may have similar presentations as HHCDs<br>• Many competing priorities in institutions make screening difficult<br>• Language/cultural barriers exist<br>• Sustaining interest and enthusiasm<br>• Keeping up to date on relevant HHCDs | • Practice triage questions signs and symptoms and travel history that trigger appropriate actions to isolate and inform<br>• Keep up-to-date information readily available (websites, designated infectious disease experts)<br>• Simple signage in multiple languages at entry points for patients/help families to self-identify<br>• Prioritize simple simulations: Mystery patient and tabletop drills |
| ***Isolate***<br><br>Mask patient, separate from other patients, place in pre-designated isolation room | • Accompanying family members may also be infectious<br>• Designated isolation room may be occupied<br>• Disease-specific clinical manifestation and developmental and behavioral issues may impact efforts to contain secretions | • Mask accompanying family members (they could be infectious)<br>• Pediatric and adult masks readily available with loops to secure<br>• Consider security issues<br>• Drill rapid turnover of occupied isolation room to facilitate availability |
| ***Inform***<br><br>Internal and external stakeholders | • Requires both internal and external communication structure<br>• Rapid turnover of trained health care worker staff and administration<br>• Unfamiliar with local health department staff | • Tabletop drills<br>• Up-to-date phone trees<br>• Testing of communication pathways<br>• Protocol to alert local health department<br>• Easy access to contact information |

Although several highly specialized biocontainment units have been created in the United States, there are few beds available for pediatric patients with confirmed HHCDs.

## INFECTION PREVENTION AND CONTROL AND PERSONAL PROTECTIVE EQUIPMENT

The first step in managing patients suspected of HHCD is identifying those at high-risk for infection on the basis of travel and symptom screening. Patients who are identified with a potential HHCD should be immediately placed in isolation, preferably in a negative-pressure

ventilation room, until a full assessment and diagnostic testing, if indicated, can be performed. For viral hemorrhagic fevers, the personal protective equipment (PPE), as well as the process for donning and doffing, is well outlined by the CDC and should be strictly followed in the event there is a suspected patient. A tiered approach was developed for hospitals during the Ebola outbreak, and is outlined on the CDC Web site (www.cdc.gov/vhf/ebola/healthcare-us/preparing/hospitals.html).

The first tier includes all frontline health care facilities, which should be equipped with PPE, identify and isolate suspected patients in a private room (preferably with a private bathroom or covered commode; a negative-pressure ventilation room should be used whenever possible), initiate testing in low-risk patients, and transfer high-risk patients, if needed, for further care.

Tier 2 hospitals are Ebola assessment facilities that have the capacity to care for the patient for up to 5 days until confirmatory testing is performed. These facilities should have sufficient PPE for staff to safely care for a possible Ebola-positive patient for these 5 days.

Lastly, tier 3 includes Ebola treatment centers, capable of caring for confirmed cases for the duration of illness. In each of these settings, standard contact and droplet precautions should be employed.

In all settings, staff should be appropriately trained in the proper use of PPE and should have a plan in place for how they will manage and dispose of biohazardous trash, safely clean and disinfect patient care areas, and care for staff who are involved in patient care. Additional infection prevention and control measures when evaluating patients under investigation or those confirmed as having Ebola virus disease include the following key components:

- Patient placement in a single room (with an attached bathroom) with log maintained of all persons entering the room
- PPE to be used by health care workers
- Dedicated or disposable medical equipment
- Hand hygiene (includes consistent and appropriate handwashing after removing gloves),
- Active monitoring of all personnel for exposure and signs and symptoms
- Environmental cleaning and management of waste

The specific type of PPE varies, and guidelines are available on the CDC Web site (www.cdc.gov/vhf/ebola/hcp/ppe-training/index.html).

Regardless of which type of PPE each institution chooses, it has been shown that the proficiency of use and specific training and practice in donning and doffing PPE is most important. This requires active and consistent, ongoing training (at least quarterly), including computer simulation and spoken instructions. Compared with passive training, active training leads to fewer errors among health care staff.

## SCREENING AND IDENTIFICATION

Whether patients are being seen in the emergency department or in another outpatient setting, travel screening should be a part of every child's intake questionnaire as well as a general symptom screen. Although this can be an understandably daunting task with the large amount of

international travel that occurs in today's world, encouraging frontline staff to incorporate travel screening into initial history taking is key in identifying patients with possible HHCDs. It is reported that 34% of children with recent travel are diagnosed with infections, and travel screening is important in diagnosing even common febrile illnesses associated with the pediatric traveler.

When considering HHCDs, each institution should work closely with their own infection control and infectious disease staff to identify key screening questions, and frontline staff should be kept up-to-date if possible on the current "hot spots" for emerging infections and outbreaks, which will change over time. All frontline providers caring for children should be prepared to screen, identify, and isolate suspected patients and rapidly inform the proper authorities (eg, infection control and infectious disease teams, local/state health department, CDC) if they are faced with a pediatric patient suspected of having an HHCD. This requires having not only an established screening protocol but also well-established and up-to-date phone trees of "who to call" in the event of a patient with a suspected HHCD.

Identification of these children with potential exposure to high-risk pathogens can be extremely challenging, particularly in the height of influenza and respiratory virus seasons, when seemingly every child evaluated has symptoms including cough, fever, and/or diarrhea. Hospitals and clinics should use appropriate travel screening algorithms, ideally built into the electronic health record admission process and available at all possible points of entry in pediatric centers, including emergency departments, and ambulatory and inpatient settings. Pediatric-specific triage screening questions should be developed with the help of infectious diseases experts, and these questions should be updated with new outbreaks as needed. It is critical to realize that as the international climate changes, outbreaks and diseases will change as well, and frontline staff will require re-education, making travel screening challenging and requiring flexibility and dedication to training and education. The CDC travel advisory Web site can provide quick assistance if needed in a triage setting: wwwnc.cdc.gov/travel/notices.

Example screening questions include:

- *"In the past 3 weeks, have you or your child traveled outside the US or had close contact with someone who traveled outside the US?"*
- *"Has your child had a fever, rash, diarrhea, or cough?*
- "*Are there ill family members with these symptoms to whom your child was exposed prior to travel?"*

## ISOLATION

Pediatric patients and their caregiver(s) must be promptly isolated if the screen for potential HHCD exposure is positive, and they should be evaluated by appropriate experts to determine whether the child is indeed at risk for an HHCD requiring special isolation. Immediate isolation may require masking the patient and recognizing that the accompanying family members may also be infected. Patients believed to be at significant risk for an HHCD should, when possible, be placed in a negative-pressure ventilation room with their family member/caregiver to limit exposure to other patients and staff.

Although limited data exist on triage and isolation of patients with HHCDs, lessons can be

learned from examining previous outbreaks, including the 2003 SARS outbreak, the ongoing MERS outbreak, and the Ebola outbreak from 2014-2015. For example, triage and isolation data from the SARS outbreak from China and Toronto show that in larger outbreaks, it may not be feasible to isolate patients in the few rooms available in small hospital emergency departments, and in these cases, entire floors of hospitals were evacuated and dedicated as SARS triage wards to prevent the nosocomial spread of the virus. Additionally, a dedicated team of clinicians was assigned to evaluate patients presenting with these symptoms to limit the spread of the virus.

Although it may not be feasible in many institutions, it may be wise to consider a safe and effective isolation and triage plan in advance, which does work. This may involve designating a set of rooms that can be isolated from the remaining rooms, and care providers for these patients, or discussing with key stakeholders how patients would be transferred to other wards or facilities to make room for isolation patients. Regardless, these plans should be developed and practiced (simulated) in advance.

When a patient does present with a suspected HHCD, only a single nurse and attending physician should assess the patient, and contact should be limited. Ideally, learners should be limited from seeing high-risk patients. Once a patient has been identified, isolated, and assessed, internal and external stakeholders must be promptly informed to facilitate testing and, if needed, transport specimens and/or the patient. The challenges and potentially solutions are outlined in **Table 2: Preparedness Steps for a Child with a Suspected EID: Identify, Isolate, and Inform.**

## FAMILY INCLUSION

It is important to have a plan in place to screen family members for symptoms to reduce the risk of disease spread. *It must be presumed that if a child is infected with an HHCD, family members are at high risk for exposure as well.* At the same time, it is critical to address the complex social and ethical considerations for family members when dealing with pediatric patients in special isolation, and protocols for how these issues will be handled will vary from institution to institution. The AAP offers guidelines for such issues ("Parental Presence During Treatment of Ebola or Other Highly Consequential Infection," available at: http://pediatrics.aappublications.org/content/early/2016/08/18/peds.2016-1891). Adults will also require screening, evaluation, and potentially specialized treatment at an adult treatment center. For this reason, the local health department should immediately be involved in all suspected cases of HHCDs.

The complex needs of family members of isolated pediatric patients, including family visitation policies, requires advanced planning, and each institution must decide on their own policies *before* facing this situation. Ideally, these plans should be vetted with state/local public health authorities.

These policies can range from a "zero tolerance" visitation policy, in which families are not allowed any contact with the patient while in isolation, to an "all or nothing approach," in which a caregiver may choose to remain at the patient's bedside for the entirety of the admission after demonstrating proper technique in both donning and doffing PPE. These decisions should be made in consultation with a team including infectious diseases experts, state and/or local public health authorities, risk management, and the clinical care staff who will be involved in caring for

the child. All decisions should be made with the safety of the staff and community at large in mind, and if the decision is made to allow family visitation, this should be closely observed at all times. The impact of family visitation must also be balanced with the risk it may pose to staff members caring for the patient. The ability of families to follow instructions, including appropriate donning and doffing of PPE, should be carefully considered, and may require a case-by-case evaluation. Lastly, the decision to allow families to visit children in strict isolation may differ depending on the pathogen.

Regardless of institutional policies, it is critical to address the obvious stress these issues will have on family members as well as on staff. Working with professionals such as social workers, child life specialists, chaplains, and behavioral health specialists to develop policies and procedures is key to ensure both families and staff are supported in the best possible manner. Parents should be given information on how to obtain updates 24 hours a day, with a way to easily communicate with the team caring for their child. Establishing a comfortable, secure and private space where a family can find solace is recommended. Additionally, family members should be screened daily for symptoms and isolated immediately if there is suspicion of infection.

Although local health departments should be partners in the screening of family members, it is critical to establish institutional protocols regarding how family will be cared for while their children are patients in special isolation. Protocols should include how family will be entering and exiting the hospital, ensuring families are provided adequate privacy, and monitoring family movements within the hospital to ensure family members who may in fact be contagious are confined to specific, controlled areas. These points are particularly important with respiratory pathogens, for which symptoms may be vague, and patients may be contagious before they are identified.

## EMERGING INFECTIOUS DISEASES CONCLUSIONS

Being prepared to safely care for pediatric patients with HHCDs is a necessity for every institution in the United States that provides care for children, as emerging and re-emerging infectious diseases are a constant threat to pediatric health care worldwide. It takes a system-wide dedication to continued training and education; it is only with sufficient preparation and training that safe, high-quality care can be provided to both pediatric patients with HHCDs and their families, while at the same time ensuring the staff dedicated to caring for them, as well as our greater communities, stay safe. This requires that all health care facilities, at all points of entry, be prepared to identify, isolate, inform, and provide care for these vulnerable patients and their families. Steps to help facilities prepare and relevant resources are included in Tables 5.3 and 5.4.

| Table 5.3: The Basic Steps in Preparing for Highly Infectious Patients |
|---|
| 1. Develop an institutional personal protective equipment (PPE) plan in which frontline providers are consistently trained (ER, clinics, ICUs). |
| 2. Develop a consistent screening plan feasible for your institution at the triage level. |
| 3. Develop a plan on how patients of concern will be rapidly isolated for each frontline facility (emergency departments, clinics, etc): identify a room and a general protocol. |
| 4. Develop a phone tree: include leadership, consults/specialists, and local health department contacts. Keep this up-to-date. |
| 5. Know where to find up-to-date information, and keep this material available for frontline staff (Table 4: Where to Find Up-To-Date Information). |
| 6. Identify your local and state partners, including Ebola assessment and treatment centers ( www.cdc.gov/vhf/ebola/healthcare-us/preparing/current-treatment-centers.html). |
| 7. Develop a plan for highly biohazardous waste now. Where will the waste be safely stored until it can be removed? (www.cdc.gov/vhf/ebola/healthcare-us/cleaning/handling-waste.html) |
| 8. PRACTICE these plans: quarterly training recommended, twice yearly at minimum. |

| Table 5.4: Where to Find Up-To-Date Information |
|---|
| CDC Emerging Infectious Diseases and Travel Notices:<br>• www.cdc.gov/niosh/topics/emerginfectdiseases/default.html<br>• wwwnc.cdc.gov/travel/notices |
| CDC Influenza Web page:<br>• www.cdc.gov/flu/ |
| World Health Organization (WHO) Outbreaks and Emergencies:<br>• www.who.int/en/ |
| National Ebola Training and Education Center:<br>• https://netec.org |
| American Academy of Pediatrics:<br>• www.aap.org |
| The Society for Healthcare Epidemiology of America:<br>• www.shea-online.org |
| Infectious Disease Society of America:<br>• www.idsociety.org/Index.aspx |
| AAP *Red Book: Report of the Committee on Infectious Diseases*:<br>• https://redbook.solutions.aap.org/redbook.aspx |

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# CHAPTER SIX:
# PEDIATRIC PREPAREDNESS EXERCISES

## WHAT IS AN EXERCISE?

Exercises are designed to help an organization test a hypothetical situation, such as a natural or man-made disaster, and evaluate the group's ability to cooperate and work together and to test their readiness to respond. Some exercises "test out" components of a written preparedness plan. Exercises can enhance knowledge of plans, allow members to improve their own performance, and identify opportunities to improve capabilities to respond to real events. Exercise objectives provide the framework for addressing gaps or developing or improving the pediatric plan.

Exercises and their objectives can focus on:

- Testing a plan, protocol, or new procedure
- Practicing skills (such as those used for patient triage or tracking)
- Preparing for more complex exercises
- Training on new equipment (such as radio equipment or devices used during patient evacuation)
- Assessing/improving ways in which stakeholders work with each other in various situations

Exercises can be conducted in-person or virtually. Virtual exercises are options to enhance response capability and conserve resources.

### Pediatric Exercises Are Different

Although hospital and community exercises concentrate on various aspects of operations and medical treatment and provide an opportunity to prepare for disasters and enhance disaster planning and preparedness, in many cases exercises lack specific planning for the pediatric population and may not include children in sufficient numbers to test the system. During disasters, pediatric patients may represent a significant portion of the casualties. Children may need specialized resources related to their needs on the basis of anatomic, developmental, immunologic, and psychosocial differences from the general population. Pediatric patients may present to community providers and hospitals that do not routinely care for children. In conducting exercises specifically geared toward pediatric populations, hospitals and community-based providers can identify gaps in preparedness, training, response, and recovery for children in disasters and address issues such as:

1. Treating children who arrive without a parent or caregiver;
2. Identifying and reuniting children with their families;
3. Pediatric triage;
4. Utilizing pediatric-sized equipment; and
5. Addressing disaster mental health problems in pediatric patients.

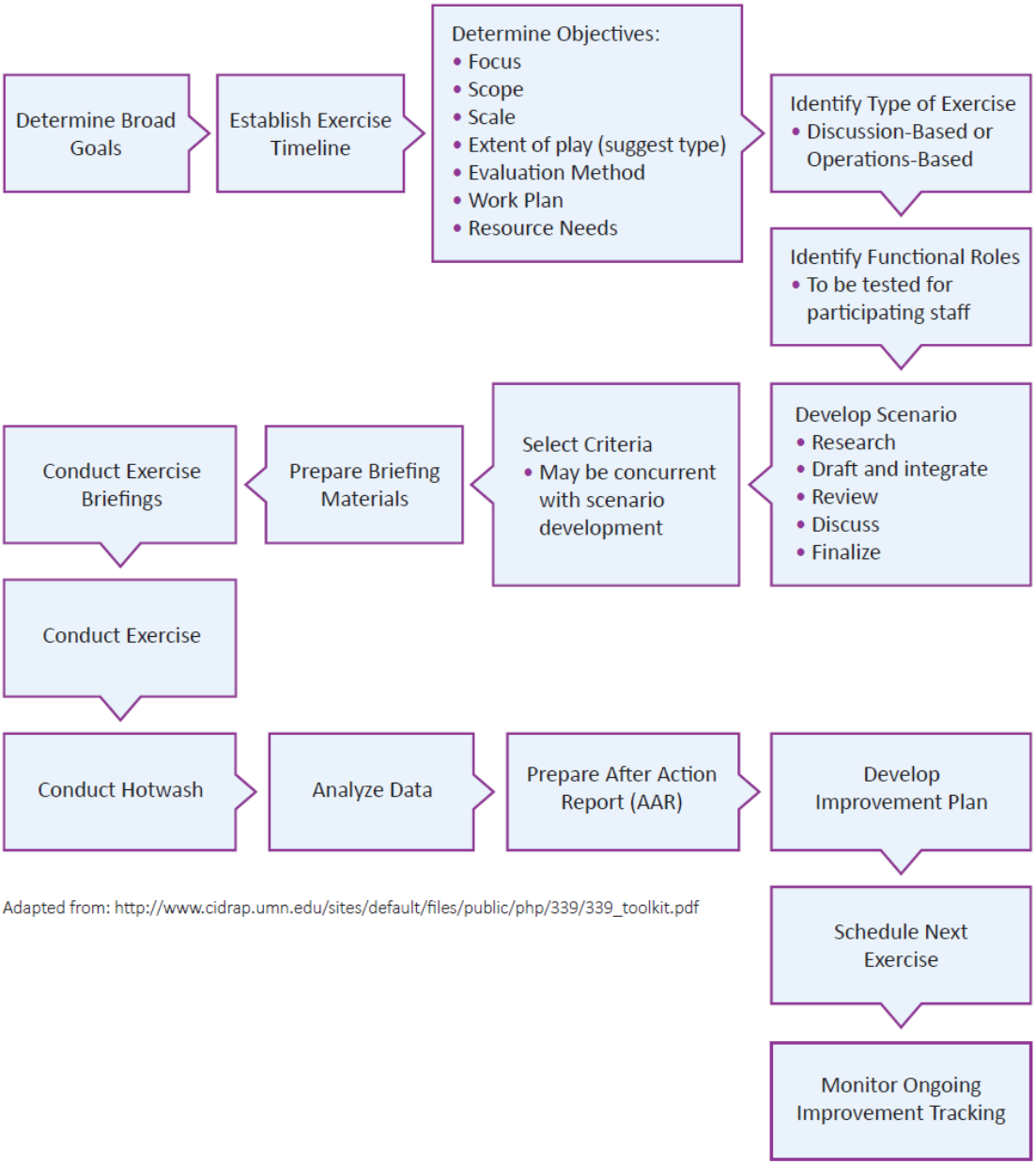
Optimally, all disaster-related exercises should include a component or subset of pediatric victims based on their representation in the population and likelihood of being affected by mass-casualty events.

### Pediatric-Specific Exercise Versus Incorporating Pediatrics Into General Exercises

Most hospitals conduct exercises to meet requirements, such as those of The Joint Commission or Centers for Medicaid and Medicare Emergency Preparedness Rule (www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertEmergPrep/Emergency-Prep-Rule.html). Planning exercises to simulate 25% of the casualties as pediatric patients allows for a response that is a more realistic mix of the entire patient population. Some hospitals may choose to conduct a pediatric-specific exercise. This type of exercise is most suitable for pediatric hospitals, but pediatric-specific exercises can also be a good tool for hospitals who wish to develop or improve their pediatric-specific disaster plan. Community, state, and federal disaster exercises and drills should include community pediatricians, pediatric casualties, and pediatric scenarios as part of a "whole community" approach to preparedness. Although those typically involved in disaster planning and response may have little experience or comfort with children's issues, exercises provide opportunities for education and discovery of potential problems in advance of a disaster.

It should be noted that for the vast majority of pediatricians in non-hospital-based practice, there may not be much of an opportunity to participate in these kinds of exercises. Hospitals and coalitions involved in exercise planning can consider ways to specifically include community pediatricians in private practice in exercises as a way to promote the importance of disaster preparedness. Schools and child care programs are required to conduct exercises and drills, and there are opportunities for pediatricians to have input into these exercises and disaster planning.

## EXERCISE CYCLE




Adapted from: http://www.cidrap.umn.edu/sites/default/files/public/php/339/339_toolkit.pdf

## GENERAL EXERCISE GUIDELINES AND TYPES

### The Homeland Security Exercise and Evaluation Program

The Homeland Security Exercise and Evaluation Program (HSEEP) provides a standardized policy, methodology, and terminology for exercise design, development, conduct, evaluation, and improvement planning. Exercises that use or receive Homeland Security Grant Program funds require HSEEP compliance. The New York State Division of Homeland Security and Emergency Services provides resources and training on designing and conducting HSEEP-compliant exercises (www.dhses.ny.gov/oem/exercise/hseep.cfm).

The HSEEP suggests a progressive approach: as exercises escalate in complexity and planning, they also increase the hospital's or the community's ability to respond to the type of scenario for which they are preparing.

There are various types of exercises. Typically, exercises are discussion-based (meeting-type format held in 1 location, with all participants in the room together) or operational in nature (can be held in various locations; a real-time simulation with participants serving as "players"). A basic description of various exercise types is provided below. Additional information about each of these exercises can be found in the HSEEP manual (https://preptoolkit.fema.gov/web/hseep-resources). Although the hospital or community group that is planning the exercise can skip a step, the HSEEP guidance recommends that exercises proceed upward from discussion to operations-based exercises, depending on existing capabilities and the stage of plan development.

### Discussion-Based Exercises

- ***Seminars:*** Orient participants to authorities, strategies, plans, policies, and protocols.
- ***Workshops:*** Like seminars with increased participant interaction and a focused product. The purpose of a workshop is to fine-tune a protocol, plan outline, portion of a plan, or a full plan.
- ***Tabletop Exercises:*** Generate discussion around a hypothetical emergency to facilitate conceptual understanding. Can enhance general awareness, validate plans and procedures, rehearse concepts, and assess systems needed to guide preparedness for a defined incident. The AAP offers a Pediatric and Public Health Preparedness Exercise Resource Kit (www.aap.org/en-us/Documents/Tabletop_Exercise_Resource_Kit.pdf) that provides tools and templates to make it easier for states, communities, hospitals, or health care coalitions to conduct a pediatric tabletop exercise. This kit was based on implementation of an AAP and CDC virtual exercise, using the Zoom platform.
- ***Games:*** Simulation of operations with 2 or more teams to use rules, data, and procedures to depict a hypothetical situation and explore the consequences of player decisions and actions.

### Operations-Based Exercises

- ***Drill:*** Designed to test a specific operation with a single entity. Only one procedure or plan aspect is exercised to determine whether the plan will work as designed or if training is required.
- ***Functional Exercises:*** Designed to validate and evaluate capabilities and various functions. Functional exercises are focused on exercising plans, policies, procedures, and staff involvement in management, direction, command, and control functions. The events are

projected through an exercise scenario with updates that drive activity. These exercises are conducted in a realistic, real-time environment with some aspects simulated.

- ***Full-Scale Exercise:*** This is the most complex and resource-intensive type of exercise and involves multiple agencies, organizations, and jurisdictions and validates many facets of preparedness. A full-scale exercise includes many players operating under cooperative systems such as the Incident Command System or Unified Command. Events are projected through an exercise scenario with event updates that drive activity at the operational level. Full-scale exercises are conducted in a real-time, stressful environment that mirrors a real incident. Personnel and resources may be mobilized and deployed to the scene, where actions are performed as if a real incident had occurred. The exercise simulates reality by presenting complex and realistic problems that require critical thinking, rapid problem solving, and effective responses by trained personnel. A summary of the various exercise types and the respective components is shown below. However, it is important to keep in mind that depending on the objectives and planning team input for each exercise, the components vary.

Table 6.1 provides an overview of the different types of exercises and respective components.

**Table 6.1: Comparison of Exercise Types**

| | Discussion-Based Exercise | | | | Operation-Based Exercise | | |
|---|---|---|---|---|---|---|---|
| ***Component*** • ***= YES*** | **Seminar** | **Workshop** | **Tabletop Exercise** | **Game** | **Drill** | **Functional Exercise** | **Full-Scale Exercise** |
| ***Length**** | 2-5 hours | 3-8 hours | 4-8 hours | 2-5 hours | 2-4 hours | Varies | 1 to 5 days |
| ***Planning Time*** | Minimal | 1 month | 5 months | Varies | Varies | 6-12 months | 6-12 months |
| ***Planning Team*** | Presenter | Small group | • | • | • | • | • |
| ***Objectives*** | • | • | • | • | • | • | • |
| ***Planning Meetings*** | | | • | • | • | • | • |
| ***Scenario*** | | | • | • | • | • | • |
| ***PowerPoint*** | • | • | • | | | • | • |
| ***Moderator*** | | • | • | | | • | • |
| ***Facilitator*** | • | • | • | • | Controller | Controller | Controller |
| ***Facilitator Guide*** | Optional | Optional | • | • | | | |
| ***Situation Manual*** | Optional | Optional | • | | | | |
| ***Participant Feedback Form*** | • | • | • | • | • | • | • |

**The length of an exercise will depend on the capability being tested, the preferences of organizational leaders, and input from the planning team. Refer to the subject matter experts and the planning team to determine the proper length for each exercise.*

## STEPS FOR PLANNING AN EXERCISE

Although the word "hospital" is used throughout the sections below, it is recognized that another community organization could be taking the lead on planning an exercise.

**Selecting Exercise Participants**
Participants should be invited to participate in an exercise based on the capabilities being exercised. Too many participants can be unmanageable and can make the exercise difficult to evaluate. Too few participants may place a burden on those who are playing and can make the exercise seem unrealistic. Defer to the planning team and the plan to strike the right balance and mixture of the type and number of players.

**Creating a Planning Team**
The exercise planning team designs and conducts the exercise. If the hospital is planning to conduct series of exercises, the planning team should remain the same throughout the entire process.

The planning team should include people who are integral to the hospital's response operations (see **Table 6.2: Exercise Planning Team Representatives Within a Hospital**). This is not an exhaustive list of participating departments. Hospitals or organizations can create the planning team at their own discretion. Designate one person on this team—usually the hospital's Emergency Preparedness Coordinator—to lead the project and manage the planning team.

**Table 6.2: Exercise Planning Team Representatives Within a Hospital**

| | | |
|---|---|---|
| Emergency Preparedness Coordinator | Hospital Administration | Social Work |
| Pediatric and/or Neonatal Intensive Care Unit (medical and nursing) | Respiratory Therapy | Facilities/Engineering |
| Emergency Management or Emergency Medical Services (if applicable) | Emergency Department | Admitting/Patient Tracking/Bed Management |
| Security/Safety | Labor and Delivery | Surgery |
| Trauma Team | Patient Safety/Quality Risk | Child Life (if applicable) |

The planning team's responsibilities include conducting the meetings outlined in the HSEEP manual and the steps below:

- Creating objectives for the exercise
- Preparing a dynamic scenario for the exercise
- Identifying a date and location for the exercise
- Inviting participants
- Deciding on evaluation activities
- Creating various guides, such as a situation manual, facilitator's guide, or evaluation guide
- Developing a PowerPoint presentation to guide presentations and discussions
- Choosing and training exercise evaluators

- Conducting a hot wash, if planned (described below)
- Holding an after action meeting, if relevant (described below)
- Drafting a postexercise report and/or improvement plan

**Conducting Planning Team Meetings**

Table 6.3 provides an overview of the exercise planning meetings referenced in the HSEEP manual and relevant actions to be taken during each one:

**Table 6.3: Overview of Exercise Planning Meetings**

| Meeting | Purpose |
|---|---|
| **1. Scenario, Concept, and Objectives Meeting** | • Determine exercise objectives<br>• Create a scenario<br>• Define circumstances/triggers that set the plan in motion |
| **2. Initial Planning Meeting** | • Choose date and location<br>• Designate team members<br>• Review objectives and scenario<br>• Discuss next steps for drafting the situation manual, exercise evaluation guide, and PowerPoint presentation |
| **3. Midterm Planning Meeting** | • Review draft situation manual, exercise evaluation guide, and presentation |
| **4. Final Planning Meeting** | • Complete final review of all documents<br>• Verify exercise logistics<br>• Review planning team roles (eg, facilitators, evaluators) |

**Conduct Exercise Evaluation**

There are various evaluation aspects that can be considered by the exercise planning team. Evaluations can address the logistical aspects of the exercise (like a meeting evaluation) as well as whether the exercise led to increased topical awareness or skills.

Questions to consider for the evaluation plan include:

1. Should participant awareness of certain topics or protocols be assessed before and/or after the exercise to document changes in awareness or skills?
2. If participant awareness or skill level is part of the evaluation plan, should a participant feedback form or pre- and postexercise survey be used?
3. Should the exercise include a hot wash?
4. Should the planning team hold an after action meeting?

***What is a Hot Wash?*** A hot wash is a briefing or an opportunity for exercise participants to share their thoughts on the exercise, including feedback, concerns, and what they think was accomplished. Participants can discuss exercise strengths and areas for improvement together with the planning team. The hospital can use this information to identify gaps in the response and

to learn about what worked or did not work well in the exercise The hot wash is held immediately following the conclusion of the exercise.

***What is an After Action?*** An after action is a meeting that is held among elected and appointed officials or their designees from the exercising organizations, as well as the lead evaluator and members of the exercise planning team, to debrief on the exercise, decide on needed improvements, and review and refine written recommendations that could be included within a report or follow-up action plan.

It is recommended to conduct an after action meeting within 3 weeks after the exercise. After the exercise is completed, the responsible parties can update any protocol or plan documents as needed and create a report or improvement plan. The report should include an outline of the exercise as well as strengths and weaknesses. The improvement plan should include recommendations and designate staff members to follow up on those recommendations. Sometimes these are considered "summary reports" or "after action reports." Planning team members can use the after action meeting to review draft reports and improvement plans for accuracy and to determine who will follow up on the recommendations in the improvement plan by when. Members of the leadership should make sure to address any recommendations before moving on to the next exercise, and they should also hold staff accountable for the improvements. Exercise participants can be invited to attend or participate in the after action meeting if that is desired.

Information on the evaluation mechanisms and assessments used during AAP tabletop exercises is summarized in the literature. The *Disaster Medicine and Public Health Preparedness Journal* published an article titled "Addressing Children's Needs in Disasters: A Regional Pediatric Tabletop Exercise," which describes the activities and outcomes specific to the 2016 tabletop exercise (www.cambridge.org/core/journals/disaster-medicine-and-public-health-preparedness/article/addressing-childrens-needs-in-disasters-a-regional-pediatric-tabletop-exercise/EC4FF759A0119768D355D5C475F1AAC1). An article titled "Extending the Reach of Pediatric Preparedness: A Virtual Tabletop Exercise Targeting Children's Needs" is pending publication in *Public Health Reports*. The AAP can provide evaluation instruments on request.

**Developing a Situation Manual**

A situation manual is developed by the planning team and used by this team and all participants. The situation manual is generally used in discussion-based exercises, and it serves as the core document that provides the textual background for a facilitated exercise. The situation manual supports the scenario narrative and serves as the primary reference material for all participants during exercises. The situation manual generally includes the following information:

- Exercise scope, objectives, and core capabilities
- Exercise assumptions and artificialities
- Instructions for exercise participants
- Exercise structure (ie, order of the modules)
- Exercise scenario background (including scenario location information)
- Discussion questions and key issues
- Schedule of events

The AAP can provide a sample situation manual that was developed for the in-person and virtual AAP/CDC Pediatric and Public Health Tabletop Exercises (www.aap.org/disasters/tabletop).

**Determining Facilitator Guidelines**
During a discussion-based exercise, the facilitator(s) are responsible for keeping participant discussions on track with exercise objectives and ensuring all issues and objectives are explored as thoroughly as possible within time constraints. If an exercise uses breakout groups, more than one facilitator may be needed.

It is recommended that facilitators:
- Attend an HSEEP training program.
- Support the development of realistic and solvable scenarios.
- Prepare injects (adjustments to scenarios) to keep the exercise moving forward.
- Set "ground rules" to encourage participants to stay on task and remain "in role."
- Aim for full participation from all participants.
- Discourage individuals from dominating the conversation. The exercise should be a collaborative effort, and the facilitator should aim to control the pace and tenor of the exchanges.
- Incorporate new information into the exercise to get or keep participates engaged, if needed.

According to the HSEEP guidelines, a facilitator guide is designed to help facilitators to manage a discussion-based exercise. The facilitator guide usually outlines instructions and key issues for discussion during the event and provides background information to help the facilitator answer questions from participants or players. This guide may also include an evaluation section that provides evaluation staff members with guidance and instructions on evaluation or observation methodology to be used as well as essential materials required to execute their specific functions.

**Determining Exercise Ground Rules**
The AAP conducted exercises in 2016 and 2017 (www.aap.org/disasters/tabletop). An example of exercise ground rules can be found in the 2016 AAP Pediatric and Public Health Preparedness Exercise meeting proceedings on page 7 (www.aap.org/en-us/Documents/disasters_meeting_proceedings.pdf).

**Developing Controller Guidelines**
According to the HSEEP manual, in operations-based exercises and some games, "controllers" plan and manage exercise play and set up and operate the exercise incident site. Controllers can represent or assume the roles of individuals and agencies not actually participating in the exercise. Controllers direct the pace of exercise play, provide key data to players, and may prompt or initiate certain player actions and injects to the players as described in the master scenario events list to ensure exercise continuity. Controllers issue exercise materials to players as required, monitor the exercise timeline, and supervise the safety of all exercise participants. Controllers are the only participants who should provide information or direction to players. All controllers should be accountable to an exercise director or senior controller.

Choose controllers who are familiar with the processes being evaluated. Controllers should use both the exercise evaluation guide and the master scenario events list to control the exercise

flow. They should also be very familiar with the exercise process and how it is meant to unfold. It is recommended that facilities choose members of the planning team to work as controllers. Be sure to train controllers before the exercise to ensure that they understand their responsibilities, the scenario, and the objectives of the exercise.

### Determining the Room Set-up

The discussion-based exercises can be set up using a conference table or by arranging tables/chairs in a U-shape so that everyone can see and interact with each other and view the presentations.

## WORKSHOP

A workshop resembles a seminar in how it is conducted, but it aims to build a specific product, such as a draft plan or policy. Some planning team members recommend not using time within a workshop to draft written policies, but instead suggest that participants review, update, or test written policies already developed. The workshop objectives provide the framework for developing or improving the pediatric plan. Conducting a workshop is the first exercise in a series. If the hospital is not conducting any operations-based exercises, it is possible to use discussion-based exercises for both plan writing/revision and plan socialization purposes. It is recommended that hospitals conduct a workshop once a year to review and update their plan.

One of the first steps in developing a workshop (see **Table 6.4: Steps to Conduct a Workshop**) will be to designate an exercise facilitator. This person should be familiar with emergency preparedness and with the plan, if one exists. The exercise facilitator should be able to engage the audience in a discussion about any shortfalls or gaps in the plan. To do this, the facilitator will need to create a stress-free environment where people feel comfortable expressing their opinions. If feasible, give participants a hard copy of the plan for editing, and encourage everyone to actively engage in plan revision and recommendations. At the end of the workshop, exercise evaluation staff should collect and analyze participants' suggested revisions. The exercise evaluation staff can include members of the planning team or others brought in to assist with evaluating and an analyzing the exercise. Encourage participants to read the plan in advance of, and during the workshop, and discuss gaps in planning as well as potential solutions. Instruct participants to refrain from dwelling on details that cannot be addressed during the exercise series. Workshops are not performance-based and therefore can require a significant amount of moderating by the facilitator. Group discussions and problem solving should occur with the guidance of the facilitator and without time pressures.

### Workshop Logistics

***Who Should Be Involved?*** The following groups of people should participate in the workshop:

- Managers from departments who have a role in the plan
- People who would support or inform decision makers in writing or editing the plan
- People who are able to make decisions during an actual event

If any of the above participants were not involved in the process when the plan was developed, be sure to get their input early on in the exercise design process.

| Table 6.4: Steps to Conduct a Workshop | |
|---|---|
| **Day Before the Workshop** | **Day of the Workshop** |
| Review the list of attendees | Confirm room set-up (tables, chairs, etc) |
| Send an e-mail reminder to participants | Check audiovisual connections and set-up |
| Confirm room reservation | Load presentations |
| Confirm catering order and set-up | Position all documents (eg, plans, table tents, sign-in sheets, forms) |
| Review and organize printed materials | Ensure caterers are set up before the event |
| Designate a notetaker and timekeeper | Confirm responsibilities with planning team |

**After the Workshop**

***Plan Revision or Creation:*** After the workshop is completed, the planning team (or relevant designee) should be sure to update or create the plan that was exercised or discussed. It is recommended that hospitals complete this step within 1 month after the workshop to keep up momentum and handle revisions while the information is still fresh. The timeline will, of course, depend on when any after action meetings are scheduled to review the plan updates or improvement steps.

***Summary Report:*** A summary report outlines the workshop's main discussion items, observations, and any necessary follow-up. It also serves as a written record of any decisions, identified gaps, and/or established goals. The summary report should be based on the workshop structure and objectives, as well as information from the participant evaluations. The report can either be presented as a formal report or as meeting minutes with action items (if applicable), to be shared with individuals who were unable to attend the workshop. It is important to share the summary report with department heads and interested parties.

## TABLETOP EXERCISES

As mentioned previously, the AAP offers a Pediatric and Public Health Preparedness Exercise Resource Kit (www.aap.org/en-us/Documents/Tabletop_Exercise_Resource_Kit.pdf) to provide tools and templates to make it easier for states, communities, hospitals, or health care coalitions to conduct a pediatric tabletop exercise. Additional items to consider when conducting a tabletop exercise can be found below.

During a tabletop exercise, key personnel discuss simulated scenarios and assess plans, policies, and procedures. The main difference between a tabletop exercise and a workshop is that in the tabletop exercise, participants are expected to perform or play out actions and decisions based on the well-developed scenario provided by the facilitator. There is an expectation that participants will utilize the plan and identify any practical or operational issues that impede the facility's capacity to respond to the scenario as prescribed in the plan.

A tabletop exercise is the second exercise in the series, after the workshop has been completed. If the hospital is planning a drill and/or full-scale exercise, the tabletop exercise should be conducted once the planning team has decided on the objectives for the drill or full-scale exercise. Tabletop exercises allow the exercise planning group or facility to test objectives to

determine whether they are appropriate for a drill or full-scale exercise. Planners should allow enough time between the workshop and the tabletop to make any necessary plan and exercise design changes. A tabletop exercise should be held once a year to update and review the plan, unless this is occurring during a functional or full-scale exercise.

If the hospital is planning an exercise series or using the progressive approach, it is suggested that the same scenario be used throughout the entire process. If desired, hospitals can increase the complexity of the scenario as they progress in the exercise series.

**Scenario**
The scenario is the driving force behind the tabletop exercise. Exercise planners must develop a plausible scenario that is solvable within the timeframe allotted for the tabletop exercise. It will be the facilitator's job to make the participants feel as if the exercise is realistic. This is accomplished only through synergy between the scenario, the presentation, and the delivery of the facilitator. The scenario should not make the participants feel as though they are in a "no win" situation; realistic hazards and numbers of patients are crucial to getting the most out of the tabletop exercise. Lastly, the scenario can unfold in waves or phases in which the situation progressively gets a little worse. This allows the group to build confidence in each other and themselves as they solve increasingly complex situations. See sample scenarios in the AAP Pediatric and Public Health Preparedness Exercise Resource Kit (www.aap.org/en-us/Documents/Tabletop_Exercise_Resource_Kit.pdf).

**Developing Presentation Materials**
The tabletop exercise designer and facilitator should work hard to create not only a plausible scenario, but also a realistic PowerPoint presentation that will simulate the stressful conditions that the facility is perceived to encounter. The presentation should include as many visual images and details as required to stimulate the discussion. High-quality images should be used from simulated scenarios or from previous exercises to help participants "feel" like they are actually experiencing the crisis being simulated. The AAP can provide the presentation materials used for its tabletop exercises on request.

**What to Bring to the Tabletop Exercise**
- PowerPoint presentation
- A copy or outline of the existing plan for participants to reference
- Sign-in sheets
- Name tents
- Participant feedback forms (if appropriate)
- Writing pads, pens, and highlighters for participants
- Situation manual
- Exercise evaluation guides
- Controller/evaluator handbook

**Conducting a Tabletop Exercise**
The HSEEP manual and the AAP Resource Kit provide many details on the process of planning and conducting a tabletop exercise (see **Table 6.5: Conducting a Tabletop Exercise**).

| Table 6.5: Conducting a Tabletop Exercise | |
|---|---|
| **Week Before the Tabletop** | **Day of the Tabletop** |
| Review the list of attendees | Confirm that the room is properly set up (tables, chairs, etc) |
| Send an e-mail reminder | Confirm audiovisual connections work |
| Confirm room reservation | Load presentations |
| Confirm catering order, if applicable | Set up table tents (if used) |
| Ensure print materials are ready | Set up all documents, including plans, sign-in sheets, and feedback forms |
| Designate a note taker or person to draft any necessary reports | Ensure caterers set up before the event |

The following are guidelines for a successful tabletop exercise:

The facilitator can begin the tabletop exercise with these steps:

- Introduce themselves and give the participants an idea of their background and what they bring to the exercise.
- Ask participants to briefly introduce themselves; make sure to ask them if they have read the pediatric plan that is being exercised. Consider the level of detail participants should include in their introductions. Examples are: name, current profession, organization/department they work for, why they wanted to attend the session, and what they hope to gain.
- Use the information gleaned from the introductions to help facilitate the session.
- Read the exercise ground rules out loud. Explain that participants are operating in a **"no-fault environment,"** in which all participants' feedback is respected, and comments or suggestions should be constructive.
- Fully articulate the exercise goal and objectives.
- Provide a brief overview of the schedule or timeline for the tabletop exercise schedule.
- Encourage participants to speak up, and explain that this will add to their learning experience.
- Reading the scenario and offering directions on next steps for the participants.

End the tabletop exercise by:

- Conducting the hot wash.
- Summarize key points illustrated by the exercise; tie these points back to the learning objectives.
- Acknowledging gaps in the plan or the hospital's ability to operationalize certain aspects of the plan.
- Listing "parking lot" issues and how they will be captured and/or addressed.
- Ensuring that participant feedback or evaluation forms are completed and collected.
- Discussing next steps (ie, after action report, future exercises, etc).
- Thank the group and end the exercise.

## FULL-SCALE EXERCISES

A full-scale exercise is a multiagency, multijurisdictional, and multidisciplinary exercise involving functional (eg, emergency operation centers) and frontline (eg, firefighters) response officials. Once the hospital or other facility is confident in the plan and the staff's ability to execute it, it can consider conducting an full-scale exercise to test plan components and coordination among hospital decision makers, unit-level staff, partners, and public health and/or government officials. These exercises require a significant amount of planning and should be as realistic as possible (consider using props, mannequins, and actors). A full-scale exercise should be the last exercise in the exercise series. Hospitals should not plan a full-scale exercise without first conducting a workshop and tabletop exercise.

### Exercise Director Guidelines for Full-Scale Exercises

There are often gaps in the following capabilities during full-scale exercises at various hospitals. Consider these gaps when setting objectives for a pediatric disaster-based full-scale exercise:

- ***Notifications:*** The ability to effectively provide internal emergency communications during a crisis is a leading cause of concern for many hospitals that conduct full-scale exercises. Consider testing for timely notifications, call trees that show the correct individual to contact, and reliable notification methods.
- ***Communications:*** Hospitals often experience challenges with in-house communications. When choosing an alternate evacuation location or surge space, note the available phones, write down the numbers, and identify any "dead zones" (areas where portable radios or cell phones do not work).
- ***Establishment of an Emergency Operations Center (EOC):*** In certain circumstances, EOCs are not set up quickly enough to respond to an event. In rapidly expanding situations, assign a liaison to affected areas. This person can provide critical information to the EOC once it has been set up to help leadership maintain situational awareness and give guidance as soon as possible.
- ***Security and Patient Tracking:*** Pediatric intensive care units (PICUs) and neonatal intensive care units (NICUs) have some of the most intensive security in hospitals. Although these systems prevent problems in daily operations, many hospitals found that the systems either did not work or hindered operations during an emergency. It is recommended that hospitals meet with security and patient tracking experts in their facility to review existing plans and devise mechanisms to properly track and secure pediatric patients during a crisis.

### Master Scenario Events List Planning Meeting

For a full-scale exercise, an additional meeting is recommended for the planning team. The master scenario events list is a chronologic outline of event synopses, including expected participant responses, objectives, and responsible personnel. It includes specific scenario events (or "injects") that will prompt participants to implement plans, policies, and procedures that require testing during the exercise. The master scenario events list also records the methods (eg, phone call, facsimile, radio call, e-mail) that will be used to provide injects. This meeting should take approximately 3 hours and should include all members of the planning team.

Consider the following when drafting the master scenario events list:

- Is the event directly related to meeting an exercise objective?

- What is the desired task?
- Who will demonstrate the task?
- Who or what will provide inject(s) (eg, course of play, phone call, actor, video) and who will receive it/them?
- What tasks are the participants expected to complete?
- What are the back-up injects in case the participants fail to complete a task?

### Controller and Evaluator (C/E) Training

The C/E training should be held no more than a week before the exercise date. Use this meeting to train the designated controllers and evaluators on how to use the master scenario events list, exercise evaluation guide, and communication device(s). If controllers and evaluators are using cellular telephones to communicate, be sure to distribute a list of everyone's phone numbers at this meeting. This meeting should take approximately 2 hours and should include all members of the planning team as well as any additional controllers or evaluators selected.

## DEVELOPING A DRILL OR A FULL-SCALE EXERCISE

### Exercise Director Guidelines

For every drill, clearly define protocols, concepts, and objective and areas of play, and make sure that personnel are familiar with the plans and trained in the procedures to be drilled.

### Determine Areas of Play

The planning team should identify which locations will be drilled and/or affected during a full-scale exercise on the basis of what capabilities the hospital is exercising. Areas of play are particular physical locations where the hospital wants to test, practice, and evaluate a process or function. When deciding areas of play, special attention should be paid to exercise play and its effect on operations or functions in nearby areas.

### Develop Drill and Full-Scale Exercise Documents

To conduct an organized and HSEEP-compliant exercise (see **Table 6.6: Conducting a Full-Scale Exercise**), planners will need to develop and utilize standardized documents.

- Master scenario events list
- Exercise evaluation guide
- Player handout
- Exercise plan
- Controller/evaluator handbook
- Controller/evaluator training
- Participant briefing
- Exercise badges
- Participant feedback forms
- Sign-in sheets

| Table 6.6: Conducting a Full-Scale Exercise | |
|---|---|
| **Week Before the Full-Scale Exercise** | **Day of the Full-Scale Exercise** |
| Review the list of attendees | Confirm that the room is properly set up (tables, chairs, etc) |
| Send an email reminder | If multiple spaces are being exercised, make sure all spaces are prepared |
| Confirm catering order, if applicable | Confirm audiovisual connections work |
| Ensure print materials are ready | Load presentations |
| Prepare signage for public spaces (if needed) | Set up table tents |
| Conduct a controller and evaluator training and walkthrough. Make sure that all controller and evaluation staff:<br>• Have reviewed and understand the exercise evaluation guide and the master scenario events list<br>• Have no questions or concerns<br>• Are capable of communicating with the entire exercise staff or lead exercise controller<br>• Have received their assignments and documentation | Set up all documents, including plans, sign-in sheets, and feedback forms |
| | Ensure caterers set up before the event |

## NEXT STEPS AFTER COMPLETION OF EXERCISES

After an exercise is completed, be sure to update or create the plan that was exercised or discussed. It is recommended that hospitals complete this step within a month after the workshop to keep up momentum and while the information is still fresh. Most plans are written by a small group of people with an idealistic mindset of how the actual event will be handled. This can lead to problems when it comes to operationalizing the plan. The purpose of certain exercises is to share the plan with exercise participants who can offer input to improve the plan and the professionals' abilities to use plan concepts in a real-world situation.

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# Chapter 7:
# NUCLEAR AND RADIOLOGICAL EVENTS

Although radiation is a constant exposure in daily life, a nuclear or radiological incident could pose danger to a great many people and the environment. The public may have misconceptions about what are the specific threats of harm. Medical professionals, including pediatricians, need to be knowledgeable regarding the principles and management of radiological injury, not only to provide proper diagnosis and treatment to those affected, but also to alleviate public fear and reduce potential chaos from those who are worried.

## PART 1 -- SCOPE AND IMPLICATIONS

The scale of a nuclear or radiological incident can range from small to large. Nuclear incidents—whether a nuclear explosion attributable to splitting of atomic nuclei and characterized as a nuclear weapon, caused by an improvised nuclear device, or resulting from an incident at a nuclear power plant—would cause damage both at the site of an event and far away because of distribution of radioactive particles. Radioactive dispersal or exposure devices, as well as medical and industrial radiological sources, would cause additional limited damage. Health implications in any of these situations could result in radiation contamination or exposure.

### Nuclear Weapons

Detonation of a weapon could occur in several contexts. The yield of a nuclear weapon is likely related to the origin of the weapon and is linked to the capacity to cause destruction. An improvised nuclear device (IND) constructed outside of a national program is anticipated to have a yield of less than 10 kilotons of TNT equivalent (1 kiloton [kT] = 1000 tons of TNT), while a stockpile weapon deployed either by a nuclear nation or after being stolen from a nuclear nation could produce a yield up to 1000 times greater.

Detonation of a nuclear weapon would cause:

- *A nuclear flash* characterized by extreme heat, light, and prompt radiation (defined as being released instantaneously)
- *A nuclear blast,* which includes an initial fireball
- *A destructive shockwave* moving outward from the explosion and resulting in extremely high winds
- *Fallout,* in which particles containing, or contaminated with, radioactive material descend to the earth's surface from a radioactive cloud

Following a nuclear detonation at elevated height, an electromagnetic pulse could produce a high-voltage surge that would not impact health but would cause local or even widespread disruption to electronic equipment.

Mechanistically in decreasing order, injuries would result from pressure, heat and light, prompt radiation, and residual radiation. Each of these has predictable effects.

- The pressure from a nuclear explosion is hundreds to millions of times more powerful than that of a conventional explosion. Injuries related to the blast are attributable to trauma with intracranial injuries, fractures, lacerations, projectile injuries, rupture of internal organs, and pulmonary hemorrhage and edema. Ruptured tympanic membranes or damaged inner ear structures may result in temporary or permanent deafness.

- The temperatures attained by nuclear explosion are much higher (tens of millions of degrees versus a few thousand) than those of a conventional explosion, causing much more of the explosive energy to be emitted as heat and light (thermal radiation). Heat can result in incineration and burn injuries and may cause fires even at considerable distances from the detonation. Light can cause flash blindness and retinal burns resulting in temporary or permanent blindness.
- Prompt radiation results quickly from the fission of nuclear material and early radioactive decay. This may contribute significantly to radiation exposure, which depends on dose, type of radiation, rate of exposure, length of exposure, and amount of the body exposed (partial or whole body).
- Residual radiation describes radiation from fallout particles and radiation activated during the initial nuclear event. Residual radiation can lead to ionizing radiation exposure and contamination. Heaviest dispersal patterns are close to the blast zone, and fallout can be carried long distances by wind. Residual radiation may persist for an extended period of time and affect animals and human living in the area.

The extent of likely radiation injury from a nuclear incident is inversely correlated with the amount of time that has passed since the event. Radiation would be highest during and immediately after an event. One hour later, radiation would be decreasing. By 24 hours after an event, radiation would have decreased significantly. Based on this timeline, avoiding radiation risks attributable to fallout would be facilitated by sheltering in place for 1 day to allow the largest radioactive particles to settle and dissipate.

Distance from ground zero could be used to estimate generalizable patterns of injury after a 10-kT IND ground explosion (see Figure 7.1). Sequelae of the explosion appears in a circular pattern, while sequelae of fallout is roughly elliptical and significantly impacted by buildings and atmospheric conditions, especially wind.

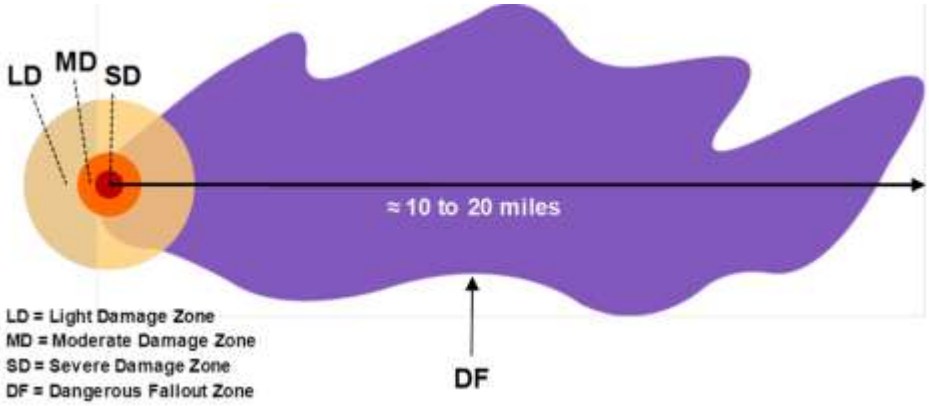


Figure 7.1. Estimate patterns of injury after a 10-kT IND ground explosion

From: Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. Quick Reference Guide: Radiation Risk Information for Responders Following a Nuclear Detonation. December 2016. Accessed February 24, 2022.

- Severe damage would occur at 0 to 0.5 miles from ground zero. Buildings would be completely destroyed. Radiation levels would be very high for 72 hours. Bodies would be vaporized. Survivors are unlikely and most would not survive even if rescued.

- Moderate damage would occur at 0.5 to 1 mile from ground zero. Significant structural damage and early limited visibility would be expected. People would have serious injuries. Rescue efforts should be focused here, as many will only survive if rescued and treated.

- Light damage would occur at 1 to 3 miles from ground zero. Broken windows and similar structural challenges are anticipated. Most people would have non–life-threatening injuries, so they would be expected to survive without rescue or treatment. Rescue efforts will need to canvas for survivors trapped in buildings with structural damage.

- A dangerous fallout zone would extend up to 20 miles from ground zero. People should initially shelter in place, but after 24 hours, radiation levels are expected to be similar to those in the light damage zone.

- Elevated radiation area could extend up to several hundreds of miles. People should be monitored for cumulative radiation exposure and absorbed dose related to contamination.

It is important to note that the area in which a nuclear explosion occurs is likely to incur substantial physical damage, with loss of power, communication, and utilities as well as damage to electronics and communications. Medical infrastructure within the area may not be functional, requiring injured survivors to be transported to surrounding medical facilities. Survivors with chronic medical conditions (such as renal failure requiring dialysis) will also need to have their medical care transferred to functional medical facilities.

**Nuclear Power Plant**

The primary danger of a nuclear power plant event is release of radioactive iodine gas 131-I in the form of a plume. This plume could result in environmental deposition of radioactive material that contaminates people, livestock, food, and water. In countries where they are well regulated, nuclear power plants have significant safeguards to limit radiation injury. These include the physical structure of the facility, highly trained staff, detailed security precautions, formal incident response plans, and regular exercises.

In the United States, nuclear power plant safety is closely monitored by the Nuclear Regulatory Commission. The Nuclear Regulatory Commission has defined emergency planning zones (EPZs) adjacent to nuclear power plants to ensure a unified response. A plume exposure pathway EPZ extends around a plant at a 10 miles radius, where the risk of exposure to and inhalation of airborne radioactivity is greatest. The ingestion pathway EPZ extends around a plant at a 50-mile radius, where the risk of ingestion of contaminated food and liquid is highest.

Protective actions in case of an event could include sheltering in place or evacuation, with administration of potassium iodide (KI) when appropriate.

## Radiological Dispersal and Exposure Devices

Radiological dispersal devices (RDDs) designate an attack where radioactive material is spread with the intent of doing harm, most notably psychological. A colloquially described example of an RDD is a "dirty bomb," in which a conventional explosive is used to disperse radioactive material over a targeted area.

In the case of a dirty bomb, affected people would be those closest to the site of the explosion. Most injuries would be attributable to trauma from the blast of the conventional explosive. Radiation exposure to a large group of people would be unlikely, as it would be difficult to design an RDD that could deliver a high enough radiation dose to cause clinically significant radiation exposure. Still, radioactive particles dispersed by the explosion could cause external contamination or internal contamination to limited numbers of people via inhalation, ingestion, or wounds. People who have radiation contamination attributable to an RDD would require medical evaluation and may need specific care. Long-term monitoring may be indicated to assess for delayed effects.

An attack could also be carried out with a radiological exposure device (RED) that is intended to expose passersby in a high traffic or public area to a hidden radiation source. Immediate symptoms related to acute radiation syndrome and cutaneous injury would require close proximity to the source for an extended time; however, these would likely be rare and difficult to attribute to a single attack. Hence, recognition of the radiological event and identification of the radioactive source and its location would be the greatest challenges in a situation where seemingly unconnected symptoms (hair loss, nausea/vomiting/diarrhea, low peripheral blood counts) are noted in unrelated individuals.

After an RDD or RED, mass psychosomatic symptoms may result in large numbers of people seeking care based on fears of the effects of radiation. This would strain the medical system, and it would add to the difficulty of distinguishing truly exposed people from those with gastrointestinal, dermatologic, and respiratory illnesses that are prevalent in any population at baseline.

Because the number of people with radiation injuries after an RDD or RDE would be limited, the intended effects of such attacks would be to disrupt social and economic infrastructure by causing fear. Hence, in the event of an RDD or RED, a key priority is clear communication with the community. In order to allow appropriate authorities to contain and manage the incident methodically, effective communication with the public must provide reassurance that all necessary steps are being taken to safeguard their health.

## Medical and Industrial Radiological Sources

If they are used incorrectly, radioactive materials used in medical or industrial settings can cause harm from radiation exposure or contamination. Sealed sources may be used for powerful industrial radiography or Cesium-137 (an important decay product resulting from the fission of uranium and plutonium fuels) and in medical therapies. Materials that have been lost and/or stolen can result in radiation injuries.

**Implications and Planning**

Following a nuclear or radiological event, radiation can impact health through contamination or exposure. Radiation contamination occurs when radioactive material is on or in a person's body. Contamination can be external, as on the skin, or internal, as after inhalation or ingestion. Radiation exposure occurs when energy from radiation damages cells. Being able to distinguish between radiation contamination and radiation exposure is crucial (see Figure 7.2).

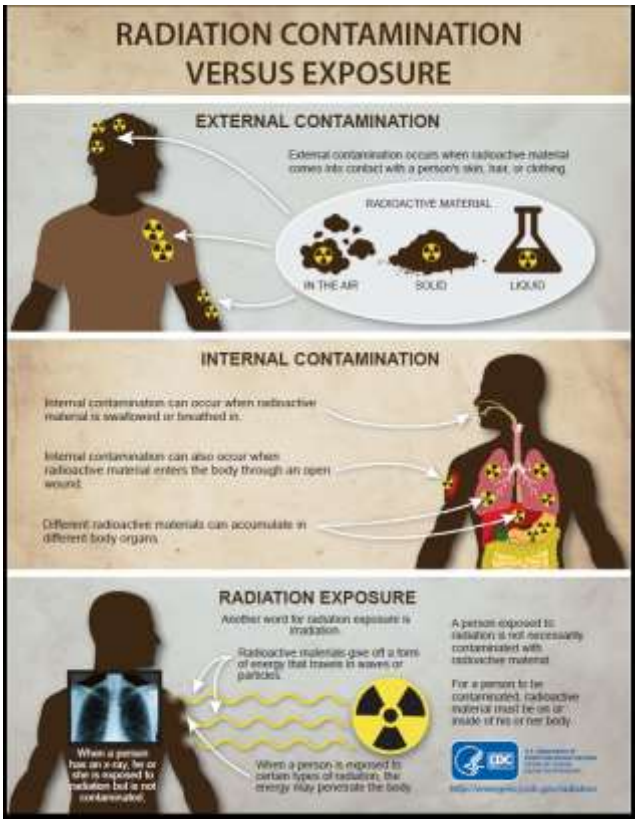


Figure 7.2. Infographic radiation contamination versus exposure

Infographic from: Centers for Disease Control and Prevention. Radiation Contamination Versus Exposure. Accessed February 24, 2022.

Public perception of the threat of a nuclear or radiological event has increased since detonation of atomic bombs in Japan that ended World War II, more recent nuclear power plant accidents, and current international events. Planning may be useful for events attributable to nuclear power facilities, RDDs, and REDs. However, responses to a large-scale event would be challenging to prepare for effectively, as detonation of a nuclear weapon would cause such destruction and crippling of infrastructure that plans would not be able to be implemented.

Planning for a smaller scale nuclear event like an IND has been undertaken thoughtfully. Although an IND has a smaller yield than a nuclear weapon, many would be killed immediately,

the injured would be numerous, and first responders attempting to help could receive significant exposure and contamination from residual radiation and radioactive fallout. Emergency management and public health expertise, including police, fire, and emergency medical service personnel, would be needed to triage patients and communicate a clear message. Treatment (see below) of patients would require subspecialty clinical expertise. Coordination of patient management would require municipal, state, and federal agencies.

The Radiation Injury Treatment Network (RITN), a cooperative effort of the National Marrow Donor Program and the American Society for Transplantation and Cellular Therapy (formerly known as the American Society for Blood and Marrow Transplantation), was formed to provide subspecialty care around a nuclear or radiological incident. A partnership of the RITN with the federal government has been formalized through a memorandum of understanding with the US Department of Health and Human Services – Assistant Secretary for Preparedness and Response, and RITN is described in federal plans. The goals of the RITN are to educate hematologists, oncologists, and stem cell transplant practitioners about their potential involvement in the response to a radiation incident and provide treatment expertise. Toward that end, the RITN developed a Concept of Operations following detonation of a 10-kT IND in which tens of thousands of people could be affected. RITN has produced standard operating procedures and treatment guidelines that can be used outside its network. These procedures address principles of acute radiation syndrome (ARS) management with recommendations for casualty triage, hospital admission order templates, and considerations for selection of candidates for HLA typing and marrow transplantation. In the case of an actual event, RITN centers will collect patient demographic, clinical, and treatment data using the standard Network Data Management Protocol (NMDP) data collection process for future research.

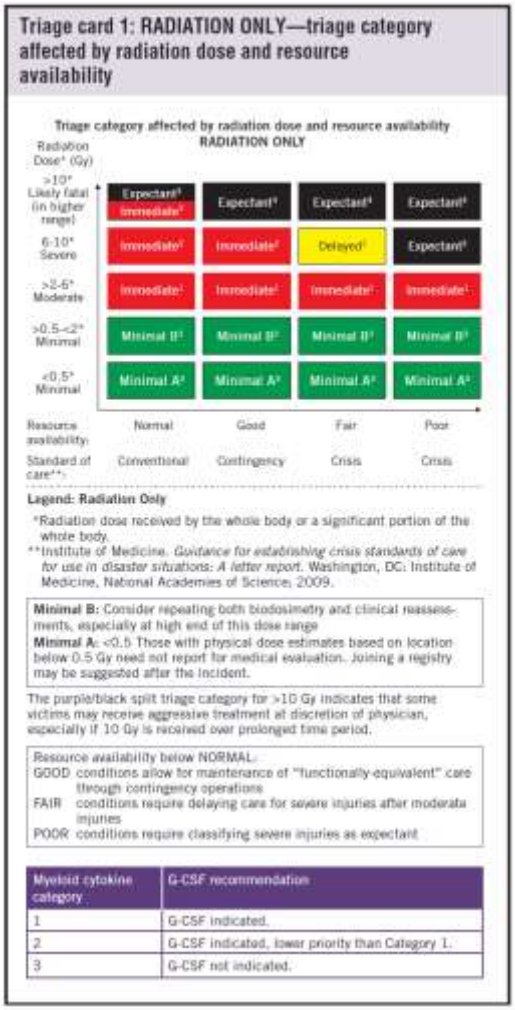


Figure 7.3. Radiation triage category affected by radiation dose and resource availability

From: REMM. Nuclear Detonation Scarce Resources Project. https://remm.hhs.gov/triagetool_intro.htm. Accessed February 24, 2022; Coleman CN, Weinstock DM, Casagrande R, et al. Triage and Treatment Tools for Use in a Scarce Resources-Crisis Standards of Care Setting After a Nuclear Detonation. *Disaster Medicine and Public Health Preparedness*. 2011;5(S1):S111-S121.

Triage and treatment of victims after an IND detonation would be challenged by limited resources and abnormal standards of care. Crisis standards of care, where normal standards of care could not be maintained, would be appropriate in this circumstance. The Scarce Resources for a Nuclear Detonation Project (https://remm.hhs.gov/triagetool_intro.htm) has made recommendations for patients requiring care that is immediate, delayed, and minimal—where minimal care means some radiation but not enough to require hospitalization early on; or expectant, where patients are treated with palliative care only (see Figure 7.3). In order to maintain ethical decision making in such a situation, treatment would be based on order of presentation, patient's medical need, and effectiveness of an intervention, while shifting the priority to those with the highest need for whom an intervention is expected to be effective.

Then, assessment for physical trauma, radiation dose, and combined injury can help to determine who should receive aggressive care.

Triage algorithms for victims of a nuclear or radiological incident can be accessed online:

- REAC/TS, Radiation Emergency Assistance Center/Training Site. https://orise.orau.gov/reacts/infographics/radiation-patient-treatment-algorithm.pdf

## PART 2 – DETECTION OF RADIATION CONTAMINATION

Radiation surveillance is used to determine whether a person or the environment has been contaminated and for evaluating the effectiveness of decontamination. External contamination results when radioactive particles in solid, liquid, or gaseous form are in contact with the body. Internal contamination results when particles are internalized as a result of inhalation, ingestion, or by an impaled object or shrapnel. Decontamination is the methodical removal of external contamination.

When a nuclear or radiological event is suspected or known, then surveillance and collection of samples from people and the environment should start at the scene. Survey results should be documented before and after decontamination, by recording on an anatomic figure drawing. Sample collection must be performed with integrity, as it is crucial for both clinical and forensic evaluations. Each figure and sample must be labeled with respect to patient identification, body site, and date and time of collection. Life-threatening complications, such as the need for cardiovascular or respiratory resuscitation and management of injuries, should be treated first, prior to radiation surveillance. It is imperative that immediate life-saving procedures are not delayed to survey or decontaminate a victim.

### Radiation Surveillance

Radiation detection relies on incoming radiation interacting with electrons of atoms in a detector and generating a signal that is changed into a reading or measurement. The Geiger-Mueller pancake probe is a portable instrument that can detect alpha, beta, or gamma radiation, at low levels, on people or surfaces. Electronic dosimeters have alarms that indicate preset radiation levels or cumulative exposure. Passive dosimeters may absorb radiation energy to allow later calculation of whole body exposure.

**How to Perform a Survey for External Radiation Contamination**

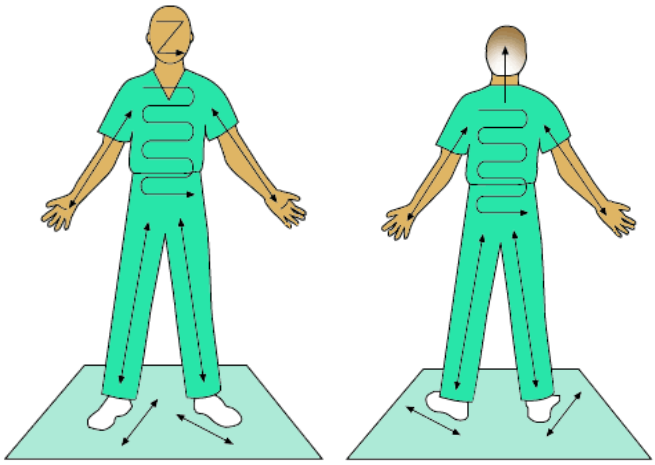

Figure 7.4. Survey for external radiation contamination

From: OSHA. *Best Practices for Protecting EMS Responders During Treatment and Transport of Victims of Hazardous Substance Releases*. OSHA 3370-11 2009. Accessed February 24, 2022.

Ideally, for each patient, the entire body should be surveyed. In brief, the survey should be conducted from head to toe as well as from side to side, with sweeping at 2 to 3 cm/sec. Counts per minute should be recorded frequently (see Figure 7.4).

In case of a large mass casualty incident, guidance exists for decontamination without radiological monitoring if there is a lack of monitoring equipment or for performing expedited survey at the most likely locations of contamination. The decision to use a "quick look" survey should be made by senior incident leaders in collaboration with specialists in radiation protection.

**External Contamination and Sampling**

External contamination occurs when radioactive material is in contact with the outside of a person's body or clothing. Radioactive material can be imparted primarily from radioactive fallout following a radiological incident, or secondarily from a contaminated person or the environment. External contamination can be deposited on skin and hair. The most likely areas of the body to be contaminated include hands, face, and lower legs. Fortunately, removing clothing, clearing the exposed surfaces of the body, and swabbing the nostrils and ears will remove 80% to 90% of contamination.

External contamination could occur after any nuclear or radiological incident that involves radioactive particles. External contamination increases the risk of internal contamination. Only in limited situations (external contamination with high gamma ray emitting particles or internal contamination with alpha particles) would contamination result in significant radiation exposure. With correct use of personal protective equipment (PPE) to limit secondary contamination, there is minimal risk of radiation exposure to emergency or medical personnel after most nuclear or

radiological events (except possibly after a nuclear weapon where risks and amounts of primary and secondary contamination would be higher).

If surveillance detects external radiation, then a smear or wipe sample should be collected at each site where increased signal is found. Each sample should be saved individually and labeled in a suitable specimen container for later analysis.

### Internal Contamination and Sampling

Internal contamination occurs when radioactive material is taken into the airway and lungs by breathing (inhalation), into the intestines by swallowing (ingestion), or into the body through an open wound or by being impaled with radioactive shrapnel.

Evaluation of the orifices of the nose and mouth should be carried out in a timely manner, as natural clearance is completed within about 1 hour. Both nostrils should be swabbed separately and then surveyed. Of note, signal from just one nostril may suggest touching with contaminated hands. Sample collection can include saliva, sputum, vomitus if present, and urine and stool.

Wounds should be evaluated carefully, as they are more likely to be contaminated than intact skin. It is reasonable to consider that all wounds may be contaminated and that all foreign bodies may emit radiation. The wound should be uncovered for surveillance, and a swipe sample should be taken. Exudate should be collected, and embedded shrapnel should be saved for radioactive isotope identification.

## PART 3 – PREVENTION AND MANAGEMENT OF RADIATION CONTAMINATION

Emergency and medical providers must use appropriate personal protective equipment (PPE) to prevent contamination of self and others and to minimize contamination of the environment. Notably, PPE does not provide protection against radiation exposure. Radiation decontamination is used to remove external contamination from victims and providers. Radiation contamination from the environment should be minimized immediately after a radiation incident and during recovery.

### Personal Protective Equipment

PPE should ensure protection of the skin, eyes, nasal or oral orifices, and hands and feet. In general, PPE in the case of a radiological accident or incident involves:

- Respiratory protection to prevent internal contamination by inhalation
- Protective clothing and coverings to prevent external contamination of the skin
- Equipment for radiation surveillance

The level of PPE to be worn would be determined by the incident commander or radiation safety officer. For nuclear or radiation incidents, PPE are considered separately for first responders and first receivers.

First responders usually are at the site of an event where conditions may be hazardous. After a radiological event like an RDD, there is generally no significant risk of exposure, and therefore, a low risk of primary or secondary contamination. However, after a nuclear event like an IND, there would be some risk of residual radiation or fallout causing radiation exposure and primary

external radiation contamination. Additionally, there may be some risk of secondary radiation contamination from patients. Hence, first responders need access to PPE with the highest levels of protection. Recommended PPE includes hooded chemical-resistant clothing with optional chemical-resistant inner suit, face shield, hard hat, and chemical-resistant boots or boot covers. Recommended respiratory PPE includes a full-face air purifying respirator with a P-100 or high efficiency particulate air (HEPA) filter. Tearing of PPE should be avoided and can be prevented or managed with tape.

First receivers include clinicians and hospital staff who receive and treat exposed and contaminated victims, as well as those in roles supporting those functions. First receivers are expected to be remote from the site of an event. Therefore, they are at minimal risk of radiation exposure. However, they are at risk of secondary external contamination during care or decontamination of contaminated patients. PPE should prevent external contamination of providers and contamination of the environment, as well as later internal contamination by ingestion or inhalation. After hazardous substances have been identified and quantified and a negative-pressure respirator has been determined to be protective, then a nonpowered air-purifying respirator is recommended. In that situation, PPE is similar to that in the operating room, with water-repellent surgical gown, head cover, safety glasses/face shield/goggles, face mask, gloves, and disposable chemical-resistant outer boot covers. Double gloving with taping of the inner glove to the sleeve and frequent outer glove changes are encouraged and may additionally help to prevent spread of contamination.

Disposal of PPE should be conducted in a manner to prevent further contamination of the environment. All PPE should be collected in one area, placed in double plastic bags, and labeled as radioactive material. Later, a health physicist can assess the amount of radioactivity present to determine whether PPE should be washed, disposed of, or stored.

**Decontamination**

Life-saving medical care should be initiated prior to patient decontamination. Decontamination carries some risk of transferring external contamination to the health care provider; hence, appropriate PPE should be worn. Pregnant people should not provide care to patients who are externally contaminated. Radiological decontamination is not an emergency, although first aid to wounds within the first hour following contamination can significantly improve radioactive contamination removal. Decontamination should be performed by trained medical personnel or supervised by radiation safety experts.

Especially during decontamination, radiation detection for the health care provider should include a personal radiation dosimeter. Ideally, this dosimeter would provide real-time readings in addition to cumulative measurements. A finger ring dosimeter should be worn on one or both hands if débridement of radioactive shrapnel is undertaken.

Decontamination should proceed from areas of greatest contamination to least. The process should proceed as follows:

- Gross/clothing
- Embedded radioactive shrapnel
- Wounds

- Body orifices around the face
- Intact skin

Following each round of decontamination, surveillance, sampling, and documentation should be performed.

To ease triage of children after a nuclear or radiological event, questionnaire and patient flow algorithms have been developed to identify those children who are affected and to efficiently direct resources to children requiring intervention.

During radiation surveillance and contamination, children have increased risk of hypothermia and should be kept warm and dry. Further, children are anticipated to have less reserve with higher risk of dehydration from gastrointestinal (GI) tract losses with the GI subsyndrome of ARS attributable to lower intravascular volume reserve. Additionally, with respect to treatment, children may have increased risk of side effects like dehydration and electrolyte imbalance or aspiration with drugs that decrease internal contamination.

Gross external decontamination should be identifiable with a radiation detector and can be significantly reduced by removing the patient's clothing and shoes. The clothing should be removed carefully or cut, not torn, and then rolled outward away from the patient's skin such that the radioactive material is trapped in the clothing. To minimize risk of internal contamination of the patient, clothing should be moved away from the patient's face and airway; a splash shield may be applied to the patient for further protection. Contaminated clothing should be placed in a single plastic bag that is sealed and labeled.

After clothing is removed, a whole body survey should be conducted. Areas of external contamination should be noted on a body diagram that is labeled and, if possible, marked on the patient's skin. Two decontamination cycles should be conducted if detectable contamination persists. If the goal of decreased contamination to less than 2 times background is not achieved after 2 cycles of decontamination, then waterproof dressings should be applied to limit spread of contamination.

Wound decontamination starts with preparation. Any pre-existing dressing should be removed and saved. The intact skin adjacent to a wound should be decontaminated to minimize transfer into the wound and to prevent confusion with actual contamination in the wound. Waterproof drapes should be applied around and under the wound to prevent spread of contamination. Anticipated splash should be collected with absorbent pads and run-off can be directed into a receptacle like a lined waterproof can.

After preparation, the wound should be irrigated with sterile water or saline. The initial irrigation is expected to remove the bulk of contamination. When contamination is believed to be significantly reduced, the wound should be covered, the drapes removed, and a clean pad placed. Then the wound should be resurveyed. If the wound is still contaminated, then the process should be repeated until no further progress is made with reducing contamination. Multiple irrigation attempts will likely be necessary. The wound should be dried by application of absorbent material and not by rubbing with gauze, which can force contaminants into the wound. Not all contamination needs to be removed, as some remaining radiation will be incorporated

into a scab and sloughed off. After decontamination, the wound should be covered with a waterproof bandage. For a laceration, suturing should be performed after decontamination in and around the wound. For a puncture wound, simple wet débridement following standard surgical procedures should be performed. Usual infection prevention interventions should be carried out.

If contamination continues to be elevated and is not being reduced, then the wound should be explored for a radioactive foreign body. If a foreign body is visualized or suspected, distance should be maximized between it and the provider trying to remove it using forceps or other long surgical instrument. Removed tissue, foreign bodies, and instruments used to remove them should be collected and labeled with identifiers as radioactive and stored.

External contamination of the facial orifices poses risk of internal contamination. Decontamination of the eyes with irrigation can be used if the globe is not ruptured, but run-off must be directed away from the nose and mouth and prevented from entering the ears. Blowing the nose can facilitate decontamination. If necessary and tolerated, the nares can be irrigated if doing so does not force more contamination into the body. The mouth can be decontaminated by brushing with toothpaste, mouth rinsing, and gargling with 3% hydrogen peroxide. Decontamination of the ear canal should involve irrigation only if the tympanic membrane is visualized to be intact. In all these cases, irrigation fluid can be collected, labeled, and stored.

Hairy areas can be washed with tepid water and mild soap or shampoo, even repeatedly. Conditioner should not be used, as it may bind radiation particles to hair. Run-off should be directed away from the patient to avoid further contamination. Hair can be clipped if necessary but should not be shaved.

Decontamination of intact skin should proceed using techniques from least to most aggressive to balance potential injury with removal of external radiation. It should avoid abrasions that may allow increased entry of external contamination. Dry decontamination can be attempted first, especially if water is limited. The skin can be brushed gently to dislodge radioactive particulates. Adhesive tape (masking tape, not duct tape) can be pressed onto a contaminated area to lift off the contaminant, but this should not be performed on hairy areas or fragile tissue like eyelids. Alternatively, the skin can be washed with tepid water and mild soap for 1 to 3 minutes to float contaminants off the skin and rinse them away. Care should be taken not to splash contaminated water, and run-off should be collected, labeled, and stored.

Minimally aggressive methods include use of baby wipes and application/removal of waterless hand cleaner to a small area. If gentler methods are not effective, gentle scrubbing can be performed using a soft cloth or soft surgical scrub brush. Serial cloths or brushes should be used to avoid recontamination. Decontamination of intact skin should be discontinued if erythema develops. In that vein, possibly only 2 decontamination cycles should be performed. If decontamination has not been effective, then the area can be wrapped or covered with a bandage to allow removal of contamination through sweating and skin sloughing. In that case, the bandage must be monitored periodically, changed as necessary, and labeled and stored when removed.

## PART 4 – MEDICAL TREATMENT OF INTERNAL RADIATION CONTAMINATION

The goal of internal decontamination is to reduce the risk of future biological effects to the whole body or to a specific organ. This can be achieved in the appropriate clinical context with medications specific to corresponding nucleotides. Consultation with a toxicologist, a poison control center, or a Pediatric Environmental Health Specialty Unit (PEHSU) (www.pehsu.net) can provide expert guidance. Mechanistically, these medications can block uptake of the radionuclide, decrease absorption, change distribution, or enhance elimination. The medications discussed are approved by the US Food and Drug Administration (FDA) and are available in the Strategic National Stockpile, an equipment and pharmaceutical cache operated by the US Department of Health and Human Services for use during a national disaster.

### Potassium Iodide to Treat Radioactive Iodine Contamination

A nuclear power plant incident would release radioactive iodine and other radionuclides. Radioactive iodine inhaled or ingested in contaminated food, milk, or water, concentrates in the thyroid gland where it causes thyroid injury and a significantly increased risk of thyroid cancer. The indication for using KI is determined by the predicted thyroid dose. Timing of administration is crucial, as treatment within 1 hour of an incident is optimal and after 12 hours is expected to be minimally effective. Hence, KI must be readily available in high-risk areas. Therefore, coordinated advanced distribution of KI to many communities around nuclear power plants has been carried out by the Federal Emergency Management Agency and the Department of Energy.

Children and fetuses are at relatively increased risk of increased radioactive iodine toxicity since the smaller thyroid gland concentrates proportionately more radioactive iodine that that of an adult. Hence, risk-stratified treatment should be indicated preferentially for children and pregnant women.

KI dosing is age dependent. Tablets would need to be dissolved for administration to young children. Because of a salty taste, additives may be necessary to increase palatability. Treatment with KI can cause occasional GI symptoms and rash. Breastfeeding will need to be temporarily suspended because of associated risks of KI therapy in infants and neonates. In neonates, transient hypothyroidism can develop, so thyroid-stimulating hormone level should be monitored every 2 to 4 weeks and supplemental thyroid hormone should be given to those found to have hypothyroidism. Severe reactions include allergy that would be expected to increase with repeat dosing.

### Prussian Blue to Treat Radioactive Cesium, Thallium, and Rubidium Contamination

Prussian Blue, ferric hexacyanoferrate, is prescribed for the treatment of internal contamination with cesium, thallium, or rubidium. Prussian blue is administered orally. Treatment should start as soon as possible after contamination is suspected and should continue for a minimum of 30 days. Side effects are rare, the most common of which is mild to moderate constipation.

### DTPA to Treat Radioactive Plutonium, Americium, and Curium Contamination

Diethylenetriamine pentaacetate (DTPA) is a chelating agent that can remove heavy metal isotopes. Both calcium-DTPA and zinc-DTPA can be used to increase rates of elimination for

people with known or suspected internal contamination with plutonium, americium, or curium. These chelators should not be used in case of internal contamination with uranium because of risk of renal toxicity. Instead, bicarbonate should be used to alkalinize urine to promote excretion.

Calcium-DTPA is more immediately effective than zinc-DTPA but has increased side effects. Calcium-DTPA should be started on the first day of treatment and then transitioned to zinc-DTPA thereafter. However, pregnant women should be given zinc-DTPA starting from the first day. Both medications are given IV daily. Few serious side effects are reported for these medications, but nausea, vomiting, diarrhea, chills, fever, pruritus, and muscle cramps have been noted in the first 24 hours when given repeatedly.

## PART 5 – DIAGNOSIS OF RADIATION EXPOSURE

The effects of radiation exposure vary by dose, rate, and extent of exposure. (See also Figure 7.5). Dosimetry allows the best dose estimate, with implications for management of complications like acute radiation syndrome and cutaneous radiation injury. Exposure to ionizing radiation induces cellular damage directly by interacting with cellular components or indirectly through production of free radicals and other harmful molecules. Physiologically, radiation exposure causes depletion of stem cells and microvascular injury. The biological impact of radiation exposure is apparent both acutely and in the long term. Acute effects cause delay in cell division and promotion of cell death. Late effects include fibrosis and carcinogenesis.

### Dosimetry

Biodosimetry is the use of a biological response as an indicator of radiation dose. It is a crucial element of evaluation for any patient with possible radiation exposure. Ideally, laboratory evaluation should include a complete blood count with white blood cell differential, sent every 6 hours for 48 hours. Decrease in the value of the absolute lymphocyte count can be used to estimate radiation dose. An increase in the neutrophil to lymphocyte ratio is anticipated to occur over 2 days after radiation exposure. If resources are limited, estimates of dose exposure can be performed with 1 or 2 complete blood cell counts.

Cytogenetic biodosimetry is the standard for detecting chromosomal changes after radiation exposure. It is sensitive and specific within days to about 6 months. There are various permutations, including the dicentric chromosome analysis, which counts chromosomes with 2 centromeres in stimulated lymphocytes after arrest in the first metaphase, and employs a previously established dose-response curve.

The Armed Forces Radiobiology Research Institute suggests obtaining the following, if feasible:

- C-reactive protein (CRP), which increases with dose
- Serum amylase at presentation and at 24 hours which is expected to rise in a dose-dependent way after radiation exposure
- Blood FLT-2 ligand levels as marker for hematopoietic damage
- Blood citrulline as decreasing levels indicate GI tract damage
- Interleukin-6 (IL-6) as a marker increased at higher radiation dose
- Quantitative granulocyte colony stimulating factor (G-CSF) as a marker increased at higher radiation dose

When rapid diagnosis is required to predict the need for treatment, time to onset of vomiting and speed of lymphocyte depletion on serial testing of blood tests can be used. Interindividual variability is great, but these tests can be sensitive even if not highly specific.

At a time removed from the incident, multiparameter dose assessment could be performed with knowledge of the patient's field history (where the patient was at the time of the event and afterwards, whether the patient was shielded, what the patient ate or drank, etc), including signs and symptoms, radioactivity assessment, hematologic parameters, personal and area dosimetry, cytogenetics, and other laboratory testing. Over time, as more information about the event is learned and as patient testing results return, the dose estimate of exposure may be able to be refined.

**Medical Issues: Acute Radiation Syndrome**

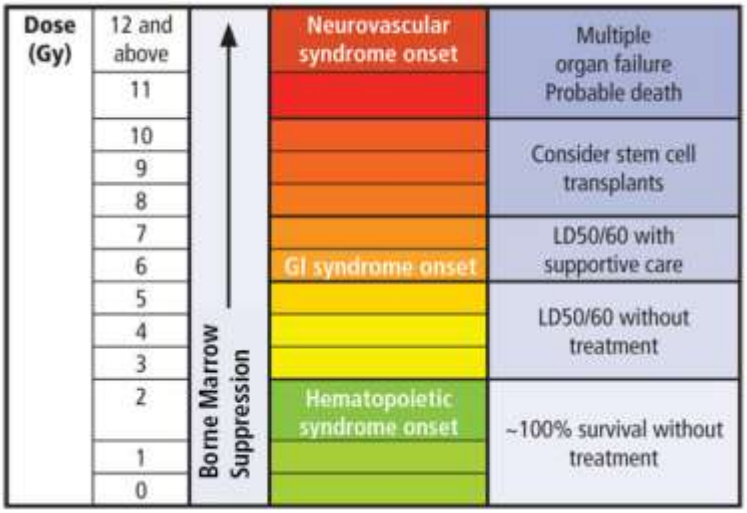


Figure 7.5. Radiation dose dependent medical presentation and outcome

From: Military Medical Operations. Armed Forces Radiobiology Research Institute. *Medical Management of Radiological Casualties*. 4th ed. Bethesda, MD: Armed Forces Radiobiology Research Institute; 2013. Accessed February 24, 2022.

Clinically, radiation exposure results in ARS. ARS occurs when the radiation dose is large, external, penetrating, affecting the whole body, and delivered in a short time. Patients experience an acute illness with signs and symptoms starting within hours to weeks. Radiation exposure of significant dose to cause ARS would occur after a nuclear explosion but not a radiological dispersal device.

Clinical stages of ARS include the prodromal stage that starts within minutes to days, a latent stage without symptoms that can last from hours to weeks, and then the manifest illness stage that can last for hours to months and is characterized by various subsyndromes - each affecting a different organ system. The subsyndromes appear in a stereotyped order, affecting the hematologic, gastrointestinal, and cardiovascular/central nervous systems. The subsyndromes are

progressive in that higher doses are associated with worse symptoms, especially in the hematologic and gastrointestinal systems. The subsystems are also additive, as higher doses are associated with involvement of more subsyndromes. Full expression of the manifest illness stage is followed by recovery over months or death.

**Hematopoietic Subsyndrome**
The blood system shows effects with exposure to ionizing radiation greater than 0.7 Gy. Clinical severity increases with dose such that pancytopenia occurs at 2 Gy and supportive care would be required for survival. Leukopenia, fall in lymphocytes and granulocytes, can result in increased risk of viral, fungal, and bacterial infections. Thrombocytopenia can result in increased risk of spontaneous bleeding. Anemia can result in hemodynamic compromise.

**Gastrointestinal Subsyndrome**
The GI system shows effects with exposure to ionizing radiation greater than 5 Gy. Where exposure to ionizing radiation greater than 8 Gy, it is likely lethal without supportive care. The prodrome can be severe and may be followed by a latent period of 5 to 7 days. Enteropathy is the clinical presentation with ileus that may cause abdominal distention, vomiting/diarrhea that can cause dehydration, decreased tissue integrity and bleeding in association with leukopenia and thrombocytopenia as described above, and death resulting from bacterial infection and sepsis.

**The Cardiovascular and Central Nervous System Subsystems**
The cardiovascular and central nervous system (CNS) subsystems are affected at greater than 20 Gy and reach full penetrance at >50 Gy. At these high doses of radiation exposure, cerebral edema can ensue in minutes with altered mental status progressing to seizures. A latent period of 2 days may ensue, during which orthostatic hypotension and weakness present. Ultimately, coma and death resulting from cerebral edema occur over several days. Other symptomatology may ensue over time, as radiation exposure >5 Gy can present weeks later with radiation pneumonitis.

An interactive tool based on METREPOL guidance (MEDical TREatment ProtocOLs) for Radiation Accident Victims is found on the Radiation Emergency Medical Management (REMM) website (https://remm.hhs.gov/). Symptoms of ARS are used to estimate radiation exposure and to offer recommendations regarding prognosis/follow-up.

**Surgical Issues: Cutaneous Radiation Injury, Embedded Radioactive Material**
Cutaneous radiation injury (CRI) describes damage to the skin and underlying tissues attributable to exposure to radiation. CRI may occur alone, as after exposure to a minimally penetrating source or external contamination of clothing or skin, or it could complicate ARS. In the case of combined CRI and ARS, morbidity and mortality could be attributable to CRI causing a progressive and complex inflammatory process including fever, metabolic disorders, and neurologic side effects resulting from release of endogenous factors.

Visible changes in the skin reflect both the dose and depth of penetration of radiation exposure. Although a small superficial area may show damage, deeper tissues and organ systems may be affected. Skin damage evolves, with tissue furthest from the most affected area showing damage later. CRI tends to appear in cycles that can occur over months or years.

A prodromal erythematous stage occurs minutes to hours after exposure and may last for a few days. Symptoms include erythema, heat, and itching. Time to onset, intensity, and duration of changes may aid prognosis. Early erythema likely is attributable to release of vasoactive amines and secondary vasodilation.

A clinically asymptomatic latent stage may follow for 7 to 21 days. The length of the latent period is inversely proportional to the dose. Concurrent symptoms of ARS would suggest whole body irradiation in addition to cutaneous injury.

A manifest illness stage occurs days to weeks after exposure characterized by bright erythema accompanied by a burning sensation, heat, and edema, as well as increased pigmentation. Depending on severity, dry desquamation or ulceration to necrosis may occur. These findings are attributable to injury to blood vessels and underlying connective tissue. Radiation-sensitive areas of the body like axillae, groin and skin folds may be more affected than less radiation-sensitive ones such as the neck, palms, and soles. Wound infection with bacteria, fungi, or viruses is possible during this stage. Prevention and treatment are key. If affected areas are extensive, care in a burn unit may be necessary.

The subacute stage follows 10 to 16 weeks after exposure. This is characterized by late erythema, blood vessel injury, edema, and pain. There is initiation of progressive dermal and subcutaneous fibrosis.

Finally, a chronic stage usually starts from 16 weeks to 2 years after initial injury, with symptoms that range from mild dermal atrophy to ulcers, dermal necrosis, and deformity. This stage is characterized by dermal fibrosis and subcutaneous sclerosis of connective tissue. Ultimately, the inflammation progresses indefinitely such that long-term evaluation and management are indicated.

Lastly, a late stage 10 to 30 years after exposure results in development of angiomas, keratoses, ulcerations, and squamous and basal cell carcinomas.

With respect to treatment, ulceration and localized necrosis without regeneration may require surgical intervention. Rapid progression suggests increased tissue injury and should encourage earlier intervention, which is intended to remove injured and dead tissue to allow effective engraftment.

Antihistamines and topical anti-pruritic agents may be used for relief of symptoms and may attenuate the inflammatory process. High-dose systemic glucocorticoids with topical class III or IV steroids should be considered.

## PART 6 – MEDICAL TREATMENT OF RADIATION EXPOSURE

Treatment for radiation exposure includes both general supportive care and therapy directed at specific symptoms. These therapies are modeled after those for patients who have been treated with chemotherapy or radiation.

**Gastrointestinal Support: Anti-emetics, Hydration, and Nutrition**
The earliest clinical symptoms of radiation exposure are manifestations of the GI subsyndrome including nausea, vomiting, and diarrhea. Nausea and vomiting can be treated with antiemetics like ondansetron and granisetron, at doses used to manage chemotherapy-induced symptoms. Antiemetics may be contraindicated initially if catharsis is necessary for internal decontamination of ingested radioactive material. Anti-diarrheal agents generally should not be given because of concern for worsening possible infection.

Fluid losses through the GI tract can be severe or prolonged enough to cause dehydration resulting from hypovolemia. Further, fluid intake may be limited with anorexia. Intravenous fluids may be required intermittently or continuously to maintain fluid balance. Monitoring of electrolytes and their repletion should be carried out as clinically indicated.

Nutritional intake may need to be supplemented if oral intake is insufficient. Continued enteral feeding, either orally or via nasogastric tube, is preferred to maintain functioning of intestinal mucosa and to avoid infectious risk of parenteral feeding. If enteral feeding is not possible because of anorexia or is not tolerated because of continued vomiting or diarrhea, then parenteral feeding may be necessary. Nutritional repletion is necessary to counter catabolic effects of radiation and to promote healing.

**Hematologic Support**
Early laboratory manifestations of radiation exposure are apparent in the hematologic subsyndrome. Lymphocyte depletion can start to occur immediately. Pancytopenia with neutropenia, thrombocytopenia, and then anemia can arise over days to weeks. Neutropenia is associated with a risk of sepsis and death, thrombocytopenia with bleeding, and anemia with complications of decreased oxygen-carrying capacity. Each of the therapies described is intended to improve blood count or prevent infection.

**Growth Factors to Treat Neutropenia**
Based on experiences of chemotherapy patients as well as preclinical animal studies, early cytokine therapy can promote neutrophil recovery. Hematopoietic growth factors, granulocyte colony stimulating factor (G-CSF, filgrastim) or pegylated G-CSF (peg-filgrastim) or granulocyte macrophage colony stimulating factor (GM-CSF, sargramostim), have been approved by the FDA for management of marrow aplasia after exposure from a radiation incident. They should be given as early as possible after radiation exposure and continued until the absolute neutrophil count rises to $1000 \times 10^6$ cells/L post-nadir. Granulocyte transfusions are problematic and not indicated for neutropenia attributable to radiation exposure.

**Blood Product Transfusions to Treat Thrombocytopenia and Anemia**
Transfusion of life-sustaining blood products may be necessary for patients with profound cytopenias resulting from the hematologic subsyndrome after radiation exposure. Blood type and screen should be kept current. Institutional protocols govern procedures for blood bank staff and clinicians with respect to blood typing and obtaining consent for transfusion. Transfusions carry risks that include hemolytic reactions, febrile reactions, allergic reactions, and infections.

Thrombocytopenia results when the number of megakaryocytes in the bone marrow that give rise to peripheral blood platelets are reduced. When the platelet count falls below some threshold (often 10-20 x $10^6$ cells/mL) or the patient has symptoms of thrombocytopenia like bleeding, then platelets should be transfused. Platelet units should ideally be from single donors to limit the number of exposures and hence to decrease risk of alloimmunization. Platelet transfusion may typically be required every 1 to 2 days or possibly even more frequently.

Anemia results when production of red blood cell precursors in the bone marrow is decreased. When the hemoglobin level falls below some threshold (often 7-8 g/dL) or the patient has symptoms of anemia like tachycardia or hypotension or poor perfusion, then a red blood cell transfusion with appropriately typed and cross-matched blood should be given. In the current era, blood products must be leukoreduced to minimize risk of cytomegalovirus (CMV) transmission and irradiated to eliminate risk of engraftment of donor leukocytes that could cause transfusion-associated graft-versus-host disease. Packed red cell transfusion may typically be required every 2 to 3 weeks; more in the presence of blood loss because of bleeding.

**Management of Neutropenic Fever**

Febrile neutropenia after radiation exposure should be managed like that after chemotherapy, where bacteremia and septic shock are feared complications.

People exposed to radiation are at risk of febrile neutropenia. Each institution has guidelines about a standard plan for management of patients that is informed by local bacterial susceptibilities and nosocomial infections. With fever, broad spectrum empiric antibiotics should be started with coverage for gram negative bacteria most likely to cause sepsis in this context.

If a specific bacterial organism is identified as the cause of fever, then the empiric regimen may be adjusted and a treatment course should be completed, usually for at least 7 days and possibly until sometime after resolution of neutropenia. If the identified organism is not sensitive to the empiric antibiotics given, then the regimen must be adjusted or can be tailored to the identified organism and susceptibility.

If fever persists, then a search for another source or type of infection may be indicated. Viral infections such as herpes simplex can cause oral and pharyngeal ulcerations that mimic radiation-induced mucositis. Fungal infections can be attributable to *Candida* infection, causing thrush or disseminated disease. If fever and neutropenia persist despite empiric antibacterial therapy or recur on antibacterial therapy, then broadening of antifungal coverage to include *Aspergillus* infection or molds and investigation for fungal infection should be considered.

Infectious disease specialists who specialize in caring for immunocompromised patients may provide expertise in preventing and treating their infections.

**Prophylactic Antibiotics**

According to recommendations of the RITN, people with neutropenia after radiation exposure should receive prophylactic antibacterial, antiviral, and antifungal agents. Levofloxacin is recommended for anti-bacterial prophylaxis. Acyclovir is recommended for herpes simplex virus or vaccinia virus prophylaxis. Fluconazole or posaconazole is recommended for antifungal

prophylaxis. Supplements to prophylactic antibiotics include screening for infections that can arise in spite of prophylaxis.

### Hematopoietic Stem Cell Support for Select Patients

After a radiation event, a subset of people will have had sufficient radiation exposure to cause pancytopenia and limited traumatic or other injuries. In that situation, transplantation of allogeneic (another person's) hematopoietic stem cells – from bone marrow, peripheral blood, or conceivably cord blood – could be considered. Hematopoietic stem cell transplant has been used for radiation injury, with poor results. Limitations of transplantation include challenges with time to identify a donor, risks of conditioning with chemotherapy/immunotherapy, infection and organ toxicity, and risk of graft-versus-host disease.

To date, no cellular therapies have been approved for treatment of the hematologic subsyndrome of ARS. The recommendation of an international consensus conference to address this issue in 2009 was to administer allogeneic hematopoietic stem cell transplantation only in cases where there are no signs of endogenous bone marrow recovery. Preclinical animal models of radiation injury are being used to test possible roles for different cellular therapies to treat specific organ toxicities.

## PART 7 – ISSUES UNIQUE TO PEDIATRICS

Children may face unique challenges after a nuclear or radiological event. Some challenges are based on observational studies after prior events. Others are projected challenges based on differences in physiology between adults and children.

### Susceptibility to Radiation Contamination

Several factors cause children to be more susceptible to both external and internal contamination.

External contamination risk is amplified for crawling infants and toddlers who have increased proximity to residual radiation on the ground; older children may climb on playground equipment that has not be fully remediated.

With respect to inhalation, there is concern that children have increased vulnerability from fallout because of their higher baseline respiratory rates and a lower breathing zone; however, modeling suggests that this risk likely holds only for iodine 125I and 131I and because of their smaller thyroid glands and higher thyroid uptake rather than respiratory differences.

Several factors may influence internal contamination by ingestion. Children are more likely to put their hands up to and in their mouths and to engage in hand-to-mouth activity with radioactive particles, leading to internal contamination via ingestion. Risk of ingestion depends on dietary intake, because milk is a staple of childhood diet. Anticipated amplification in cow milk through the grass-cow-milk pathway suggest that milk from cows that graze on contaminated grass should be banned during the first weeks following an event; canned milk produced prior to the event or away from the site should be safe. Human milk can be contaminated with radioactive iodine, so in the case of contamination, breastfeeding should be discontinued until reported to be safe, while human milk that was frozen before an event would not be contaminated.

Of note, if acceptable levels for food contamination are based on adult intake, this level may not optimally protect children. For example, strontium and radium substitute for calcium in bone such that adolescents who are undergoing rapid bone growth will have a different pattern of incorporation. Additionally, with respect to treatment, children may have increased risk of side effects like dehydration and electrolyte imbalance or aspiration with drugs that decrease internal contamination. Uptake of radioiodine in the thyroid can be prevented by treatment with potassium iodine. Thresholds of predicted thyroid exposure may be set for children and pregnant or lactating women; side effects were discussed previously.

**Susceptibility to Radiation Exposure: Acute and Long-Term Issues**

Children have physiologic features that make them more vulnerable to acute injury following a nuclear detonation. After a nuclear blast, young children may be more vulnerable to burns because of less keratinization and increased permeability of their skin. They may have increased risk of ophthalmologic injury because of an inability to shield their eyes from pressure, heat, and light. Children may be more vulnerable to effects of residual or fallout radiation because of their closer proximity to the horizontal surface of the ground. For infants especially, their greater body surface area to weight ratio than adults may result in more damage from the same dose because of reduced self-shielding of vital organs.

Fetuses have different risks following radiation exposure during gestation. This difference may be direct through exposure or indirect exposure following contamination and concentration in maternal tissue or contamination with subsequent crossing of the placenta and concentration in the fetus. Radiation effects are dependent on dose and gestational age. Failure to implant, miscarriage, or neonatal death are possible outcomes. Exposure before 2 weeks is unlikely to cause non-cancer health effects if the embryo survives. There is a threshold below which radiation-induced non-cancer health effects are not detectable. Especially during the first trimester, surviving fetus may develop intellectual disabilities and microcephaly resulting from brain development effects and postnatal growth restriction. The level at which non-cancer effects are unlikely is higher from 16 weeks' gestation onward.

Children are more susceptible than adults to risks of malignancy over the same latent period. Additionally, they have a longer lifetime ahead and hence a longer period of latency. Cellular factors like differences in stem cell replication and differences in chromosome damage after radiation exposure may explain why children are more vulnerable to long-term effects of radiation. Planned follow-up should continue for a longer time, as children have a higher lifetime risk of certain cancers. Other risks related to external or internal radiation exposure, like changes in the skin or lungs, are anticipated but less well described.

With respect to risk of malignancy after radiation exposure, follow-up of people exposed after prior nuclear or radiation events has been informative. Leukemia incidence is noted to be twice as high in children as adult survivors; this risk begins within 2 years, reaches its peak at 6 years, and regresses to baseline after 25 years. Leukemias seen in children are chronic myelogenous leukemia and acute myelocytic leukemia.

Thyroid malignancy incidence begins within 4 years after ingestion or inhalation and continues. The risk is higher for those younger than 20 years of age versus those older. Notably, children born 9 months after the event are not affected.

Breast cancer incidence was increased for females 10 to 19 years of age at the time of radiation exposure relative to those 20 years of age and older, with a latency of 10 years described. Interestingly, breast cancer incidence was higher also for females younger than 10 years.

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# CHAPTER 8:
# BIOLOGICAL EVENTS

The American Academy of Pediatrics (AAP) published specific recommendations in its policy and technical report, "Chemical-Biological Terrorism and Its Impact on Children" in February 2020.

## HISTORY OF BIOTERRORISM

Although recent world events have heightened awareness of bioterrorism and biowarfare, historical accounts have documented their use for centuries. In recent decades, *Salmonella typhimurium*, *Shigella dysenteriae*, anthrax, and botulinum toxin have all been used in attacks. These attacks affected thousands of people around the world, including those who were presumed exposed and required antibiotic prophylaxis and/or vaccination; the numerous anxious and worried individuals who flooded hospital emergency rooms, physicians' offices, and public health information hotlines; and the thousands of public health, medical, and law enforcement officials who investigated potential attacks.

## EPIDEMIOLOGY OF A TERRORIST ATTACK

Biological terrorism is the deliberate use of any biological agent against people, animals, or agriculture to cause disease, death, destruction, or panic, for political or social gains. A bioterrorist agent may be a common organism, such as influenza or *Salmonella* species, or a more exotic organism such as Ebola virus or variola virus.

In 1999, a panel of public health, infectious disease, military and civilian intelligence, and law enforcement experts was convened to determine which biological agents (microorganisms and toxins) [**See Table 8.1: Biological Weapons of Concern**] posed the greatest potential for use in a bioterrorist attack, to be designated as "Category A" agents. These are the following:

- Anthrax (*Bacillus anthracis*)
- Botulinum (*Clostridium botulinum* toxin)
- Plague (*Yersinia pestis*)
- Smallpox (*Variola major*)
- Tularemia (*Francisella tularensis*)
- Viral hemorrhagic fevers (filoviruses [eg, Ebola, Marburg] and arenaviruses [eg, Lassa, Machupo])

Category A agents are considered the greatest adverse public health threat because of the current populations' susceptibility to these organisms, the resultant high morbidity and mortality, and the potential to cause public panic and need for special actions for public health preparedness and response.

Although bioterrorist attacks ultimately can affect large numbers of people, disease in a single patient may be enough reason to investigate the possibility of biological terrorism. Although some bioterrorist events are subtle, certain clues can heighten suspicion that a bioterrorist attack has occurred:

- Disease caused by an uncommon organism (eg, smallpox, anthrax, or viral hemorrhagic fevers [VHFs]).
- A less common presentation of infection with one of these organisms. For example, although a small number of cases of cutaneous anthrax occur naturally each year in the United States, cases of inhalational anthrax are highly unusual.
- Large numbers of cases of unexplained disease or death.
- A large number of people seeking medical care at a particular time (signaling they may have been present at a common site, timed with the release of an agent).
- Unexpected seasonal distribution of disease (such as influenza in the summer).
- An unexplained increase in the incidence of an endemic disease that previously had a stable incidence rate.
- A large number of people presenting with similar illnesses, in noncontiguous regions (may be a sign that there have been simultaneous releases of an agent).
- A disease identified in a geographic location where it is not usually found (eg, anthrax in a nonrural area or plague in the northeastern United States).
- Disease in an atypical age group or population, such as anthrax in children.
- Animal illness or death that precedes, follows, or occurs simultaneously with human illness or death (may indicate release of an agent that affects both animals and people).
- Antiquated, genetically engineered, or unusual strains of infectious agents.
- Multiple unusual or unexplained diseases in the same patient.

However, because no list of signs can be all inclusive, all health care providers should be alert for the possibility that a patient's condition may not be attributable to natural causes. When there is no other explanation for an outbreak of illness, it may be reasonable to investigate bioterrorism as a possible source. Common sources of exposure to an agent may include the following:

- Food and water that has been deliberately contaminated.
- Respiratory illness attributable to proximity to a ventilation source.
- Absence of illness among those in geographic proximity but not directly exposed to the contaminated food, water, or air.

For early clinical signs and symptoms after exposure to selected bioterrorist agents organized by the impacted body system(s), see Chapter 5: Emerging Infectious Diseases.

## NOTIFYING AUTHORITIES

All public health and medical responses to bioterrorism events begin at the local level. Pediatricians are front-line health care providers in every community, and they may become front-line responders in a bioterrorist attack. It is impossible to predict where a child or parent may first seek care for an illness caused by a bioterrorist agent, so primary care pediatricians, as well as those working at secondary- and tertiary-care facilities, must be prepared to promptly identify and isolate a patient who has an illness potentially related to bioterrorism and to notify the proper authorities.

Good infection control practices require that anyone, child or adult, who presents with a fever and rash be immediately placed in a private room with the door closed. This is standard practice because a number of highly contagious childhood infectious diseases (eg, varicella, measles) present this same way, regardless of whether the illness is ultimately determined to be attributable to an agent of bioterrorism. Infection control precautions may also include the use of personal protective equipment (PPE) such as masks, gowns, gloves, and equipment for eye protection, depending on each situation. All levels of health care professionals should be trained in the use of PPE, including clinical and ancillary staff such as security and environmental services personnel.

Once the initial history and physical examination have been completed, if a disease related to bioterrorism is suspected, the pediatrician must notify the proper authorities, including the infection control practitioner (if one is available at the facility) and local public health authorities. Pediatricians should be familiar with their own local and/or state public health agency and methods for public health consultation and reporting.

Rapid reporting to authorities is essential. Each agency has developed response plans to handle a bioterrorist event. Rapid activation of these plans provides the best opportunity to limit disease spread during an outbreak. Local authorities may initiate an immediate investigation or seek assistance from the state health department (www.cdc.gov/stltpublichealth/healthdirectories/healthdepartments.html).

States report investigations to and request epidemiologic assistance from the Centers for Disease Control and Prevention (CDC). The CDC can be reached 24 hours a day with toxicologists, physicians, epidemiologists, and other scientists to assist in answering questions and offering guidance during an emergency (www.cdc.gov/contact/index.htm) The CDC can also provide public health consultation, epidemiologic support, and other technical assistance to state health departments. The CDC usually becomes involved in a state's investigation at the request of the lead state epidemiologist or health officer. All suspected cases of bioterrorism are subject to criminal investigation. Public health authorities are responsible for notifying local and federal law enforcement officials.

## HOSPITAL

Hospitals should have an all-hazards disaster plan with considerations for all components of the community, including children. These plans require a unified response from the emergency department, intensive care unit, operating rooms, and other key clinical areas within the hospital. Response needs include having an adequate number of pediatric supplies and staff members trained in the care of ill children, including pediatric medication weight-based dosing (mg/kg) to minimize morbidity and mortality. Bioterrorist response plans should be a part of this larger hospital disaster plan. Hospitals play a very large role in the care of bioterrorist victims as well as management of anxious or worried parents and others. Optimally, hospitals should have been included in the response planning of local and state public health agencies. Office- and hospital-based pediatricians can become better prepared to respond to a bioterrorist attack by becoming familiar with local hospital bioterrorist and disaster plans. To be fully prepared for biological terrorism, pediatric and community hospitals must also have an evacuation plan for times when the hospital environment becomes uninhabitable.

In addition, pediatricians are uniquely qualified to ensure that the special needs of children (eg, medical supplies and therapeutics specific for children) are addressed in local medical response plans. See Chapter 3: Preparedness Planning in Specific Practice Settings. For preparing for high-consequence infectious outbreaks, see Chapter 5: Emerging Infectious Diseases.

For hospitals that do not treat large numbers of children, telehealth and telementoring technologies offer access to information and to pediatric infectious disease specialists to facilitate the care of children.

## LABORATORY SUPPORT AND SUBMISSION OF SPECIMENS

Collecting the appropriate clinical laboratory specimens utilizing appropriate PPE in a case of an actual or suspected bioterrorist-related illness is critical for the medical care of the patient as well as for public health and legal investigations. Specimen collection varies by the agent suspected and should be done in consultation with public health authorities. Local and state public health authorities can advise pediatricians and others on specific specimen collection and transport or in consultation with the CDC as needed. Each state health department may facilitate specimen submission to 1 of more than 150 laboratories that are members of the federal Laboratory Response Network (https://emergency.cdc.gov/lrn/index.asp).

## LIMITING THE SPREAD OF INFECTION

Rapidly detecting and isolating patients with an infectious illness related to bioterrorism is essential to prevent transmission in health care settings and the broader community. If an infection related to bioterrorism is suspected, the patient should be placed on contact precautions and airborne isolation, in addition to standard precautions, until preliminary test results become available, and the transmissibility of disease can be reevaluated.

Fortunately, agents of bioterrorism are generally not transmitted from person to person. Acquisition will typically be by exposure to a point source release of the agent. Exceptions, however, include smallpox, VHFs, and pneumonic plague, each of which may be highly transmissible from person to person via respiratory droplet and, in some cases, aerosol spread.

## PRECAUTIONS

At the very least, patients suspected of infection with a category A bioterrorist agent should be cared for using standard precautions. Standard precautions include handwashing, gloves, eye protection, and gowns as appropriate to prevent direct contact with blood, other body fluids, secretions, excretions, nonintact skin/rashes, and mucous membranes. Additional precautions may be needed to prevent spread and to protect care providers and are instituted based on the organism suspected. Information on precautions to prevent transmission of infectious agents are available (www.cdc.gov/infectioncontrol/guidelines/isolation/index.html).

## EQUIPMENT AND SUPPLIES

The equipment and supplies necessary to diagnose and treat a patient suspected of being infected with a bioterrorist agent vary by the level of care that will be provided at each facility. An office-

based primary care pediatrician may need to be concerned only with short-term isolation and preliminary stabilization of a patient, which will require a relatively short list of supplies that usually are available in the well-stocked pediatric medical office. Hospital-based pediatricians may be providing longer term and more complex care to patients and should consult their hospital administration regarding the hospital's bioterrorist response plan for children and the response plans of state and local health authorities.

Response planning requires a detailed and integrated approach between public health and medical facility administrators. For specific guidance for personal, business, health care facility and local or state preparedness, see https://emergency.cdc.gov/planning/index.asp.

## MANAGING PATIENTS: TREATMENT AND PREVENTION

Treatment consists of supportive care (eg, fever management, fluid management, nutritional supplementation, ventilatory support, and emotional care) and medical treatment (antibiotics and antitoxins) or postexposure prophylaxis specific to the bioterrorist organism implicated.

### Strategic National Stockpile

The Strategic National Stockpile (SNS) is a national repository of antibiotics, chemical antidotes, antitoxins, vaccines, life-support medications, and other medical and surgical items to supplement and resupply local inventory. The SNS maintains a stock of supplies that are specific for the medical needs of children and has received guidance from the American Academy of Pediatrics (AAP) as well as from academic and public health experts in general pediatrics, pediatric infectious diseases, pediatric pharmacology, pediatric emergency medicine, and pediatric critical care medicine. Unfortunately, not all medical countermeasures (MCMs) are licensed for use in children or are available in formulations suitable for young children. Unapproved MCMs may be distributed under a US Food and Drug Administration (FDA) emergency use authorization (EUA) or investigational new drug (IND) application. These items can be relatively quickly delivered (hours), but in order to receive SNS assets, the state governor will need to directly request deployment from the US Department of Health and Human Services (HHS). It is important for pediatricians to consult with the local or state public health department that will facilitate discussion with the relevant government agency.

### Isolation of Exposed or Infected People

Isolation needs will vary greatly depending on the type of attack. For those diseases that are not transmitted person to person (eg, anthrax, botulism, or tularemia), isolation is not needed, and standard precautions apply. The people exposed will be those at the geographic location where the organism or toxin was released.

For diseases that are transmissible, such as smallpox, plague, and VHFs, infection control measures include isolation. Depending on the number of cases, victims may be isolated within a hospital. If demand exceeds the capabilities of a traditional health care facility, supplemental isolation and medical care facilities may be needed (eg, schools, college campus buildings, motels, churches, or unused hospitals). If patients do not require advanced medical care, home isolation may be sufficient. Home isolation was used successfully during the severe acute respiratory syndrome (SARS) and monkeypox outbreaks of 2003 as well as during the COVID-

19 pandemic. Each state health department will help determine the best course of action based on local response plans.

**Vaccination and Postexposure Prophylaxis**
Large-scale vaccination may be recommended in some outbreaks related to bioterrorism. Postexposure prophylaxis (PEP) may be recommended in response to certain outbreaks. Vaccination and/or PEP may be offered to an affected community, county, or state or to the entire nation. Surveillance and containment strategies require that individuals who are ill are quickly identified and isolated, followed by rapid identification and vaccination and/or PEP treatment of their contacts.

## CATEGORY A AGENTS

As mentioned above, category A agents are considered the greatest public health threat because of their potential ease of dissemination, resulting high morbidity and mortality, and potential to cause public panic and need for special actions for public health preparedness. Additional information about these agents can be found in the AAP *Red Book* (https://redbook.solutions.aap.org/).

As mentioned, if a case of any category A agent is suspected, the local and state health departments and hospital infection control practitioner should be contacted immediately.

**Anthrax**
*Bacillus anthracis*, the etiologic agent of anthrax, is a gram-positive, anaerobic, spore-forming, bacterial rod. The 3 virulence factors of *B anthracis* are edema toxin, lethal toxin, and a capsular antigen. Human anthrax has 3 major clinical forms:

- Cutaneous, which can develop after contact and causes papules/vesicles and later ulcers.
- Inhalational, which is the most lethal form, with incubation period of days to weeks.
- Gastrointestinal, which is the least common and can cause lesions anywhere along the gastrointestinal tract.

If untreated, anthrax in all forms can lead to septicemia and death. Anthrax is not spread by person-to-person contact, except in rare cases of transmission from cutaneous lesions.

Empiric treatment is typically with ciprofloxacin or doxycycline but may include additional multidrug therapy and Anthrax Immune Globulin or raxibacumab antitoxin for severe disease. There is an approved vaccine that is effective in preventing cutaneous anthrax in adults, but it is for use in a bioterrorism incident and should be guided by local health department officials or the CDC.

Standard precautions are recommended for hospitalized patients with systemic disease. For patients with cutaneous infections, contaminated dressings and bed linens should be incinerated or steam sterilized to destroy spores and contact isolation implemented. Autopsies performed on patients with systemic anthrax require special precautions.

The AAP and CDC offer more information including details on PEP, treatment recommendations, and recommended specimen collection (www.cdc.gov/anthrax and

https://www.aap.org/en/patient-care/disasters-and-children/disaster-management-resources-by-topic/anthrax/).

**Botulinum Toxin**

Botulism is a rare disease caused by ingestion of the anaerobic, spore-forming bacillus *Clostridium botulinum*. Botulism neurotoxins are the most potent toxins known. There are 3 forms of naturally occurring botulism: foodborne, wound, and infant (intestinal). Iatrogenic botulism may occur after an overdose of injected botulinum toxin. A bioterrorist incident with release of aerosolized botulinum toxin inhalational disease could occur. The incubation period for aerosolized botulism is unknown, but limited reports suggest hours to less than 3 days. Regardless of the means of exposure, botulinum toxin results in a descending flaccid paralysis in a patient who remains mentally alert and afebrile. Early symptoms include double or blurred vision, difficulty speaking and swallowing, dry mouth, and fatigue. As the disease progresses, symmetrical muscle weakness develops, starting at the trunk and descending to the extremities; deep tendon reflexes generally remain intact. Without ventilatory support, death occurs when the toxin attacks the respiratory system, resulting in airway obstruction and respiratory paralysis. Recovery may occur if paralyzed muscles are reinnervated, but this process requires weeks to months of intensive supportive therapy.

Treatment should begin as soon as the diagnosis is suspected without waiting for laboratory confirmation. Botulinum antitoxin (available via the state health department, the CDC Emergency Operation Center, or BabyBIG for infants <12 months of age) should be administered to all patients with known or suspected disease. Antitoxin cannot reverse the effects of toxin bound to nerve receptors, but it does prevent further damage (www.infantbotulism.org/general/babybig.php).

Standard precautions should be used in the care of hospitalized patients with botulism. Person-to-person transmission does not occur. Individuals known to be exposed or suspected of having been exposed to aerosolized botulinum toxin should be closely monitored. At the first sign of disease, but not before, patients should be treated with antitoxin.

*Clostridium botulinum* is a hardy spore that is highly heat resistant, but botulism toxin in food is easily destroyed through the normal cooking process (heating >85ºC for 5 minutes). Weather conditions and size of the aerosolized particles determine how long the toxin can remain airborne, but it is estimated that most toxin would be inactive within 2 days of aerosol release. If a warning is issued before a release, some protection can be achieved by covering the mouth with cloth or a mask; toxin may be absorbed through mucous membranes but cannot penetrate intact skin. After a known exposure, patients and their clothing should be washed with soap and water. Surfaces exposed to the initial release should be cleaned with a 1:10 hypochlorite (bleach) solution (http://www.cdc.gov/botulism).

**Plague**

Plague is caused by *Yersinia pestis*, a pleomorphic, bipolar-staining, gram-negative coccobacillus. In nature, plague is a zoonotic infection of rodents and their fleas that is found in many areas of the world. Bubonic plague usually is transmitted through the bites of infected rodent fleas. Septicemic plague occurs most often as a complication of bubonic plague. Primary

pneumonic plague is acquired by inhalation of respiratory droplets from a human or animal with respiratory plague or from exposure to laboratory aerosols. Secondary pneumonic plague arises from hematogenous seeding of the lungs with *Y pestis* in patients with bubonic or septicemic plague.

A bioterrorist incident involving plague would most likely occur through aerosolization and result in pneumonic involvement. Incubation after aerosolization is in the range of 1 to 3 days. Clinical features of pneumonic plague include fever, cough with mucopurulent sputum (gram-negative rods may be seen on Gram stain), hemoptysis, and chest pain. A chest radiograph will show evidence of bronchopneumonia.

If plague organisms are suspected, the laboratory examining the specimens should be informed so that steps can be taken to minimize risks of transmission to laboratory personnel. All people with exposure to a known or suspected plague source should be offered antimicrobial prophylaxis or be cautioned to report fever greater than 101°F or other illness to their physician. For adults and children, including those younger than 8 years, doxycycline or ciprofloxacin is recommended.

In addition to standard precautions, droplet precautions are indicated for all patients with suspected plague until pneumonia is excluded or after 48 hours of appropriate treatment. PEP with doxycycline or ciprofloxacin should begin after confirmed or suspected exposure to *Y pestis* and for postexposure management of health care workers and others (eg, household members) who have had unprotected face-to-face contact with symptomatic patients. The CDC offers further information and fact sheets (www.cdc.gov/plague/index.html).

**Smallpox**
Variola is the virus that causes smallpox. People are the only natural reservoir for variola virus. As a result of worldwide vaccination efforts, this infection has been eliminated. The last naturally occurring case of smallpox occurred in Somalia in 1977. Nonetheless, variola virus could be used in a biological attack.

The incubation period to the disease is similar to that of chickenpox at 7 to 19 days. Symptoms include fever, malaise, headache, backache, vomiting, abdominal pain, enanthema, and cutaneous rash, which begins as macules, forms papules, then firm vesicles and then deep-seated hard pustules. Patients are infectious from the development of enanthema until all skin lesions have separated, typically 3 to 4 weeks into the illness. The illness can be distinguished from chickenpox, as the latter lesions progress much more quickly, often have multiple stages of lesions in the same body region, and remain superficial at the dermis.

In addition to the typical presentation of smallpox (≥90% of cases), there are 2 uncommon forms of variola major: 1) hemorrhagic, characterized by hemorrhage into skin lesions and disseminated intravascular coagulation; and 2) malignant or flat type, in which the skin lesions do not progress to the pustular stage but remain flat and soft.

Smallpox is typically spread in droplets from the oropharynx of infected individuals, although infrequent transmission from aerosol and direct contact with infected lesions, clothing, or

bedding has been reported. If a patient is suspected of having smallpox, standard, contact, and airborne precautions should be implemented immediately; hospital infection control personnel should be notified when the patient is admitted; and the patient should be placed in a private, airborne isolation room equipped with negative-pressure ventilation with high-efficiency particulate air (HEPA) filtration. Anyone entering the room must wear an N95 or higher-quality respirator, gloves, gown, and shoe covers, even if there is a history of recent successful immunization. If the patient is moved from the room, he or she should wear a mask and be covered with sheets or gowns to decrease the risk of fomite transmission. Rooms vacated by patients should be decontaminated using standard hospital disinfectants, such as sodium hypochlorite or quaternary ammonia solutions. Laundry and waste should be discarded into biohazard bags and autoclaved, and bedding and clothing should be incinerated or washed in hot water with laundry detergent followed by hot-air drying.

Vaccination: Postexposure immunization (within 3–4 days of exposure) provides some protection against disease and significant protection against a fatal outcome. Any person who has had significant exposure to a patient with confirmed smallpox during the infectious stage of illness should be immunized as soon after exposure as possible, but ideally within 4 days of the first exposure. Because infected individuals are not contagious until the rash (and/or enanthema) appears, individuals exposed only during the prodromal period are not at risk. The AAP and the CDC collaborated to produce the Clinical Guidance for Smallpox Vaccine Use in a Postevent Vaccination Program in 2013 (https://www.cdc.gov/mmwr/preview/mmwrhtml/rr6402a1.htm).

Antivirals: With expert consultation, tecovirimat, cidofovir, and brincidofovir have shown promise in animal studies and in limited data from treatment of vaccinia related complications in humans.

Vaccinia Immune Globulin (VIG): Current supplies of VIG are used in the treatment of complications of smallpox immunization. The CDC is the only source of VIG in the United States (www.cdc.gov/smallpox).

**Tularemia**

Tularemia is caused by *Francisella tularensis*, a small, nonmotile, aerobic, gram-negative coccobacillus. *F tularensis* is one of the most infectious pathogens known; inoculation with or inhalation of as few as 10 organisms can cause disease. Natural infection in people occurs through bites of infected arthropods; handling infectious animal tissues or fluids; direct contact with or ingestion of contaminated food, water, or soil; or inhalation of infective aerosols. Aerosol release of *F tularensis* as a bioterrorist event would be expected to cause primarily pleuropneumonitis, but some exposures might result in ocular tularemia, ulceroglandular or glandular disease, or oropharyngeal disease with cervical lymphadenitis. Release in a densely populated area would be expected to result in an abrupt onset of large numbers of people with acute, nonspecific febrile illness beginning 3 to 5 days later (incubation period is 1–14 days), with pleuropneumonitis developing in a significant proportion of cases during the ensuing days and weeks.

Illness begins with symptoms that include fever, headache, chills and rigors, generalized body aches, coryza, and a sore throat. There may be a dry or slightly productive cough and substernal

pain or tightness with or without objective signs of pneumonia. These findings are followed by sweats, fever, chills, progressive weakness, malaise, anorexia, and weight loss. *F tularensis* can be isolated by growth in culture from respiratory secretions and sometimes from blood in cases of inhalational infection. Specimens may also be tested by Gram stain, fluorescent antibody, immunohistochemical stains, or polymerase chain reaction (PCR) assay. If tularemia is suspected, the laboratory should be informed so that steps can be taken to minimize risks of transmission to laboratory personnel.

In case of a bioterrorist event, antimicrobial susceptibility testing of isolates should be conducted quickly, empiric therapy given, and treatment altered according to test results and clinical response.

If a bioterrorist attack with tularemia is discovered before individuals become ill, those who have been exposed should be treated prophylactically with oral doxycycline or ciprofloxacin. If an attack is discovered only after individuals become ill, full treatment regimens should begin promptly among those who develop an otherwise unexplained fever or flu-like illness within the 14 days incubation period from the presumed exposure (www.cdc.gov/tularemia).

**Viral Hemorrhagic Fevers**

The term VHFs refers to a group of illnesses that are caused by several distinct families of viruses. In general, VHF is used to describe a severe multisystem syndrome. Characteristically, the overall vascular system is damaged, and the body's ability to regulate itself is impaired. Although some types of hemorrhagic fever viruses cause relatively mild illnesses, many of these viruses cause severe, life-threatening disease. The viruses include arenaviruses (including Lassa fever), filoviruses (including Ebola and Marburg hemorrhagic fever), bunyaviruses (including Rift Valley fever and hantavirus), and flaviviruses (including yellow fever and tickborne encephalitis).

Specific signs and symptoms vary by the type of VHF, but initial signs and symptoms may mimic an influenza-like illness, often including marked fever, fatigue/exhaustion, dizziness, muscle aches, and loss of strength. Other symptoms can include vomiting, diarrhea, abdominal pain, chest pain, cough, and pharyngitis. A maculopapular rash, predominantly on the trunk, develops in many patients about 5 days after the onset of symptoms. Patients with severe VHF often show signs of bleeding under the skin, in internal organs, or from body orifices like the mouth, eyes, or ears. However, although individuals may bleed from many sites around the body, patients rarely die because of blood loss. Severely ill patients may go into shock with nervous system malfunction, coma, delirium, and seizures. A diagnosis of VHF introduced through bioterrorism is likely to be recognized only after a cluster of patients present with similar, severe illness. Clinical suspicion should prompt notification of infection control and state health officials. Information for the collection, transport, and testing of specimens from patients suspected of having a VHF should be coordinated with the state health department and/or the CDC.

The incubation period for VHF is 4 to 21 days. In general, there is no specific treatment or established cure for VHFs. Treatment is supportive. Some antiviral agents (including investigational) or plasma from recovered diseased patients may be helpful in selected

circumstances. Clinicians may call the CDC Info Line and mention that they are a physician to discuss treatment options.

Some viruses that cause hemorrhagic fever—including Ebola, Marburg, Lassa fever, and Crimean-Congo hemorrhagic fever viruses—can spread from 1 person to another (once an infected person has become symptomatic). Both standard precautions and contact precautions should be used in caring for patients with suspected or confirmed VHF. Airborne isolation, including use of a HEPA-filtered respirator, should be used if patients with these conditions experience a prominent cough, vomiting, diarrhea, or hemorrhage. More extensive precautions may be warranted to protect care providers. Clinicians should contact the local department of public health or hospital infection control department for guidance. Specific infection control recommendations for Ebola virus are available (https://www.cdc.gov/vhf/ebola/clinicians/index.html).

## CATEGORY B AND C AGENTS

The second highest-priority agents (category B) are moderately easy to disseminate, with moderate morbidity and low mortality. Category B agents also require additional enhancements of CDC diagnostic and surveillance capabilities. Category C agents are of concern because of their future potential to be engineered for mass dissemination, with attendant major health impact with high morbidity and mortality. Additional information about these agents can be found in the AAP *Red Book* (https://redbook.solutions.aap.org/). If a case of any category B or C agent is suspected, clinicians should immediately contact the local and state health department and hospital infection control practitioner.

### Brucella

*Brucella* species that infect people include *Brucella abortus*, *Brucella melitensis*, *Brucella suis*, and rarely, *Brucella canis*. *Brucella* species are small, gram-negative coccobacilli. People contract this disease naturally through direct contact with infected animals and their carcasses or secretions or by ingestion of unpasteurized milk or milk products. *Brucella* species, particularly *Brucella melitensis* and *Brucella suis*, are potential terrorist agents. Aerosolization can result in human infection.

Most infected individuals become ill within 3 to 4 weeks of exposure, but the incubation period may vary from <1 week to several months. Clinical features after natural exposure are extremely variable and nonspecific. They include influenza-like symptoms—ie, fever, sweats, malaise, anorexia, headache, myalgia, and back pain. Physical findings may include lymphadenopathy, hepatosplenomegaly, and occasionally, arthritis. Serious complications include meningitis, endocarditis, and osteomyelitis.

*Brucella* organisms can be recovered in culture from blood, bone marrow, or other tissues. Specimens should be incubated for a minimum of 4 weeks. Serum samples collected at least 2 weeks apart can confirm the diagnosis with a 4-fold rise in antibody titers. Treatment is typically prolonged and most often with doxycycline and another agent such as rifampin, streptomycin sulfate, or gentamicin sulfate to prevent relapse or treat more severe infections. Prophylaxis after suspected exposure should be provided using doxycycline and rifampin. Standard precautions

provide adequate protection from spread of infection, except that contact precautions should be added for patients with draining wounds.

### *Clostridium perfringens* epsilon toxin

The epsilon toxin is produced by *Clostridium perfringens* types B and D and is an extremely potent toxin that does not naturally cause human poisoning. Bioterrorist uses could be via aerosol, food, and/or waterborne exposures. The toxin remains stable in the environment for 8 hours. Minute doses (1 microgram/kg) may be fatal. Epsilon toxin is a pore-forming toxin that increases cell permeability to small molecules and ions. This toxin can disseminate through the circulation, causing microvascular endothelial lesions in the brain, lungs, and kidneys, leading to toxic shock and death. Management is with standard supportive care. Standard precautions should be used. In a mass bioterrorism event, pediatric decontamination procedures should be followed.

### Glanders Disease *(Burkholderia mallei)*

Glanders is caused by the gram-negative bacillus *Burkholderia mallei*. People may become infected through handling infected animals; however, there have been no naturally acquired human cases of glanders in the United States in several decades. Therefore, human cases in the US in the absence of travel and contact with potentially infected animals should raise suspicion of terrorism.

The incubation period after exposure ranges from 1 to 14 days. Acute and chronic presentation is possible, but acute illness is most likely after a bioterrorist event. Disease may be localized (eg, pneumonia) or disseminated (fulminant sepsis). Most commonly, symptoms include high fever, mucositis, and abscesses in multiple organs, predominantly the lungs, liver, and spleen. Symptoms and signs associated with acute septicemia include fever, rigors, headache, muscle pain, night sweats, pleuritic chest pain, jaundice, sensitivity to light, and diarrhea. Diffuse erythroderma may be accompanied by necrotizing lesions. Cervical adenopathy, tachycardia, and mild hepatomegaly or splenomegaly may be present.

Small bacilli may be seen on methylene blue or Wright stain of exudates. Both *B mallei* and *Burkholderia pseudomallei* can be grown and identified from standard cultures. Without effective antibiotic therapy, mortality nears 100%. Definitive antibiotic therapy should be based on susceptibility testing. Empiric therapy should be provided in consultation with an infectious disease specialist. Postexposure treatment in the setting of a bioterrorist attack will require consultation with the CDC, as the efficacy of such treatment is unknown. Standard precautions are adequate for most patients, while contact precautions should be added for patients with skin lesions.

### Melioidosis (*Burkholderia pseudomallei*)

Melioidosis is caused by the gram-negative bacillus *B pseudomallei*. People may become infected through soil and water predominantly in rural areas of southeast Asia and northern Australia. Therefore, human cases in the United States in the absence of travel to these countries should raise suspicion of bioterrorism. The incubation period after exposure ranges from 1 to 21 days based on the size of inoculum. Clinical disease is much more common in adults than children, who may seroconvert without evidence of disease. Acute and chronic presentation is

possible, but acute illness is most likely after a bioterrorist event. Disease may be localized (eg, most commonly in the skin and soft tissue infections of the head and neck) or disseminated (fulminant sepsis with or without pneumonia). Most commonly, symptoms include high fever, mucositis, and abscesses in multiple organs, predominantly the lungs, liver, and spleen.

Small bacilli may be seen on methylene blue or Wright stain of exudates. *B pseudomallei* can be grown and identified from standard cultures. Treatment is difficult, with relapse being common. Definitive antibiotic therapy should be based on susceptibility testing. Empiric therapy should be provided in consultation with an infectious disease specialist.

Postexposure treatment in the setting of a bioterrorist attack will require consultation with the CDC, as the efficacy of such treatment is unknown. Standard precautions are adequate for most patients, while contact precautions should be added for patients with skin lesions.

**Psittacosis (*Chlamydia psittaci*)**
Psittacosis is caused by an intracellular gram-negative bacteria, *Chlamydia psittaci,* and is typically acquired by inhalation of dust containing dried urine, feces, and respiratory secretions of infected birds. With an incubation period of 5 to 15 days, the usual symptoms include abrupt onset fever, chills, headache, myalgias, and nonproductive cough that can easily be confused with the typical presentation of other more common causes of community acquired pneumonia. Complications are rare but can be severe including respiratory failure, endocarditis, myocarditis, hepatitis, encephalitis, and sepsis.

Diagnosis is confirmed by PCR testing of sputum, swabs of the nasopharynx/oropharynx within specialized laboratories, or more commonly with paired acute and convalescent sera. Empiric therapy is typically with doxycycline or when doxycycline is contraindicated, macrolide antibiotics can be used.

**Q Fever (*Coxiella burnetii*)**
Q fever is caused by *Coxiella burnetii*, a rickettsial organism that causes usually asymptomatic infection in farm animals (eg, cattle, sheep, goats). Exposure through terrorism would likely involve aerosolization, and the resulting disease would appear similar to naturally occurring disease.

The incubation period for Q fever is 9 to 39 days after exposure, depending on the inoculum size. Initial symptoms include sudden onset of fever, chills, headache, weakness, lethargy, anorexia, and profuse sweating. Approximately 50% of infected individuals have pneumonia. Liver function tests are often abnormal—a result of granulomatous hepatitis—but jaundice is rare. Neuropathies sometimes develop. The infection becomes chronic in approximately 1% of infected individuals and can manifest as endocarditis or hepatitis.

If Q fever is suspected, blood cultures are not recommended because of the risk of exposure of laboratory personnel. The PCR assays and paired acute and convalescent sera can be used to confirm disease. Most infections resolve without specific therapy. Several suggested treatment combinations are recommended depending on the severity of infection and organ involvement. Consultation with an infectious disease specialist or the CDC is recommended. Treatment most

often includes doxycycline but may include hydroxychloroquine or other agents as well. Chronic infection may require prolonged or repeated treatment. Chemoprophylaxis is only considered effective if administered within 8 to 12 days of exposure. Person-to-person transmission is not known to occur, although transmission from contaminated clothing has been reported. Soap and water or a 0.5% chlorine solution can be used for decontamination.

**Ricin**

Ricin is a potent cytotoxin that can be prepared in liquid, crystalline, or powder form and as an agent of terrorism can be disseminated as an aerosol, directly injected, or used to contaminate food or water. Symptoms depend on the route of exposure: respiratory, enteral, or parenteral. Compared with other biological toxins (eg, botulinum toxin), ricin has low toxicity, and large quantities would be required to affect large numbers of people.

Ricin exposure should be suspected if a geographic cluster of individuals develop acute lung injury manifested with symptoms of fever, chest tightness, cough, dyspnea, nausea, and arthralgias after a delay of 4 to 8 hours. Pulmonary edema develops 1 to 3 days after exposure (compared with about 12 hours after *Staphylococcus* enterotoxin B exposure and about 6 hours after phosgene exposure). Treatment involves supportive care, including appropriate respiratory support and treatment for pulmonary edema, if required. Enteral exposure should be treated by vigorous gastric lavage and use of cathartics. Masks are effective in preventing exposure. No vaccine is available.

**Staphylococcal Enterotoxin B**

*Staphylococcus* enterotoxin B (SEB) is an exotoxin that acts on the intestine to produce a brisk cascade of proinflammatory cytokines, resulting in an intense inflammatory response. Food poisoning attributable to SEB results from ingestion of improperly handled food that contains enterotoxin. Inhalational exposure, as expected in an incident of bioterrorism, results in predominantly respiratory symptoms, including nonproductive cough, retrosternal chest pain, and dyspnea. Gastrointestinal symptoms may appear if toxin is inadvertently swallowed. Fever (103°F–106°F) is likely and may last up to 5 days with chills and prostration. There may be conjunctival injection, and fluid losses may lead to postural hypotension. Chest radiographs are likely to be normal, but overt pulmonary edema can occur. The SEB exotoxin is not absorbed through intact skin, and secondary aerosolization from affected patients is not hazardous. Environmental surfaces may be decontaminated using soap and water.

**Epidemic Typhus (*Rickettsia prowazekii*)**

Epidemic typhus is typically transmitted to humans through the bites of the human body louse, *Pediculus humanus corporis*. This disease is caused by *Rickettsia prowazekii.* Incubation is 7 to 10 days with the disease lasting 14 to 21 days without treatment. Symptoms typically begin abruptly and include fever, chills, headache, myalgias, altered mental status, lymphadenopathy, and in 25–50% of patients, rash. An eschar is not present as in other rickettsial diseases. Some patients will have hepatosplenomegaly, laboratory findings of thrombocytopenia, and elevations of liver enzymes and/or creatinine. In bioterrorism, the *R prowazekii* would most likely be delivered by aerosol, making the diagnosis somewhat more difficult.

Diagnosis can be established by PCR assay of blood or skin rash biopsies. More commonly, diagnosis is with indirect immunofluorescence assay (IFA) of paired acute and convalescent sera, and therefore, treatment is empiric with doxycycline (which is the preferred agent in adults and children). Standard precautions suffice as human-to-human spread requires a vector—an infected body louse. People with active lice infestation should be treated with pediculicides, and their clothing managed appropriately (eg, washed in hot water). PEP is not indicated.

**Viral Encephalitis**

Viral encephalitis viruses include eastern equine encephalitis (EEE) virus, western equine encephalitis (WEE) virus, and Venezuelan equine encephalitis (VEE) virus. In nature, in the absence of bioterrorism, disease attributable to these viral agents is limited to the geographic areas in which the arthropod vectors (mosquitos) live.

Asymptomatic infection is common. Clinical illness, when it occurs, ranges in severity from a self-limiting febrile illness with headache and vomiting to a syndrome of aseptic meningitis or acute encephalitis. The EEE virus infection is typically a fulminant illness that leads to coma and death in one-third of cases and to serious neurologic sequelae in another third. The clinical severity of WEE virus infection is intermediate, with a case fatality rate of 5%; neurologic impairment is common in infants. The VEE virus infection produces acute systemic febrile illness, with encephalitis developing in a small percentage (4% in children; <1% in adults). The incubation period for EEE and WEE encephalitis viruses is 2 to 10 days, while the incubation period for VEE virus infection is 1 to 4 days.

Diagnosis of all of these viruses is most commonly established by paired acute and convalescent serologic testing of cerebrospinal fluid (CSF) or serum. The PCR testing of CSF or brain tissue may also be used. Standard precautions are recommended for patients with EEE, VEE, and WEE virus infection.

**Water Safety Threats (*Vibrio cholerae*, *Cryptosporidium parvum*)**

*Vibrio cholerae* is typically acquired by the ingestion of contaminated food or water. Disease attributable to *V cholerae* manifests as an acute profuse diarrheal illness with associated vomiting and signs and symptoms of mild, moderate, or severe dehydration. Diagnosis is by culture of stool specimens or multiplex PCR panels. Treatment is typically supportive care, although antibiotics may be useful in severe cases guided by local susceptibility testing. Doxycycline is a common first-line therapy for short duration (<21 days) without regard to patient age. Ciprofloxacin, azithromycin, and erythromycin may be alternative treatments.

Antibiotic PEP is not generally recommended, although patients with high-risk exposures or high-risk patients may benefit. Vaccines are not recommended for postexposure use, but the decision to use oral cholera vaccines in the setting of a bioterrorism event will depend on the risk of ongoing contamination and the feasibility of mass vaccination. *Cryptosporidium parvum* is the leading cause of waterborne disease among humans in the United States. This parasite causes watery diarrhea, abdominal cramps or pain, dehydration, nausea, vomiting, and less commonly, fever. Symptoms are highly variable and usually last from 1 to 2 weeks. Immunocompromised patients have more severe disease. Diagnosis is by testing of stool specimens by PCR assay,

antigen tests, or direct staining techniques. If treatment is required, nitazoxanide is the recommended therapy.

| Table 8.1: Biological Weapons of Concern* |
|---|
| **Category A** |
| Anthrax (*Bacillus anthracis*) |
| Botulinum (*Clostridium botulinum* toxin) |
| Plague (*Yersinia pestis*) |
| Smallpox (*Variola major*) |
| Tularemia (*Francisella tularensis*) |
| Viral hemorrhagic fevers (filoviruses [eg, Ebola, Marburg] and arenaviruses [eg, Lassa, Machupo]) |
| **Category B** |
| Brucellosis (*Brucella* species) |
| Epsilon toxin of *Clostridium perfringens* |
| Food-safety threats (eg, *Salmonella* species, *Escherichia coli* O157:H7) |
| Glanders (*Burkholderia mallei*) |
| Melioidosis (*Burkholderia pseudomallei*) |
| Psittacosis (*Chlamydia psittaci*) |
| Q fever (*Coxiella burnetii*) |
| Ricin toxin from *Ricinus communis* (castor beans) |
| Staphylococcal enterotoxin B |
| Typhus (*Rickettsia prowazekii*) |
| Viral encephalitis (alphaviruses [VEE, EEE, WEE]) |
| Water-safety threats (eg, *Vibrio cholerae*, *Cryptosporidium parvum*) |
| **Category C** |
| Emerging threat agents (eg, Nipah virus, hantavirus) |

*This table was adapted from the 2020 AAP technical report, "Chemical-Biological Terrorism and Its Impact on Children."

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# CHAPTER 9:
# CHEMICAL EVENTS

The American Academy of Pediatrics (AAP) published specific recommendations in its policy and technical report, “Chemical-Biological Terrorism and Its Impact on Children” in February 2020.

## LESSONS LEARNED FROM PAST CHEMICAL EVENTS

- Chemical terrorism can be a real incident anywhere and anytime. Medical health systems need to be prepared.
- When many patients present with similar symptoms from the same place, suspicion for chemical exposure should be raised.
- Information about the actual chemical used will be delayed.
- Chemical attacks can easily overwhelm hospital resources, and a written disaster plan that has been exercised or tested out is necessary.
- The majority of patients will come independent of the prehospital system and can overwhelm local hospital resources. Be prepared to care for the sicker patients who will arrive later.
- Medical providers will be forced to care for patients with incomplete information and a high degree of suspicion for a chemical etiology.
- Treatment needs to be guided by clinical findings in the beginning.
- On-site decontamination and triage should be set up immediately once a chemical event is suspected.
- Medical supplies, including antidotes, will be quickly exhausted during a massive chemical attack. Hospitals should have disaster plans in place to obtain additional medication from local, regional, and national stockpiles.
- Time course of symptoms can vary depending on substance. Knowing the expected symptoms and time course about specific chemical agents will guide the triage/treatment plan. Some chemicals have delayed effects.
- Resources, such as the HHS Chemical Hazards Emergency Medical Management website, poison control centers, and the Pediatric Environmental Health Specialty Units website are available to assist medical providers.

## INTRODUCTION

Chemical terrorism is the intentional use of toxic chemicals to inflict mass casualties and mayhem on an unsuspecting civilian population, including children. Such an incident could potentially overwhelm the capacity of regional emergency medical services and pose extraordinary medical management challenges to pediatricians. However, careful community planning, robust research and development (by academic, private, and governmental collaborative efforts), and rigorous medical education could mitigate such a catastrophe.

The risk of chemical terrorism is more tangible since the events of September 11, 2001, and the subsequent intentional spread of anthrax through the US mail. However, the specter of purposeful toxic exposures predates the September 11 attack. The 20th century witnessed Iraqi military attacks with nerve agents on civilian villages in Iran in the 1980s, the release of the nerve agent sarin in the Tokyo subway system in 1995, and a chlorine bomb scare at Disneyland

in 1995. Unfortunately, chemical attacks continue to occur with the finding of ricin in US Senate office buildings in 2004, the sarin attacks in Syria in 2013 and 2017, and the use of nerve agent VX at Kuala Lumpur airport in 2017.

Chemical terrorism often refers to the use of military chemical weapons that have been illicitly obtained or manufactured de novo. However, additional concerns might include the intentional explosion of an industrial chemical factory, a tanker car, or a transport truck in proximity to a civilian residential community, school, child care facility, or worksite. These events underscore the need for all pediatricians to expand their working knowledge of the approach to mass casualty incidents involving traditional military chemical weapons and other toxic chemicals that might be used as "weapons of opportunity."

The medical consequences and epidemiology of a chemical terrorist attack mimic more conventional disasters but also reflect some distinct differences. Such an incident combines elements of both a traditional mass disaster (eg, an earthquake) and a hazardous materials incident. Potential differences of a chemical terrorist attack compared with a "routine" hazardous materials incident include the following:

- Intent to cause mass casualties
- Great toxicity of substances
- Delayed initial identification of substance
- Greater risk to first responders
- Overwhelming numbers of patients
- Many anxious individuals
- Mass hysteria, panic
- Discovery of dispersal device

Casualties occur almost immediately, and the attack would likely be recognized rapidly. Decontamination and initial care of small children on scene pose enormous management issues for personnel wearing bulky personal protective equipment (PPE). In addition, many children who have been exposed but not critically injured will be taken by parents to hospitals and pediatricians' offices without prior on-scene decontamination—thus posing similar challenges for and possibly personal risk to pediatric care providers themselves.

## SPECIFIC PEDIATRIC VULNERABILITIES TO CHEMICAL AGENTS

Children have inherent physiologic, developmental, and psychological differences from adults that may enhance susceptibility and worsen prognosis after a chemical agent exposure. Additional information is available in Chapter Three: How Children are Different.

**Table 9.1: Pediatric Vulnerabilities to Chemical Terrorism** summarizes pediatric-specific vulnerabilities to chemical agents.

**Table 9.1: Pediatric Vulnerabilities to Chemical Terrorism**

| Realm | Potential Vulnerability | Potential Response |
|---|---|---|
| Physiologic | • Nerve agents may penetrate the blood-brain barrier more easily in children than adults. | Early warning, sheltering (gas masks |

| | | |
|---|---|---|
| | Children may only exhibit central nervous system (CNS) effects.<br>• Children younger than 4 years with status epilepticus have the highest risk of death<br>• A child's smaller mass alone reduces the dose of nerve agent required for toxic/lethal effects. Animal studies have shown that the lethal dose of nerve agent in an immature vs adult animal is 10%.<br>• Increased respiratory exposure (high minute ventilation, live closer to the ground). | not advised because of risk of poor fit, suffocation) |
| | Increased dermal exposure (larger body surface area/mass ratio). | Protective clothing, early decontamination |
| | Increased risk of dehydration, shock with illness-induced vomiting, diarrhea (decreased fluid reserves, larger body surface area/mass ratio). | Recognition, aggressive fluid therapy |
| | Increased risk of hypothermia during decontamination (larger body surface area/mass ratio). | Warm water decontamination |
| | More fulminant disease; (possible) physiologic detoxification immaturity; more permeable blood-brain barrier. | Pediatric-specific research for early diagnosis and treatment of chemical weapons victims |
| Developmental | Less ability to escape attack site, take appropriate evasive actions (developmental immaturity, normal dependence on adult caregivers who might be injured or dead). | |
| Psychological | Less coping skill of children who suffer injury or witness parental, sibling death (psychological immaturity). | Child psychiatry involvement, research for preventing pediatric post-traumatic stress disorder |
| | Greater anxiety over reported incidents, hoaxes, media coverage, etc. | Pediatric counseling of parents and children |
| Emergency medical services (EMS) | Less capacity to cope with influx of critical pediatric patients. | Community and regional planning with significant pediatric input |
| | Loss of routine hospital transfer protocols. | |
| | Limited ability to expand pediatric hospital bed capacity through the National Disaster Medical System | |

## CHEMICAL INJURIES AND APPROACH TO THE UNKNOWN CHEMICAL ATTACK

A listing of many of the most notable chemical agents of concern has been compiled by the Centers for Disease Control and Prevention (CDC) https://emergency.cdc.gov/agent/agentlistchem.asp. Toxic effects from chemical agents usually follow dermal or inhalational exposure and may develop via injury to the skin, eyes, and respiratory epithelium as well as via systemic absorption. The intensity and route of exposure to chemical agents affect both the rapidity of onset (seconds to hours) and the severity of symptoms. For example, a mild exposure to sarin vapor results in lacrimation, rhinorrhea, miosis, and slightly blurry vision; an intense exposure leads to seizures, apnea, and rapid death within minutes.

Toxidromes after exposure to various chemical agents (nerve agents, vesicants, pulmonary agents, cyanide, and riot-control agents) are summarized in **Table 9.2: Chemical Agents, Summary of Symptoms** and detailed in the following sections.

**Table 9.2: Chemical Agents, Summary of Symptoms**

| Agent | Toxidromes | Onset |
|---|---|---|
| Nerve Agent (eg, tabun, sarin, soman, VX) | Cholinergic symptoms: miosis, increased secretions (bronchorrhea, salivation, lacrimation, urination, diaphoresis), vomiting, dyspnea, fasciculations, coma, seizure | Vapor: seconds<br>Liquid: minutes-hours |
| Vesicants (eg, mustard, lewisite) | Skin erythema/vesicles, eye irritation, respiratory irritation in high concentration exposure | Mustard: hours<br>Lewisite: immediate pain |
| Pulmonary agents (eg, chlorine, phosgene) | Respiratory irritation, dyspnea, pulmonary edema, ocular irritation | Minutes: eyes, nose, throat irritation, bronchospasm<br>Hours: pulmonary edema |
| Asphyxiant (eg, cyanide) | Dyspnea, coma, seizure | Seconds |
| Riot control agents (eg, CS, CN, capsaicin) | Ocular pain, tearing, blepharospasm | Seconds |

Understanding the epidemiology of acute mass exposure to a toxin is helpful in recognizing a covert chemical attack with unknown agents. Mass exposure to a toxin will likely manifest as an acute onset of illness (within seconds to minutes or within hours in the case of some of the vesicants and pulmonary agents). In more severe chemical incidents, numbers of people may collapse or die within minutes of exposure.

Chemical weapons can be categorized based on the predominant symptoms they cause:

- Neurologic (nerve agents or cyanide).

- Respiratory (phosgene or chlorine, high-dose riot-control agents, or sulfur mustard with a delay of several hours from time of exposure).
- Mucocutaneous syndromes (vesicants).

For additional advice on more definitive diagnosis and management strategies, contact public health authorities or the regional poison control center (800-222-1222).

Cyanide and nerve agents attacks can have similar presentations but different therapies. In both cases, large numbers of victims may collapse suddenly, have seizures, or go into a coma. Many deaths occur rapidly. Nerve agent casualties are likely to be cyanotic and have miotic pupils with altered vision, copious oral and nasal secretions, and acute bronchospasm and bronchorrhea. The differentials and treatments of cyanide and nerve agent are summarized in **Table 9.3: Differential Diagnosis and Antidotes of Nerve Agents and Cyanide**.

**Table 9.3: Differential Diagnosis and Antidotes of Nerve Agents and Cyanide**

| | Nerve Agent | Cyanide |
|---|---|---|
| Odor | None to very faint | Some say they perceive a smell of bitter almond, yet others fine this sign unreliable. |
| Clinical symptoms | Miosis, copious secretions (bronchorrhea, salivation, lacrimation, urination, defecation), fasciculation then flaccid paralysis | Normal/dilated pupils, relatively few secretions, twitching of body but no fasciculation.<br><br>With higher doses, the time of onset of symptoms typically is seconds and it may cause abrupt onset of profound CNS, cardiovascular, and respiratory effects, leading to death within minutes.<br><br>Signs and symptoms may present over a much longer period of time if the poisoning is gradual with lower doses. |
| Lab findings | Respiratory alkalosis to hypoxemia with respiratory acidosis | High anion-gap acidosis, high venous oxygen saturation, severe lactic acidosis. |

| | | |
|---|---|---|
| Antidotes | Atropine: 0.05 mg/kg, IV or IM (min 0.1 mg, max 5 mg), repeat every 2-5 min as needed for bronchorrhea<br><br>Pralidoxime: 25 mg/kg, IV or IM (max 1 g IV, 2 g IM), may repeat within 30-60 min as needed, then again every hour for 1 or 2 doses as needed for persistent weakness<br><br>Diazepam: 0.3 mg/kg, IV (max 10 mg); Lorazepam: 0.1 mg/kg IV, IM (max 4 mg); Midazolam: 0.2 mg/kg, IM (max 10 mg) as needed for seizures or severe exposure | Hydroxocobalamin: 70 mg/kg up to 5 g (adult dose) IV.<br><br>Sodium thiosulfate (25%): 1.65 mL/kg IV (max 50 mL).<br><br>Sodium bicarbonate as needed for metabolic acidosis. |

The initial protection of everyone in a community exposed to a hazardous chemical requires safe evacuation or local sheltering. Local and federal authorities will assist in informing the public whether to shelter in place or evacuate.

Information regarding evacuation in a chemical emergency can be found at https://emergency.cdc.gov/planning/evacuationfacts.asp. Information regarding sheltering in place in a chemical emergency can be found at https://emergency.cdc.gov/planning/shelteringfacts.asp.

## INITIAL APPROACH, DECONTAMINATION, AND TRIAGE

The general treatment of contaminated victims begins with extrication, triage, resuscitation as needed, and decontamination performed by rescue workers or health care providers wearing appropriate PPE. Ideally, decontamination would be performed at the scene to avoid the considerable challenges posed by the arrival of contaminated patients, including children, at health care facilities. However, in a large-scale terrorist incident, it is far more likely that some victims will arrive at hospitals or other health care facilities without having been previously decontaminated. In this context, significantly contaminated victims should be decontaminated before they are allowed into the emergency department (ED). Even if decontamination has been performed in the field, hospitals are likely to repeat decontamination procedures to protect the facility from contamination (which would result in closure or having to go “offline”); this would also address the possibility of cross-contamination moving from the scene. Decontamination to limit secondary exposures is especially important in exposures to nerve agents and vesicants.

Appropriate PPE for ED staff involved in patient decontamination is an important consideration. The amount of chemical agent believed to contaminate patients who arrive at the ED after a chemical terrorist attack would essentially consist of that on their skin and clothing (ie, far lower concentration of chemicals than rescue workers would face at the scene of exposure).

Similar to other mass casualty events, the number of victims can easily overwhelm local hospitals in a chemical terrorism attack. Health care providers will need to be trained in triage to

provide optimal medical care during such an event. There are many different triage systems with varying sensitivity and specificity such as START (**s**imple **t**riage **a**nd **r**apid **t**reatment), JumpSTART and SALT (**s**ort, **a**ssess, **l**ifesaving interventions, **t**reatment/**t**ransport).

In general, triage in a chemical event is similar to the approaches in a typical mass casualty event, but there are unique features in the triage process for chemical exposure victims:

- Clinical assessment of chemical exposure is required at the same time with triage. Often, the offending agent is not clear when the first patients arrive at a health care facility.
- Adequate antidote administration should be included in lifesaving interventions during triage based on clinical assessment in appropriate setting.
- Proper PPE should be used as described above to prevent secondary exposure. This PPE makes verbal communication and auditory and tactile examination/treatment challenging.
- Medical personnel might have difficulty in the assessment of the symptoms, because some chemicals have instant onset of symptoms (eg, nerve agent, cyanide) and immediate need for intervention, and some chemicals show no symptoms on presentation because of delayed onset symptoms (eg, sulfur mustard, phosgene).

Cardiopulmonary and airway support, including emergent intramuscular antidotal therapy, are provided as necessary and appropriate for the specific exposure. Contaminated clothing should be removed as soon as possible. The contamination hazard can be reduced by as much as 85% simply by removing clothing. More definitive decontamination follows. For vapor-exposed victims, decontamination may be accomplished primarily by clothing removal and washing of hair. In contrast, for victims with liquid dermal exposure, more thorough decontamination is required. Their skin and clothing pose considerable risk to ED personnel. Clothing should be carefully removed and disposed of in double bags. Victims with ocular exposure require eye irrigation with copious amounts of saline or water. Skin and hair should be washed thoroughly, but gently, with soap and tepid water. In the past, some authorities had recommended 0.5% sodium hypochlorite (dilute bleach) for skin decontamination of nerve agents and vesicants. However, bleach may be a skin irritant, thus increasing permeability to the agent. In addition, its use is time consuming and has not been proven superior to washing with copious soap and water or water alone. Furthermore, there is little experience with this approach in infants and young children. A difficult question that remains is whether EMS and ED staff wearing bulky PPE will be able to provide significant advanced life support to small children before decontamination.

## INDUSTRIAL CHEMICALS

The potential of a terrorist attack on industrial sources of hazardous chemicals (eg, factories, railroad and vehicular tank cars, or storage depots) expands the list of potential “chemical weapons” considerably. In general, many of the relevant industrial chemicals (see **Table 9.4: Representative Classes of Industrial Chemicals**) might be expected to induce respiratory effects analogous to those of chlorine or phosgene (see the section on pulmonary agents) or dermatologic injury from irritant or caustic properties, as well as more systemic effects in severe exposures.

| Table 9.4: Representative Classes of Industrial Chemicals | | | |
|---|---|---|---|
| Agent | Clinical Findings | Onset | Management |
| Strong acid/bases | Eye: caustic injury<br>Skin: chemical burns<br>GI: chemical burns of mouth, larynx, esophagus, stomach | Rapid | Supportive care, early endoscopy for significant ingestion |
| Respiratory tract irritants (eg, ammonia, hydrochloric acid, and HF gases) | Eyes, ears, nose, throat, and respiratory tract irritation with cough, chest pain, dyspnea, wheeze (possible pulmonary edema in severe cases) | Rapid | Supportive respiratory care (consider nebulized calcium gluconate solution for HF); see https://chemm.hhs.gov/ |
| Fentanyl and other opioids | CNS and respiratory depression, miosis | Rapid | Supportive care, naloxone 0.01-0.1 mg/kg) |
| Cellular asphyxiants (eg, phosphine, sodium azide) | Cough, dyspnea, headache, dizziness, vomiting, tachycardia, hypotension, severe metabolic acidosis; may progress to coma, seizure, death; may have delayed onset pulmonary edema with phosphine | Rapid (except pulmonary edema with phosphine | Supportive care, 100% oxygen |
| Arsine | Severe hemolysis | 2-4 h | Supportive care, enhance urine flow, consider alkalinization |

## COMMUNITY PREPAREDNESS

In the aftermath of September 11, 2001, many agencies are collaborating to ensure coordinated care of pediatric victims. All pediatricians are encouraged to participate in disaster management training. Pediatricians have a role in recognizing toxidromes and contacting appropriate agencies if suspected as well as working in their communities to optimize the overall capacity for providing disaster care to chemically exposed children.

Successful planning and response to events involving chemical terrorism require strong collaboration and integrated functioning of many agencies and facilities, both governmental and nongovernmental, including local treatment facilities, local and state health departments, and federal agencies including the Office of the Assistant Secretary for Preparedness and Response, (ASPR), the Federal Emergency Management Agency (FEMA), the Federal Bureau of Investigation (FBI), and the CDC.

## ADDITIONAL RESOURCES

In large-scale mass casualty chemical exposure incidents, additional information about event management can be found at the following:

- Chemical Hazards Emergency Medical Management (CHEMM): provided by the National Library of Medicine, mainly for first responders, first receivers, and other health care providers to use during chemical events: https://chemm.hhs.gov/.
- The American Association of Poison Control Centers has 55 regional poison centers that can be reached 24/7 at 800-222-1222.
- The CDC is available 24/7 at 770-488-7100, or 800-232-4636. The CDC has the Laboratory Response Network (LRN), a network of laboratories that can respond to chemical and biological terrorism. Online resources are available at https://emergency.cdc.gov/chemical/index.asp.
- The US Coast Guard National Response Center hotline is 800-424-8802 (https://nrc.uscg.mil/) and is the federal point of contact for reporting all hazardous substances release and oil spills.
- The FBI can be reached at 202-324-3000 (headquarters).
- The FEMA can be reached at 800-621-3362.
- The US Army Medical Research Institute of Chemical Defense/Chemical Casualty Care Division (MRICD) provides consultation on medical aspects of chemical warfare agents at https://usamricd.amedd.army.mil/Pages/default.aspx.
- WISER (Wireless Information System for Emergency Responders) assists emergency responders in hazardous material incidents, and provide a quick review of the character of specific substances, symptoms, PPE recommendations, and treatment (https://wiser.nlm.nih.gov/).
- TOXNET (TOXicology Date NETwork) is a series of online databases managed by the National Institutes of Health National Library of medicine, and these databases cover chemicals, drugs, and environmental health (https://www.nlm.nih.gov/toxnet/index.html).

## NERVE AGENTS

Nerve agents are organophosphorus compounds similar to the organophosphate insecticides used in agriculture or industry but far more toxic. Four compounds are currently regarded as nerve agents: tabun, sarin, soman, and VX. All of these agents are hazardous by ingestion, inhalation, or cutaneous absorption, the latter being particularly true for VX. The toxic effects of nerve agent vapors depend on the concentration of the agent inhaled and on the time exposed to the agent. The toxicity of nerve agent liquid depends on the time exposed and the bodily site of exposure. Nerve agents exist as liquids at standard temperatures and pressures. In gaseous form, they are denser than air and vary in volatility, with some (eg, VX) being more persistent than others (eg, sarin).

### Background

The Iran-Iraq War of the 1980s reportedly resulted in more than 100,000 casualties from chemical weapons. Iranian sources reported that the number of casualties caused by nerve agents was far greater than the number of casualties caused by mustard agent. Many nerve agent casualties that were only mildly to moderately affected were not counted.

A chemical warfare campaign by the Iraqi military on Kurdish civilians in the late 1980s caused thousands of deaths. The exact agents are not definitively known, but Iraq was known to have stockpiled tabun, sarin, and VX.

A Japanese religious cult that manufactured sarin deployed it in 1994 in attacks on a residential neighborhood of Matsumoto and again in 1995, in the Tokyo subway. Immediate mortality was low, but thousands of individuals arrived at EDs. The lack of a decontamination process resulted in significant morbidity to health care personnel. The sarin was released by a relatively primitive method (punctured plastic bags allowing sarin vapor to escape); many experts believe a more sophisticated delivery system might have resulted in far higher mortality.

Multiple chemical attacks have been reported between 2013 and 2018 in Syria. During the August 21, 2013 sarin attack, 14,000 people were killed, and 89 deaths (including 33 children) were reported on April 4, 2017 in another sarin attack. Nerve agent exposures in the United States have been individual cases associated with industrial exposures.

**Toxicology and Clinical Manifestations**

Nerve agents inhibit the action of acetylcholinesterase at cholinergic neural synapses, where acetylcholine then accumulates markedly. The resulting cholinergic syndrome is classically divided into central, nicotinic (neuromuscular junction and sympathetic ganglia), and muscarinic (smooth muscle and exocrine gland) effects.

Clinical manifestations vary with the type of exposure. Symptoms after a vapor exposure appear suddenly with a full range of clinical effects, or there may be a partial expression of the syndrome. Symptoms after dermal exposure to liquid nerve agents may have delayed effects and start with local sweating.

Central Nervous System Effects

Effects on the CNS include headache, seizures, coma, respiratory arrest, confusion, slurred speech, and respiratory depression. Although the seizures probably begin because of excess cholinergic stimulation in the first 5 minutes, other effects (eg, excitatory glutamate receptor stimulation and antagonism of inhibitory gamma-aminobutyric acid [GABA] receptors) may also play a role after 5 minutes of exposure. Case series of anticholinesterase pesticide poisonings in children suggest a disproportionate degree of depressed muscle weakness, hypotonia, and CNS depression (stupor, coma) compared with peripheral muscarinic effect. Thus, children may manifest primarily central and/or neuromuscular effects after nerve agent exposure.

Autonomic Nervous System Effects

These include both nicotinic and muscarinic findings. Nicotinic effects on sympathetic activity can result in the following:

- Tachycardia
- Hypertension
- Metabolic aberrations (eg, hyperglycemia, hypokalemia, and metabolic acidosis)

Muscarinic effects involve multiple systems:

- Ocular (miosis, eye pain, visual blurring, lacrimation)

- Respiratory (watery rhinorrhea, increased bronchial secretions, and bronchospasm causing cough, wheezing, dyspnea, and cyanosis)
- Cardiovascular (bradycardia, hypotension, atrioventricular block)
- Dermal (flushing, sweating)
- Gastrointestinal (salivation, nausea, vomiting, diarrhea progressing to fecal incontinence, abdominal cramps)
- Urinary (frequency, urgency, incontinence)

Neuromuscular Effects

At the neuromuscular junction, initial stimulation of cholinergic synaptic transmission is followed by paralysis. Thus, nicotinic effects include muscle fasciculations and twitching, followed by weakness progressing to flaccid paralysis and respiratory failure.

The clinical syndrome of organophosphate toxicity is summarized by the mnemonic DUMBBELS. See **Table 9.5: DUMBBELS**.

| Table 9.5: DUMBBELS | |
|---|---|
| D | Diarrhea |
| U | Urination |
| M | Miosis |
| B | Bronchoconstriction |
| B | Bronchorrhea |
| E | Emesis |
| L | Lacrimation |
| S | Salivation |

**Diagnostic Tests**

The diagnosis of nerve agent toxicity is primarily based on clinical recognition and response to antidotal therapy. Measurements of acetylcholinesterase in plasma (pseudocholinesterase) or red blood cells (RBC; cholinesterase) may confirm organophosphate poisoning, but correlation between cholinesterase levels and clinical toxicity is poor in some contexts; also, these analyses are rarely available on an emergent basis. RBC cholinesterase levels may help in monitoring recovery or in forensic investigations. In symptomatic patients, treatment is indicated without waiting for cholinesterase levels, while in exposed asymptomatic patients, antidotal therapy is not needed, even if cholinesterase is depressed.

**Treatment**

If recognized early, this is a treatable and reversible syndrome. Triage, resuscitation, and decontamination should begin at the scene and at accepting health care facilities. Individuals directly exposed to liquid nerve agents should be observed for at least 18 hours.

Treatment focuses on airway and ventilatory support; aggressive use of antidotes, particularly atropine and pralidoxime (2-PAM); prompt control of seizures with benzodiazepines; and decontamination as necessary. Antidotal therapy is titrated according to clinical severity. See **Table 9.6: Nerve Agent Triage and Dosing**.

**Table 9.6: Nerve Agent Triage and Dosing**

| Severity | Triage Level and Disposition | Anticholinergics | Oxime-pralidoxime Chloride (2-PAM) | Benzodiazepine |
|---|---|---|---|---|
| Asymptomatic | Delayed: observation | None | None | None |
| Mild: miosis, mild rhinorrhea | Delayed: admit or observation | None | None | None |
| Moderate: miosis, and any other symptoms | Immediate: admit | Atropine, 0.05 mg/kg, IV, IM, IO to max 4 mg; repeat as needed every 5-10 min until pulmonary resistance improves or secretions resolve<br><br>Correct hypoxia before IV use, as it can increase risk of ventricular fibrillation<br><br>Alternatives: scopolamine for nervous system and peripheral effects; glycopyrrolate for peripheral effects only | 2-PAM, 25-50 mg/kg, IV, IM, to max 1800 mg; repeat every h as needed; watch for muscle rigidity, laryngospasm, tachycardia, hypertension | If neurologic symptoms or rapid progression: Midazolam 0.15-0.2 mg/kg IM, IV, repeat as necessary or start continuous IV drip; less likely to cause apnea by IM route<br>Diazepam IV, as needed (see below)<br>Lorazepam IV at 0.05-0.1 mg/kg (IM absorption variable) |
| Severe: apnea, convulsions, | Immediate: admit, intensive-care | Atropine, 0.05-0.10 mg/kg, IV, IM, IO, repeat every 5-10 min, | 2-PAM, 25-50 mg/kg, IV, IS, as above | Midazolam, as above |

| | | | | |
|---|---|---|---|---|
| cardiopulmonary arrest | | as above, no max) | | Diazepam, 30 days to 5-y-old: 0.05-0.3 mg/kg, IV, max 5 mg/dose;<br>>5-y-old: 0.05-0.3 mg/kg, IV, max 10 mg/dose, repeat every 5-30 min as needed<br><br>Lorazepam IV, IM |
| Autoinjector use | | Atropine,<br>2 mg for >40 kg;<br>1 mg for >20 kg;<br>0.5 mg for >10 kg | 2-PAM,<br>600 mg for >12 kg (50 mg/kg/dose) | Diazepam<br>10 mg for >30 kg (0.3 mg/kg/dose) |

Atropine, in relatively large doses, is used for its antimuscarinic effects, and pralidoxime chloride serves to reactivate acetylcholinesterase and, thus, enhance neuromuscular function. Atropine counters bronchospasm and increased bronchial secretions; bradycardia; and gastrointestinal (GI) effects of nausea, vomiting, diarrhea, and cramps and may lessen seizure activity. Typical dosing for atropine after nerve agent exposure is usually between 5 and 20 mg in total. Severely affected nerve agent casualties in the military have received up to 200 mg of atropine. Atropine should be administered until respiratory status improves, because tachycardia and/or pupillary size are not an absolute end-point for atropinization. Atropine cannot reverse neuromuscular symptoms, and paralysis may persist without pralidoxime.

Pralidoxime cleaves the organophosphate away from the cholinesterase, thus regenerating the intact enzyme if aging (irreversible dealkylation of organic phosphorus compound-cholinesterase complex) has not occurred. This effect is noted most at the neuromuscular junction, with improved muscle strength. Prompt use of pralidoxime is recommended in all serious cases. Despite recommendations for the use of pralidoxime by many authorities, evidence behind this is not robust and mostly low quality. Cochrane conducted a review of oximes for acute organophosphate pesticide poisoning in 2011 and concluded, “Current evidence was insufficient to indicate whether oximes are harmful or beneficial.”

Both atropine and pralidoxime should be administered by intravenous (IV) infusion in severe cases (intraosseous [IO] access is likely equivalent to IV). Continuous IV infusion may be required for organophosphate pesticide poisoning, but usually the amount of atropine needed for nerve agent is less than that of organophosphate poisoning. The intramuscular (IM) route is acceptable if IV access is not readily available. This may be of considerable relevance in a mass casualty incident involving children. In fact, most EMS programs in the United States now stock military IM autoinjector kits of atropine and 2-PAM (Mark I kit, 2 separated autoinjector for atropine and 2-PAM). Although an autoinjector with pediatric doses for 2-PAM are currently not available in the United States, pediatric autoinjectors of atropine in 0.25-mg, 0.5-mg, and 1.0-mg sizes are available in other countries. In dire circumstances, the adult 2-PAM autoinjector (600

mg) might be used in children older than 2 to 3 years or weighing more than 13 kg. The Mark I kit is no longer manufactured in the United States, and a newer model Antidote Treatment-Nerve Agent, Autoinjector (ATNAA), which gives atropine and 2-PAM simultaneously, is now available.

Seizures are primarily controlled with benzodiazepines. Diazepam is principally used by the US military, but other benzodiazepines may be equally efficacious (eg, midazolam or lorazepam). Midazolam is believed optimal for IM administration in the treatment of status epilepticus in general, and therefore, may be especially useful in nerve agent toxicity in children. Finally, routine administration of anticonvulsant doses of benzodiazepines has been recommended in severe cases even without observed convulsive activity, because animal studies have indicated some amelioration of subsequent seizures and morphologic brain damage with such use.

Convulsive antidote nerve agent (CANA), diazepam autoinjector, is also currently in use for this purpose.

Supportive care is critical to patient outcome and includes the following:

- Protect airway/relieve bronchospasm/pulmonary toilet.
  - 100% oxygen, bronchodilators, suction, nasogastric tubes.
- Monitor for cardiac arrhythmias.
- Treat complicating injuries and infections.
  - Wounds and foreign bodies may be contaminated.
  - Treat skin lesions.
- Provide fluids, electrolytes, and nutrition.
  - Nursing mothers should discard breast milk.
- Prevent hypothermia.
- Provide eye care.
  - Consider ophthalmic analgesics for ocular pain.
  - Consider topical mydriatics for miosis (atropine given systemically may not reverse miosis).
- Consider electroencephalogram (EEG) and brain imaging for victims who do not promptly regain consciousness.

**Isolation and Control Measures**

Isolation is required only for potentially exposed victims before they are definitively decontaminated. Health care workers should wear PPE to treat victims before decontamination is complete.

## CYANIDE

Cyanide has long been used for sinister purposes, including as an agent of murder, suicide, chemical warfare, and judicial execution. In addition, it may pose an occupational hazard, and it has been ingested (usually in a precursor form) by children. Its efficacy as an agent of chemical terrorism is considered somewhat limited by its volatility in open air and relatively low lethality compared with nerve agents. However, if cyanide were released in a crowded, closed space, the effects could be devastating. This was more than amply illustrated by its notoriety as the chemical weapon used by the Nazis in the concentration camp gas chambers. More than 900

people ingested potassium cyanide salt in the 1978 Jonestown mass suicide incident. Chemical warfare agents involving cyanide include the liquids hydrocyanic acid (HCN, the form used by the Nazis, as "Zyklon B") and cyanogen chloride (deployed during World War I), which rapidly vaporize after detonation. Cyanogen chloride may cause some initial eye, nose, throat, and airway irritation, but otherwise its effects are the same as those of hydrocyanic acid and result from systemic cyanide toxicity.

**Toxicology**

Cyanide has a strong affinity for the ferric iron ($Fe^{3+}$) of the heme ring and, thus, inhibits many heme-containing enzymes. Its primary effect in acute toxicity is inhibition of cytochrome a3, thereby interfering with normal mitochondrial oxidative metabolism in the electron transport chain, causing cellular anoxia and lactic acidosis. It may also interfere with other important enzymes, including succinic acid dehydrogenase and superoxide dismutase, which may underlie some of its chronic toxicity. In addition, cyanide is believed to be a direct neurotoxin contributing to an excitatory injury in the brain, probably mediated by glutamate stimulation of N-methyl D-aspartate receptors. The primary human enzyme, rhodanese, detoxifies cyanide by combining it with a sulfate moiety such as thiosulfate to form the relatively nontoxic thiocyanate ion, which is then excreted by the kidneys. Therefore, exposure to a potentially lethal dose of cyanide that occurs slowly though continually over time may be tolerated, making it relatively unique among the agents of chemical terrorism.

**Clinical Presentation**

Clinical manifestations of cyanide toxicity vary considerably depending on dose, route of exposure, and acuteness of exposure but in general reflect the effects of cellular anoxia on organ systems. Thus, the most metabolically active tissues, the brain and heart, tend to be the most affected. With exposure to low concentrations of vapor, early findings include tachypnea and hyperpnea, tachycardia, flushing, dizziness, headache, diaphoresis, nausea, and vomiting. As exposure continues, symptoms may progress to those associated with exposures to high concentrations of vapor. The latter include rapid onset (within 15 seconds) of tachypnea and hyperpnea, followed by seizures (30 seconds), coma and apnea (2-4 minutes), and cardiac arrest (4-8 minutes). "Classical" signs of cyanide poisoning include severe dyspnea without cyanosis—or even with cherry-red skin (caused by lack of peripheral oxygen use)—and may have a bitter almond odor to breath and body fluids. However, some patients do develop cyanosis (likely secondary to shock), and only about half the population is genetically capable of detecting the cyanide-induced bitter almond odor. Laboratory abnormalities in cyanide poisoning include metabolic acidosis with a high anion gap and increased serum lactate and an abnormally high mixed venous oxygen saturation (also caused by decreased use of peripheral oxygen). Lactate levels greater than or equal to 8 mmol/L with clinical suspicion is highly sensitive for the diagnosis of cyanide poisoning. Blood cyanide levels can be determined but not usually on an emergent basis.

In an aerosol attack using recognized military chemical weapons, if people are convulsing or dying within minutes of exposure, the weapon is likely to be either cyanide or a nerve agent. Although the symptoms of exposure to cyanide and nerve agents may be hard to distinguish, when there are high concentrations of cyanide, seizures begin within seconds and death within minutes, generally with little cyanosis or other findings. The course for lethal nerve agent

toxicity is characteristically somewhat longer and accompanied by copious nasal secretions, miotic pupils, muscle fasciculation, and cyanosis before death.

**Treatment**

Management of cyanide poisoning begins with removing the victim from the contaminated environment to fresh air. Dermal decontamination is rarely necessary because these agents are so volatile, but in case of contact with liquid agent, wet clothing should be removed and underlying skin washed.

Basic supportive intensive care is critical, including providing 100% oxygen, mechanical ventilation as needed, and circulatory support with crystalloid and vasopressors; correcting metabolic acidosis with IV sodium bicarbonate; and controlling seizures with benzodiazepines. Symptomatic patients, especially those who have lost consciousness or have other severe manifestations, may benefit further from antidotal therapy, which include hydroxycobalamin (Cyanokit), amyl nitrite, sodium nitrite, and sodium thiosulfate. Hydroxycobalamin is a relatively new medication approved by US Food and Drug Administration in 2006 as a cyanide antidote. Although there is no randomized clinical study to show its superiority to the combination treatment of nitrite and sodium thiosulfate, it is widely accepted as the first line of cyanide poisoning because of its safety, simplicity of administration, and efficacy based on case series, clinical trial, and animal studies. The cobalt ion in hydroxycobalamin combines with cyanide and forms cyanocobalamin (vitamin $B_{12}$), which has low toxicity and is excreted in urine. For adults, an initial dose of 5 g of hydroxycobalamin is given over 15 minutes, and second dose of 5 g can be given depending on clinical response. In children, 70 mg/kg is the recommended dose. It can cause increased blood pressure, allergic reaction, and reddish discoloration of skin, urine, and plasma. This blood color change may affect some of common lab tests including creatinine, lactate, AST, ALT, bilirubin and magnesium for 24-48 hours, and may lead to false alarm of blood leak on hemodialysis machines. Hydroxycobalamin can be given as a solo antidote, but the combination with sodium thiosulfate may have synergistic effects. It is recommended to give hydroxocobalamin first followed by sodium thiosulfate, and avoid giving them through the same IV line or at the same time as thiosulfate can block hydroxycobalamin effect. Sodium thiosulfate will provide a sulfur donor, which is used as substrate by the thiosulfate sulfurtransferase (rhodanese enzyme) for conversion to thiocyanate. Thiocyanate can be toxic to patients with renal failure, causing abdominal pain, vomiting, rash, and CNS dysfunction, but in general it is much less toxic than cyanide. The usual dose for adults is 50 mL of a 25% solution either bolus or infusion over 10 to 30 minutes. The recommended pediatric dosage of thiosulfate is 1 mL (of the standard 25% solution)/kg, IV (with a maximal, or adult, dose of 50 mL).

Hydroxycobalamin, with or without sodium thiosulfate, is the preferred treatment in most of the cases, but when hydroxycobalamin is not available, classic cyanide antidote kit (amyl nitrite, sodium nitrite, and sodium thiosulfate) may need to be used. First, a methemoglobin-forming agent is administered, typically inhaled amyl nitrite or IV sodium nitrite, because methemoglobin has a high affinity for cyanide and dissociates it from cytochrome oxidase. However, nitrite administration can be hazardous, because it may cause hypotension, and overproduction of methemoglobin may compromise oxygen-carrying capacity. Thus, nitrite is probably not indicated for mild symptoms or if the diagnosis of cyanide poisoning is uncertain. Furthermore,

people with cyanide poisoning who may have concomitant hypoxic insult (eg, most victims of smoke inhalation) probably are not good candidates for nitrite therapy. Optimal nitrite dosing, especially when given parenterally, depends on body weight and hemoglobin concentration, which is of particular importance in pediatric patients, who have a broad range of hemoglobin concentrations. In the prehospital setting, or whenever IV access is not possible, amyl nitrite may be used to begin nitrite therapy. Amyl nitrite is provided in glass pearls, which are used by crushing the pearl and then either allowing spontaneous inhalation or introducing the vapor into a ventilation circuit, for 30 seconds of each minute. As soon as IV access is established, sodium nitrite may be given. The recommended pediatric dosage, assuming a hemoglobin concentration of 12 g/dL, is 0.33 mL (of the standard 3% solution)/kg, given slowly by IV infusion over 5 to 10 minutes (with a maximal, or adult, dose of 10 mL). Dosing may be adjusted for patients with significant anemia, although this would not likely be known in emergent treatment of a poisoned child in critical condition. Amyl and sodium nitrite have the potential to put the fetus of a pregnant woman at serious risk. In addition, there is increased vulnerability of infants and young children, those with active respiratory disease or diminished pulmonary reserve as well as those who have cardiovascular disease, particularly the elderly or frail, to increased methemoglobin levels (especially if combined with carbon monoxide exposure). If there is concern that a patient is not oxygenating well, such as in smoke exposure, consider going directly to hydroxocobalamin or sodium thiosulfate.

The second step of this classic antidote kit is sodium thiosulfate, as mentioned above. Thiosulfate treatment itself is believed efficacious and relatively benign, and thus it may be used alone empirically in cases in which the diagnosis is uncertain. This approach has also been recommended, for example, in the management of the situation described above of cyanide toxicity complicating smoke inhalation, with likely concomitant lung injury and carbon monoxide poisoning.

Both sodium nitrite and sodium thiosulfate may be given a second time at up to half the original dose as needed, or in the case of thiosulfate, even a full dose would be unlikely to pose inherent toxicity.

## VESICANTS

The term “vesicant” is commonly applied to chemical agents that cause blistering of the skin. Direct contact with these agents can also result in damage to the eyes and respiratory system. Systemic absorption may affect the GI tract, hematologic system, and CNS as well.

The 4 compounds historically included in this category—sulfur mustard, the nitrogen mustards, lewisite, and phosgene oxime—were all manufactured initially as potential chemical warfare agents. Phosgene oxime is technically not a true vesicant, because the skin lesions it causes are urticarial as opposed to vesicular. The nitrogen mustards, although first synthesized in the 1930s for anticipated battlefield use, were found to be less effective for chemical warfare than the already existing sulfur mustard. Subsequent development for of nitrogen mustards for weapons use was, therefore, largely abandoned. However, one form of nitrogen mustard, HN2, became a highly used and effective chemotherapeutic agent. Lewisite was first synthesized during the latter part of World War I, but other than reports of its use by Japan against China between 1937 and 1944, it is not known to have ever been used on the battlefield. An antidote, British

antilewisite (BAL, or dimercaprol), can minimize its effects if given promptly. Because so little is known about the toxicity and mechanisms of action of phosgene oxime and lewisite, and because anticipated medical management issues of these agents are somewhat similar, the following section focuses on the clinical effects and management issues regarding sulfur mustard exposure—historically the most frequently used and available of this class of chemical agent.

Sulfur mustard has been the most widely used of all chemical warfare agents over the last century. Approximately 80% of chemical casualties in World War I were attributable to sulfur mustard, and its use has been verified in multiple military conflicts since then. In addition, Iraq used sulfur mustard on numerous occasions during its war against Iran from 1980 to 1988 and as a weapon of terror against thousands of Kurdish civilians, including children, in aerially dispersed mustard bombs in 1988. Commercial fisherman's dermal exposure to liquid sulfur mustard attributable to artillery shells dredged from the sea reported in Massachusetts in 2012 reminds us its lengthy persistence in the environment because of its poor water solubility and low volatility.

Sulfur mustard is not difficult to manufacture, making it even more favorable for use by terrorists. In addition to its accessibility and ease of production, several other factors enhance its suitability as a terrorist or warfare agent. Although mortality associated with sulfur mustard is considerably lower than that caused by other chemical weapons such as nerve agents, sulfur mustard exposure results in significant and prolonged morbidity that may potentially overwhelm health care resources. The risk of direct contamination either from patient contact or from the agent's persistence in the environment may force health care providers to wear bulky protective gear, which makes it difficult to administer care, particularly to children. Although tissue damage occurs within minutes of exposure, clinical symptoms are delayed for hours, potentially rendering the victim ignorant of exposure until the opportunity for effective decontamination has passed. Lastly, unlike the case for lewisite, there is no known antidote for sulfur mustard exposure.

### Characteristics

Sulfur mustard is an alkylating agent that is highly toxic to rapidly reproducing and poorly differentiated cells. Under normal environmental conditions, it is an oily liquid that varies in color from yellow to brown, depending on amounts and types of impurities. Its odor has been described as similar to garlic or to mustard itself. In warmer climates, mustard vapor is a particular concern because of its low volatility, but at lower temperatures (<14°C or 58°F); it becomes a solid and may persist in the environment for an extended time. On contact with tissue surfaces, mustard vapor or liquid is rapidly absorbed and exerts its cellular damage within minutes.

### Clinical Effects

After exposure to sulfur mustard, skin findings may not appear for 2 to 48 hours, depending on the mode of exposure, the sensitivity of the individual, and the environmental conditions (see **Table 9.7: Clinical Effects from Sulfur Mustard Exposure**). The most common early sign in exposed areas is erythema resembling sunburn, which may coincide or even be preceded by significant pruritus. If the exposure is mild, this may be the only skin manifestation. More typically, yellowish blisters begin to form over the next 24 hours. Penetration of the agent is

enhanced by thin skin, warmth, and surface moisture, rendering areas such as the groin, axillae, and neck particularly susceptible. Once they appear, the vesicles frequently coalesce to form bullae. Although largely painless, these fragile bullae commonly rupture, resulting in painful ulcers that may take weeks or months to heal. The fluid from the blisters does not contain free mustard and is, therefore, not hazardous. If skin exposure has been severe, these earlier stages of developing lesions may be bypassed altogether with the direct appearance—albeit delayed—of skin sloughing similar to that seen in a full-thickness thermal burn.

Although skin findings may be dramatic, the organ most sensitive to mustard exposure is the eye, with mild symptoms occurring at concentrations 10-fold lower than those needed to produce effects on the skin. Like the skin findings, ocular symptoms are also delayed, but the delay is shorter than dermal symptoms. The first symptoms are usually pain and irritation, followed progressively by photophobia, worsening conjunctivitis, corneal ulceration, and perforation of the globe with severe exposures. Severe lid edema caused by inflammation of soft tissue around the eyes is also common.

Although visual impairment is common, it is usually transient and simply reflects eye closure from intense pain and reflex blepharospasm; at high concentration, exposure may cause corneal damage with ulceration and occlusion of conjunctival blood vessels.

With inhalation of mustard vapor, both the proximal and distal respiratory tract may be affected. Proximal involvement usually manifests after several hours and consists of rhinorrhea, hoarseness, a dry and painful cough with expectoration. With more significant inhalational exposures, necrosis of the airway mucosa can lead to a sterile tracheobronchitis with the necrotic epithelium forming pseudomembranes that may obstruct the airway.

Bacterial superinfection may develop as well, usually days later, facilitated by a weakened immune response. Respiratory failure can be the end result of either early mechanical obstruction from laryngospasm or pseudomembrane formation, or later by overwhelming bacterial infection enhanced by the denuded respiratory mucosa and necrotic tissue.

All cellular elements of the bone marrow can be affected by sulfur mustard because of its DNA alkylating effects, which impair replication in rapidly dividing stem cells. During the first few days after exposure, there may be a reactive leukocytosis that may or may not progress to leukopenia, depending on the level of exposure. When leukopenia happens, it reaches its minimum level around the ninth day.

GI symptoms can develop from the general cholinergic activity of sulfur mustard, resulting in nausea and vomiting that occurs after several hours and is rarely severe. Direct injury to the GI mucosa from ingestion of mustard either directly or from contaminated food or water can lead to a later onset of more severe vomiting, diarrhea, abdominal pain, and prostration.

Although historically a large percentage of battlefield victims have reported CNS findings such as lethargy, headaches, malaise, and depression, the role of the mustard agent itself in development of symptoms, as opposed to that of other environmental stressors, is unclear. Clinicians should be aware that, regardless of their etiology, these symptoms are a frequent

presentation. In addition, absorption of high doses of sulfur mustard can result in CNS hyperexcitability, convulsions, abnormal muscular activity, and coma.

**Table 9.7: Clinical Effects from Sulfur Mustard Exposure**

| | Eyes | Skin | Respiratory Tract | Bone Marrow | GI | CNS |
|---|---|---|---|---|---|---|
| Minimal | Tearing, burning, mild conjunctivitis, photophobia | Erythema | Rhinorrhea, hoarseness, hacking cough | Reactive leukocytosis | Nausea, vomiting | Apathy, depression, anxiety |
| Moderate | Severe conjunctivitis with blepharospasm, lid edema | Blisters | Severe cough, expectoration, aphoria | Leukopenia (often preceded by leukocytosis) | As above | As above |
| Severe | Corneal edema, severe pain, ocular perforation | Deep burning with full-thickness skin loss | Dyspnea, pulmonary edema, asphyxia, bronchopneumonia | Severe leukopenia, aplastic anemia | Later nausea, vomiting (possible bloody), diarrhea | Agitation, hyper-excitability, abnormal muscular activity, coma |

**Treatment**

The most effective treatment is decontamination, because once sulfur mustard penetrates tissues, its effects are irreversible. Unfortunately, sulfur mustard is rapidly absorbed on contact, usually exerting damage within 3 to 10 minutes of exposure. Effectiveness of decontamination is, therefore, extremely time dependent. Self-decontamination may be the quickest method and should include removing clothing and physically eliminating any mustard residue on the skin.

Anyone providing aid to an exposed person should take proper precautions including ocular, respiratory, and skin protection, ideally with a chemical protection overgarment, rubber boots, and gloves. Exposed individuals should be washed with soap and warm water, or just rinsed with water, as soon as possible. If water supply is limited, applying adsorbent powders such as flour and talcum powder, and then wiping off with a moist towel or rinsing with limited amount of water is another option. Regardless of decontamination method, the most important aspect is speed. Although ideally, all victims should be decontaminated before entering a medical treatment facility, if exposed individual arrive via personal transportation or on foot, they may first need to be taken to a separate area for decontamination. Even if delayed, decontamination should be performed to protect others from exposure, to avoid further absorption, and to prevent spread to other areas of the body.

After decontamination and basic life-support issues and other life-threatening concomitant injuries have been addressed, it is important to remain aware of the latency of most symptoms of vesicant exposure. Even if no symptoms are seen at presentation, exposed patients should be observed for at least 8 hours before being discharged. Because of the lack of a specific antidote, the remainder of therapy is supportive.

Skin lesions are treated similarly to those of burn victims. However, fluid losses tend to be less. For this reason, traditional formulas for fluid replacement in burn victims often overestimate losses in vesicant-exposed patients. Erythema and symptoms such as pruritus should be treated with topical and systemic analgesia and antipruritics, as well as soothing lotions such as calamine. Small vesicles (<2 cm) should be left intact, but larger vesicles and bullae should be incised and treated with frequent irrigation and topical application such as silver sulfadiazine (Flamazine) or mafenide acetate (sulfamylon). Widespread and severe partial or full-thickness involvement should be managed in a burn unit if possible. Skin grafting should be considered for full-thickness burns.

Eye treatment should center on removing the agent and on preventing scarring and infection. After irrigation of the eye with copious amounts of water, cyclopegic agents should be applied for comfort and to prevent formation of synechiae. Topical antibiotics should then be applied directly along with lubricating ointments, such as petroleum jelly, to the eyelids to prevent adhesions and subsequent scarring.

Mild respiratory symptoms involving the upper airway can be treated with cough suppressants, throat lozenges, and cool mist vapor. More severe lower respiratory involvement generally requires ventilation with positive end-expiratory pressure. The patient should be intubated promptly if there are any signs of laryngeal spasm or edema. Direct bronchoscopy may be necessary for removal of obstructive pseudomembranes. The temptation to use systemic antibiotics during the first 3 to 4 days despite the not uncommon findings of fever, leukocytosis, and cough should be avoided to prevent the growth of resistant organisms. However, if these signs and symptoms persist beyond this period and there is radiographic evidence of consolidation, systemic antibiotics may then be indicated. Bronchodilators such as beta agonists (eg, albuterol) and anticholinergics (eg, ipratropium) is shown to be helpful, and humidification or mucolytics such as n-acetylcysteine may be effective.

If anemia from bone marrow involvement is severe, blood transfusions may be of benefit. Granulocyte colony-stimulating factor (G-CSF) or granulocyte-macrophage colony-stimulating factor (GM-CSF) should be considered in severe leukopenia. Bone marrow transplantation can be considered in extreme cases.

## PULMONARY AGENTS

Toxic industrial chemicals used as terrorist weapons are a potentially significant threat to civilian populations. The Chemical Weapons Convention, a disarmament and nonproliferation treaty with 192 signatory countries, identifies 57 chemical and chemical precursors that can be used as weapons. Although some of the chemicals are well-known weapons (eg, sarin, VX, sulfur mustard), others are more familiar as common industrial chemicals such as chlorine, phosgene, and others. In the United States today, millions of tons of these chemicals are manufactured yearly for the production of dyes, textiles, medicines, insecticides, solvents, paints, and plastics.

The potential terrorist threat posed by industrial chemicals is well known. Huge industrial productions of these agents and often nonsecured storage and transport make it easy target for terrorists. In fact, there are many incidental exposures to pulmonary irritants reported, and multiple insurgents with chlorine use in Iraqi were acknowledged. Although of clear interest to

terrorist groups, traditional nerve agents require a greater degree of technical sophistication to manufacture and deliver as weapons.

## Chlorine and Phosgene

Pathophysiology/Clinical Effects

Pulmonary irritants include wide variety of chemicals that destroy mucosal barrier of the respiratory tract via different mechanisms that cause respiratory failure. Chlorine and phosgene are 2 major pulmonary irritants, used excessively in World War I, but there are many other pulmonary irritants such as ammonia, hydrogen chloride, hydrogen sulfide, nitrous oxide, ozone, etc. When inhaled into the lung, these agents cause damage to both type I and type II pneumocytes, followed by the release of inflammatory cytokines release, disruption of the integrity of the lung's alveolar-capillary barrier, and collection of cellular debris and plasma exudate in alveolar space. These are characteristic features of ARDS (acute respiratory distress syndrome).

Whether victims present with upper respiratory tract symptoms (naso-oropharyngeal pain, cough, hoarseness, drooling, inspiratory stridor, cough, edema) or with lower respiratory tract symptoms (tracheobronchitis, bronchiolitis, bronchospasm, ARDS) depends on water solubility, density of the gas, detection threshold, and duration of exposure. In general, water-soluble substances (eg, ammonia) cause immediate irritation and discomfort at oral, nasal, and ocular mucosa. This discomfort motivates people to escape from the exposure and results in reduced toxicity and limited upper airway symptoms. On the other hand, poorly water-soluble gas (eg, phosgene) tends to cause delayed irritation, prolonged exposure, and lower lung injury, and ARDS. The most characteristic and serious complication of pulmonary irritants is ARDS, which can be delayed and may not be apparent on presentation. Radiologic signs of ARDS often lag behind clinical symptoms. Pulmonary edema may be exceptionally profuse; in a study from the 1940s, pulmonary sequestration of plasma-derived fluid could reach volumes of up to 1 L/hour. This problem may be exceptionally profound in children, who have less fluid reserve and are at increased risk of rapid dehydration or frank shock from pulmonary edema. Additionally, because children have a faster respiratory rate, there is exposure to a relatively higher toxic dose.

Chlorine

Chlorine is a greenish-yellow gas that is denser than air and, therefore, settles closer to the ground and in low-lying areas. This may have significant consequences for small children and infants, who would be exposed to higher concentrations of the vapor and thus receive higher inhaled doses of the agent. Chlorine has a strong, pungent odor that most people associate with swimming pools. Because the odor threshold (at 0.08 ppm) is less than the toxicity threshold, the odor may warn individuals that exposure is occurring.

The initial complaints in chlorine exposure may be either intense irritation or the sensation of suffocation, or both. Low-level exposures to chlorine result in mucosal irritation of the eyes, nose, and upper airways. Higher doses lead to respiratory symptoms that progress from choking and coughing to hoarseness, aphonia, and stridor—classically upper respiratory tract symptoms. Dyspnea after chlorine exposures indicates damage to lower respiratory tract and incipient pulmonary edema.

Phosgene

Phosgene was estimated to have caused approximately 80% of the 100,000 poison gas deaths in World War I. Like chlorine, phosgene is also heavier than air, thus posing an increased risk for children who are exposed. Phosgene itself is colorless, but associated condensation of atmospheric water produces a dense white cloud that settles low to the ground. It has the characteristic odor of newly mown hay. However, the odor threshold for phosgene (at 1.5 ppm) is higher than the toxicity threshold, and unlike the case with chlorine, detection of the odor would be inadequate and too late to serve as a warning against toxic exposure. In addition, phosgene's aroma of fresh hay may not trigger immediate evacuation from the scene.

Phosgene is primarily associated with the development of pulmonary edema. Because in low to moderate doses, it does not cause the mucosal irritation in upper airway, the significance of the exposure may be underestimated. Exposure to progressively higher doses produces mild cough, sneezing, and other effects. Dyspnea is seldom present initially except when doses have been massive; instead, there is a clinically asymptomatic, or latent, period usually of several hours and inversely correlated with dose. The delay can be up to 24 hours, so prolonged observation is necessary. Dyspnea and associated clinical deterioration have in several instances been triggered by slight to moderate exertion.

## Treatment

Decontamination

Decontamination consists primarily of removing the victim from the source of the pulmonary agent to fresh air. For first responders such as paramedics and fire-rescue workers, PPE with self-contained breathing apparatus is required; however, because the gases are volatile, cross-contamination is unlikely. Victims of chlorine exposure may require copious water irrigation of the skin, eyes, and mucosal membranes to prevent continued irritation and injury.

Management

Management is primarily supportive; there are no antidotes or specific postexposure treatments for inhalational agents. Victims should be observed and monitored for development of respiratory symptoms, including pulmonary edema. Most deaths are attributable to respiratory failure and usually occur within the first 24 hours. Because of the delay in onset of pulmonary edema, prolonged observation of victims of phosgene and chlorine attacks is warranted.

Treatment of upper respiratory tract symptoms involves administering warm, moist air and supplemental oxygen, and treating bronchospasm either produced de novo by the toxicant in normal airways or resulting from toxicant-induced exacerbation of airway hyperresponsiveness in individuals with underlying pathology such as asthma or reactive airways. Aggressive bronchodilator therapy with beta-agonists is appropriate. The value of corticosteroids is inconclusive because of relative lack of well-structured studies, but they may be efficacious in victims with severe bronchospasm or a history of asthma. Steroids should be used early in the course as they are associated with worse mortality with delayed use after 14 days. Nebulized sodium bicarbonate, approximately 2%, as chemical neutralization for chlorine exposure did not show mortality benefit but was associated with small improvement of forced expiration volume.

IV or nebulized N-acetylcysteine is also suggested as a treatment option with some effects on animal study, but its clinical effectiveness is still unclear.

The possibility of laryngospasm should always be anticipated, and the necessity and timing of intubation carefully assessed. Associated central damage from inhaled particles of smoke in situations involving fire should also be considered. Pseudomembrane formation may lead to airway obstruction and may require bronchoscopic identification and removal of pseudomembranous debris. Necrotic debris from central damage provides an excellent culture medium for secondary bacterial colonization and infection, and bacterial superinfections are commonly seen 3 to 5 days after exposure. Early aggressive antibiotic therapy directed against culture-identified organisms is imperative. Prophylactic antibiotics are of no value.

Treatment of lower respiratory tract from pulmonary agents includes adequate oxygenation, establishment of effective intra-alveolar pressure gradients using positive end-expiratory pressure (for example, in conscious patients, with continuous positive airway pressure, or CPAP), and careful attention to fluid balance. The length of the latent period in a dyspneic patient can provide clinically valuable information about the intensity of exposure; patients who develop breathing difficulty within the first 4 hours after exposure may face a grave prognosis, and even patients with mild dyspnea, because of the timing of the dyspnea, may be candidates for urgent or priority evacuation. All patients at risk of pulmonary edema induced by pulmonary agents should be maintained on strict bed rest to avoid cardiopulmonary decompensation associated with exertion.

## RIOT CONTROL AGENTS

Modern riot control agents comprise a heterogeneous group of chemical compounds that have been used widely around the world since the 1950s (see **Table 9.8: Riot Control Agents**). These agents have the ability to incapacitate at low aerosol concentrations and have a high safety ratio (ratio of lethal dose to effective dose). However, prolonged exposure or release in enclosed areas can intensify the physical effects of these agents. CS (2-chlorobenzylidene), CN (1-chloroacetophenone, Mace), and pepper spray (*Oleoresin capsicum*) are commercially available to the public in the United States.

**Table 9.8: Riot Control Agents**

| Chemical Name | Abbreviated/Common Designation | Uses |
|---|---|---|
| 2-Chlorobenzylidene | CS | Military, law enforcement, personal protection |
| 1-Chloroacetophenone | CN (Mace) | Military, law enforcement, personal protection |
| Dibenzoxazepine | CR | Military |
| *Oleoresin capsicum* | Pepper spray | Military, law enforcement, personal protection |
| Diphenylaminearsine | DM | Military (rare) |
| Bromobenzylcyanide | CA | Military (rare) |

**Transmission and Pathogenesis**

Mode of transmission varies by agent. Common means include spraying a solution, release of pressurized canisters, explosive dispersion (smoke "grenades"), and burning. Explosive modes of transmission may cause traumatic injuries in addition to the incapacitating effects. CS is very flammable and poses a fire hazard. Most agents disperse soon after release, although persistent forms of CS exist. Riot control agents may contaminate clothing, buildings, and furniture and may cause ongoing symptoms in continued or repeat exposure. When dispersed, riot control agents are chemical irritants of the skin and mucous membranes of the eyes, nose, mouth, airways, and GI tract. The active agent in pepper spray, capsaicin, interact on transient receptor potential vanilloid 1 (TRPV1) in nociceptors. Activation of TRPV1 receptors causes depolarization and pain, inflammatory response through release of neuropeptides. Bradykinin release and further inflammatory change are also involved in the response to the stimulation of these receptors. This mechanism causes pain, capillary leakage, and vasodilation.

**Clinical Manifestations**

Riot control agents have specific effects on the eyes, nose, mouth, and airway with variation in intensity depending on mode of exposure and agent used. Symptoms occur quickly after exposure and typically resolve in 1 to 2 hours once the victim has been removed from the agent. On contact, these agents induce eye burning, eye pain, tearing, conjunctival infection, blepharospasm, periorbital edema, and photophobia. Exposures at close range, particularly to exploding CS and CN grenades or canisters, may cause serious damage to the eye including corneal edema, conjunctival laceration, hyphemia, vitreous hemorrhage, and secondary glaucoma. Permanent effects such as cataracts and traumatic optic neuropathy may also be seen.

After dispersal of riot control agents, nasal burning and pain, copious rhinorrhea, and persistent sneezing begin along with oral irritation and salivation. Pulmonary effects include chest tightness and burning, bronchorrhea, bronchospasm, and coughing. Gagging, retching, and vomiting frequently accompany mucosal and airway irritation. Exposed skin stings and may progress to erythema, vesiculation, and bullae depending on the conditions of exposure; prolonged exposure, high ambient temperature, and humidity exacerbate skin effects. These manifestations may occur hours to days after exposure to CS. Skin exposed to CR may become painful in water for up to 2 days after exposure. CN and CS can cause allergic contact dermatitis in people who are repeatedly exposed.

Severe clinical effects from riot control agents are uncommon. Intense exposure to CS, CN, and pepper spray has caused laryngospasm, pneumonitis, bronchospasm, noncardiogenic pulmonary edema, respiratory arrest and even death. Often, the agent was released in an enclosed space, or the victim was not able to leave the vicinity of the agent. Individuals with asthma are predisposed to serious pulmonary symptoms. Prolonged reactive airway disease has also been described after exposure in a previously healthy person. In general, riot control agents are incapacitating but rarely lethal, especially relative to other deployable chemical agents such as the nerve agents, vesicants, and pulmonary agents.

**Diagnosis**

Some physical characteristics of the compounds can assist in detection when riot control agents are used. The most common agents (CS, CN, and pepper spray) are deployed in identifiable canisters. CS and pepper spray have a pungent pepper odor. CN has a flowery apple odor.

Differentiation of clinical effects caused by riot control agents from those of other chemicals can be a challenge during early management. Tearing, salivation, bronchorrhea, bronchospasm, and vomiting suggest the cholinergic effects of nerve agent exposure. Intense exposure to riot control agents with pneumonitis and pulmonary edema mimic symptoms of exposure to pulmonary agents, such as chlorine and phosgene. The potential for delayed skin effects, including vesiculation and bullae, with riot control agents makes them similar to vesicants such as sulfur mustard. However, symptoms rapidly resolve once contact with the agent ceases. Lack of progression to more severe symptoms such as bone marrow failure, paralysis, and seizures, combined with negative results from field detection systems and the physical characteristics, mentioned above, make identification of riot control agent release ultimately possible.

### Treatment and Control

Decontamination requires that all victims be moved to a well-ventilated, uncontaminated space and have their outer clothing removed. Clothing should be double bagged to prevent secondary exposure. Medical treatment of riot control agent exposure focuses on ending contact, assessing for serious pulmonary effects, and addressing ongoing eye and skin irritation.

In most instances, clinical signs and symptoms resolve over 30 to 60 minutes, and specific medical treatment is not needed. Pulmonary effects may be delayed. Victims who exhibit prolonged dyspnea or have other objective lung findings should be admitted to a medical facility for ongoing monitoring and treatment.

All first responders should wear PPE including, but not limited to, a full-face gas mask, properly rated outer clothing, gloves, and boots. Field incident command should identify a hot zone, decontamination area, and cold zone. Ideally, decontamination should begin in the field and be complete before entry into a medical facility.

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# CHAPTER 10:
# PEDIATRIC DECONTAMINATION

The American Academy of Pediatrics (AAP) published specific recommendations in its policy and technical report, "Chemical-Biological Terrorism and Its Impact on Children" in February 2020.

## GENERAL PRINCIPLES

The purpose of this chapter is to describe many of the overarching principles specific to decontamination of the pediatric patient. General decontamination considerations with respect to child-specific procedures should include the following:

- Decontamination systems should be suitable for children of all ages, unaccompanied minors, nonambulatory children, and those with special health care needs.
- To ensure safety and protection for all, children should be directly supervised during and after a disaster. Every attempt should be made to keep children with their parents, throughout the decontamination.
- Given that children, especially smaller children and infants, are much more susceptible to hypothermia during decontamination procedures, warm water should be used and blankets for warming should be readily available.

### Skin Decontamination

Skin decontamination is critical and should occur as soon as possible after basic life support maneuvers. Whenever possible, decontamination should take place outdoors with plans to collect contaminated water. To minimize exposure to health care professionals and patients within the health care facility, the child should be disrobed outdoors—as per Occupational Safety and Health Administration (OSHA) regulations—before entering the ambulance or building, with attention to prevention of hypothermia. When dealing with infectious agents, skin contamination is a serious threat for both victims and the health care or other professionals who care for them. Health care professionals should not assist in disrobing unless they are wearing appropriate personal protective equipment (PPE).

- All clothing and shoes should be removed to decrease the likelihood of continued exposure. These items should be placed in a plastic bag or other container and sealed for later analysis for chemical residues. When possible, victims should disrobe themselves to minimize exposure to others.
- The skin should be washed with soap and water, and the hair should be thoroughly washed and rinsed.
- For field decontamination, emergency medical system professionals and some municipalities and fire departments may have portable shower units for this purpose. In other situations, these may be available for set up at the health care facility.
- Dry decontamination (absorbent or adsorbent materials) may be considered if wet decontamination is not available. Dry decontamination may be more effective with liquid contaminants than particulate matter.
- Children cannot always be decontaminated in adult decontamination units. Skin decontamination showers that are appropriate for adults may result in hypothermia in children because of their increased body surface area to mass ratio. As such, equipment such

as warming blankets and heating lamps should be readily available. Protocols should also include strategies for using warm water and low-pressure showers.
    - Principles of showering include the establishment of 3 management zones in the decontamination staging area (hot [maximum contamination], warm [less contamination), and cold [no contamination) zones), use of water that has been warmed to a temperature of 100°F, a water pressure of 60 pounds per square inch (psi), and containment of the wastewater.
- In situations such as fire exposure, consider the likelihood that the mucous membranes and respiratory tract may have been affected.
- Pediatricians and health care providers should take measures to protect themselves from contaminated skin and clothing. Health care professionals should not assist in disrobing unless they are wearing appropriate PPE. In addition, parents or other caregivers may also be at risk for skin contamination and may require decontamination and/or PPE as appropriate.
- Health care workers should also doff PPE and shower after contact with victims and cleanse nondisposable equipment.
- If the event causes significant skin injury (eg, explosive device), care should first be focused on managing bleeding wounds at the scene, followed by more careful skin cleansing at a hospital facility.

**Eye Decontamination**

Eyes should be flushed continuously with clean water or sterile saline for at least 15 minutes. If the victim wears contact lenses, they should be removed before the eyes are flushed. If there is persistent pain after eye flushing, ophthalmologic consultation is advised.

Personal Protective Equipment

The level of recommended PPE will depend on the following: 1) whether responders are working in warm or cold decontamination zones and which hazardous substance(s) are suspected to have been released. It is important to note that PPE is only one part of a comprehensive worker protection plan; there are also administrative and engineering controls, as well as work practices, that are implemented to keep workers safe. PPE may include gown and gloves to protect the skin, and mask or other head gear to protect the respiratory tract. Although not necessarily specific to pediatric decontamination, it is important to remember to use universal precautions to prevent contact with blood, other bodily fluids, nonintact rashes, and mucous membranes. In addition, handwashing should be performed after contact with blood or body fluids, whether or not gloves are worn.

Respiratory masks consist of high-efficiency particulate air (HEPA) filters and organic vapor cartridges that will protect against many airborne hazards that first receivers/responders may encounter (toxic dusts, biological agents, radioactive particulates, organophosphates, and other pesticides or solvents). Acid gas cartridges also provide protection against chlorine. This equipment should be removed and discarded after use or cleaned between the care of patients. **Table 10.1: 4 Levels of PPE** shows the 4 levels of PPE, from most protective (Level A) to least protective (Level D). Responders and health care providers working outside contamination areas but who are expected to have contact with previously contaminated victims (such as health care professionals in hospitals and clinics who are receiving and treating patients) may require Level C or D PPE.

| Table 10.1: Four Levels of Personal Protective Equipment | | |
|---|---|---|
| Level | Description and Details | Equipment to Be Used as Appropriate |
| A | Consists of a self-contained breathing apparatus (SCBA) and a totally encapsulating chemical-protective (TECP) suit. Select when the greatest level of skin, respiratory, and eye protection is required. Practical limitations include limited air supply (20–50 minutes) and potential heat stress while wearing the suit. | • Positive pressure, full-facepiece SCBA, or positive pressure supplied air respirator (SAR) with escape SCBA, approved by the National Institute for Occupational Safety and Health (NIOSH).<br>• Totally encapsulating chemical-protective suit.<br>• Inner and outer chemical-resistant gloves.<br>• Boots, chemical-resistant, toe and metatarsal impact protection (eg, steel or composite).<br>• Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally encapsulating suit).<br>• Coveralls, long underwear, and/or hard hat (under suit), optionally, as applicable. |
| B | Consists of a positive-pressure respirator (SCBA or SAR) and nonencapsulated chemical-resistant garments, gloves, and boots, which guard against chemical splash exposures. Provides the highest level of respiratory protection with a lower level of dermal protection. | • Positive pressure, full-facepiece SCBA, or positive pressure air purifying respiratory APR with escape SCBA (NIOSH approved).<br>• Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; 1 or 2 piece chemical-splash suit; disposable chemical-resistant overalls).<br>• Inner and outer chemical-resistant gloves.<br>• Boots, outer, chemical-resistant with impact resistance.<br>• Boot-covers, outer, chemical-resistant (disposable).<br>• Coveralls, chemical-resistant boot covers, face shield and/or hard hat (under suit), optionally, as applicable. |
| C | Consists of an APR and nonencapsulated chemical-resistant | • Full-face or half-mask, APRs (NIOSH approved). |

| | | |
|---|---|---|
| | clothing, gloves, and boots. Provides the same level of skin protection as Level B, with a lower level of respiratory protection. Used when the type of airborne exposure is known to be guarded against adequately by an APR. Because of limitations of an APR, its use is allowable only when oxygen levels are adequate (ie, >19.5%), air contaminants are known, and a cartridge can be selected to provide protection from contaminants. | • Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).<br>• Inner and outer chemical-resistant gloves.<br>• Eye protection is usually added if a half-face respirator is worn. Goggles or glasses, depending on the hazard encountered.<br>• Coveralls, chemical-resistant outer boots, chemical-resistant disposable boot covers, escape mask, face shield and/or hard hat (under suit), optionally, as applicable. |
| D | Consists of standard work clothes without a respirator. For example, in hospitals, consists of surgical gown, mask, and latex gloves (universal precautions). Provides minimal respiratory and skin protection. | • Coveralls.<br>• Boots/shoes.<br>• Eye protection is often added.<br>• Gloves, chemical-resistant outer boots, safety glasses or chemical splash goggles, escape mask, face shield and/or hard hat, optionally, as applicable. |

Source: OSHA. Emergency Preparedness and Response. www.osha.gov/SLTC/emergencypreparedness/gettingstarted_ppe.html. Accessed February 23, 2022.

**Management/Decontamination in the Field**

First responders or triage supervisors can initiate decontamination and treatment at the scene of an incident or nearby if necessary. If there are certain hazardous materials at the incident site, there are specific protocols that will be initiated, including mobilizing those trained in handling particularly dangerous materials such as hazardous materials (hazmat) removal workers.

First responders typically work in what is known as a "warm decontamination zone," which is any location where the type and quantity of hazardous material is unknown and where contaminated victims, equipment, or contaminated waste may be present. This zone is usually set up adjacent to the location where a chemical/biological agent release has occurred. This victim assessment and treatment area is to be distinguished or kept separate from the "cold zone" or "post-decontamination zone" (locations that are believed to be uncontaminated with the hazardous material). Usually, a hospital or other health care facility to which victims are transferred are referred to as "cold decontamination zones," where patients have already been decontaminated.

**Management/Decontamination at the Hospital (or other Facility)**
Hospitals often decontaminate patients prior to entry into the building, unless decontamination is confirmed to have occurred in the field. In contrast to the first responders in the field, hospital and other facility staff may be alerted in advance of hazardous exposure concerns and any prior decontamination efforts. Hospital staff can decrease their risk of exposure by wearing full PPE and respiratory masks until it is clear that secondary exposure risk has been eliminated. Secondary exposure usually depends on the amount of toxic substance in the victim's hair, skin, and clothing, as well as the concentration of the substance. If decontamination has not been completed prior to arrival, the victim must be treated and decontaminated in an area with adequate ventilation. Secondary exposure can be significantly decreased if a victim's contaminated clothing can be cut away using blunt-nose shears and isolated immediately. Timely removal of patients' clothing can reduce contamination and secondary exposure as much as 85%. Afterwards, victims need to shower with lukewarm water and liquid soap to remove hazardous substance from their skin and hair. As noted previously, this process must be carefully supervised when treating children; it may be necessary for a staff member wearing the appropriate PPE to assist children throughout the process.

Serious poisoning to health care workers has been reported following care of patients with organophosphate poisoning that required treatment. Victims who self-transport from the field and bypass emergency medical services personnel may increase the risk of exposure. Thus, removing contaminated clothing from all victims, improving ventilation, and using PPE may significantly decrease health care workers' exposure to hazardous materials. Physician offices should have a mechanism in place where patients can be screened in a setting outside the office, such as their vehicle, as a means to protect the facility and staff from exposure. Additionally, once victims have been transferred to the hospital or facility, it is important to have adequate documentation of exposure risks, symptoms, and clinical findings and for all patients treated.

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# CHAPTER 11:
# PHYSICAL TRAUMA: BLUNT AND PENETRATING INJURIES DUE TO EXPLOSIVES AND FIREARMS

Knowledge of the effects of blast injuries, on children in particular, is fairly recent, and is based chiefly on reported experiences in the Middle East. As a result, this knowledge is not widely shared by health care professionals who care for pediatric patients. Therefore, this chapter focuses first on what is known of the general causes, nature, and effects of blast trauma on humans before proceeding to brief reviews of the far better known effects of incendiaries and firearms. It concludes with a discussion of specific effects of explosives, incendiaries, and firearms on pediatric patients.

Because the early management of secondary, tertiary, and quaternary blast injuries is somewhat different from that encountered in routine clinical practice, this chapter will begin with a review of the physical science underlying the early management of primary blast injuries, which varies from management of conventional civilian trauma in numerous ways. The clinical findings and diagnosis of primary blast injuries will be discussed in detail as the basis for early management of these fortunately uncommon but potentially devastating injuries.

## EXPLOSIVE INJURIES

### Blast Physics

Many believe that the harmful effects on the body caused by a blast result from the pressure differentials exerted on tissues by an expanding wave. However, because the peak overpressure decays exponentially, a victim must be relatively close to the detonation for the blast wave itself to induce tissue injury. Several factors, including the following, affect the degree of blast pressure loaded to objects:

- The distance between the object and the detonation.
- The orientation of the object to the incident wave.
- The degree of reflected waves to which the object is subjected.

This latter point is the reason that, given equal peak overpressures, victims found in corners or in underwater blasts suffer greater injury. In both situations, the victim is subject to the incident wave in addition to multiple reflected waves.

### Blast Trauma

Many mechanisms of injury are involved in blast injuries.

- Primary blast injury refers to tissue damage by the blast wave itself, specifically in areas with tissue-gas interfaces such as the lungs, the intestines, and the tympanic membrane.
- Secondary injury refers to penetrating or blunt injury that results from the acceleration of fragments or debris, caused by the blast wave or the blast wind. Terrorists often add metallic fragments, such as nails, to devices to maximize the potential for penetrating injuries. Secondary injury is the most common type of injury that occurs, because it does not require the victim to be near the point of detonation.

- Tertiary injuries result from acceleration-deceleration forces imposed as the blast wave or blast wind propels the victim. As the body is tumbled on a rigid surface, it suffers from blunt injury as well as penetrating injuries as it is accelerated over sharp debris.
- Quaternary injuries include crush injuries incurred from structural collapse, flash and flame burns, inhalational injury, and acute stress response to catastrophic events.

Secondary blast injury (SBI) and tertiary blast injury (TBI)—not to be confused in this usage with traumatic brain injury—overlap significantly, and both are more common than primary blast injury (PBI) in the hospital setting. Those close to the detonation of a high-energy explosive are most likely to suffer PBI and to die on scene.

**Primary Blast Injury**

The effects of the blast wave on structural elements and on human tissues combine to cause complex combinations of injuries in blast victims. Injuries may be variable within a single event. The principal factor that determines severity of PBI is the distance of the victim from the site of detonation (**Table 11.1: Expected Injuries at Relative Distances from Detonation in Open Air**). Injuries also vary depending on the victim's position with respect to incident waves and the degree of reflected shock waves to which the victim is exposed.

A blast that occurs in an enclosed space, such as a bus, is associated with more severe injuries and a higher incidence of primary blast injuries. The number of casualties from PBI would be expected to be more than in an equipotent detonation in open space. Mortality is also higher when a blast occurs in an enclosed space, because the shock wave is contained, reaches a higher overpressure and a longer positive phase, and echoes in numerous directions from the internal structures it encounters.

PBIs are injuries caused specifically by exposure of the body to the blast wave. Pulmonary barotrauma, air embolization, and intestinal perforation are the unique principal causes of death after a blast. Although most injuries in an explosion are secondary, tertiary, and quaternary (crush, burn, inhalational), a person close enough to a detonation would be subjected to the effects of the blast on a microscopic level.

**Table 11.1: Expected Injuries at Relative Distances from Detonation in Open Air**

| Injury | Closest to Farthest | | | | | | |
|---|---|---|---|---|---|---|---|
| Body disruption | ● | | | | | | |
| Burn/inhalation | ● | | | | | | |
| Toxic inhalation | ● | ● | | | | | |
| Amputation | ● | ● | ● | | | | |
| Primary blast injury, lung and bowel | ● | ● | ● | ● | | | |
| Tertiary mechanism | ● | ● | ● | ● | ● | | |
| Primary blast injury, ear | ● | ● | ● | ● | ● | ● | |
| Secondary mechanism | ● | ● | ● | ● | ● | ● | ● |

The spectrum of PBI reflects involvement of the gas-containing organs and the pathophysiologic effects of these organs on other systems. As in conventional trauma, all victims should be managed with careful attention to the airway, breathing, and circulation. However, in certain patients, complications may arise with respect to positive-pressure ventilation and fluid resuscitation management.

**Blast Lung Injury and Air Embolization**

The anatomic structure of the lung makes it susceptible to the effects of blast barotrauma. Alveolar spaces are surrounded by a delicate capillary network in a way that maximizes the surface area available for gas exchange.

Clinical findings range from contusion and ecchymosis to massive hemoptysis, severe ventilation/perfusion mismatch, and air leak, leading rapidly to death. Most blast lung injury develops early in the course of treatment, within 1 to 2 hours. Signs and symptoms may progress within 24 to 48 hours to respiratory failure and acute respiratory distress syndrome (ARDS). Respiratory failure is frequently exacerbated by the secondary additive effects of shock, organ failure, or inhalation of smoke and toxic substances.

The most important diagnostic test for blast lung injury is a chest radiograph, which commonly shows bilateral pulmonary infiltrates in a “butterfly” pattern. Computed tomography (CT) can provide important additional information in a patient with respiratory findings but an unrevealing chest radiograph. Pulmonary hemorrhage is the most consistent microscopic finding in blast lung injury.

***Management***

Blast lung injury is not universally fatal, given aggressive and timely management. Initial management involves maintaining adequate oxygenation and minimizing additional barotrauma. A patent airway free of blood and secretions should be maintained. Control of massive hemoptysis involves tracheal intubation and, whenever possible, selective ventilation of the contralateral lung. The source of bleeding in massive hemoptysis may be from one or both lungs and is often difficult to determine. Having a high index of suspicion for pneumothorax or tension pneumothorax is essential.

The development of systemic air embolization from injured lung tissue is a grave complication. The greater the degree of lung injury, the higher the risk of embolus formation. Although the actual incidence is unknown and is probably underrecognized, air embolization in blast injury is speculated to be the main cause of death within the first hour after a blast. Air emboli in the vascular system carry a high mortality rate, because the air bubbles can potentially cause occlusion of the coronary arteries (myocardial ischemia), cerebral vessels (stroke), or cardiac outflow tracts (shock). Air emboli cause additional morbidity such as blindness (occlusion of retinal arteries) and ischemia of end organs. The ultimate clinical result depends on the site and volume of embolization.

Air emboli pose a challenge in emergency management of blast victims. Air emboli are not only difficult to diagnose but also have a clinical presentation similar to that of other more familiar

clinical entities. For example, myocardial ischemia, which is usually easily recognized, is most likely to be secondary to coronary vessel embolization (versus the traditional mechanisms of ischemia) in victims with blast lung injury. Management of these patients should focus on halting the passage of air. However, in patients exhibiting a change in their mental status, more common traumatic causes (eg, intracranial hemorrhage from blunt head injury) should be addressed first, before focusing on embolization.

Air emboli can be confirmed by direct visualization of air bubbles or disrupted air passages via echocardiography, transcranial Doppler ultrasonography, CT scan, or bronchoscopy. Unfortunately, there are no data on the sensitivity of these techniques in detecting emboli in blast victims. Transesophageal echocardiography can detect gas bubbles as small as 2 micrograms, but its availability is limited. Sudden circulatory or neurologic collapse, especially if positive pressure ventilation has been started, combined with a high index of suspicion, is enough to make the diagnosis of air embolization until proven otherwise. Other suggestive clinical findings include possible evidence of bubbles in retinal vessels, aspiration of air from arterial lines, or marbling of the skin or tongue.

Treatment of air emboli might require thoracotomy. However, a temporizing maneuver is placing the patient with the injured lung down, or in the dependent position, to minimize embolization by increasing venous pressures on that side. Hyperbaric oxygen therapy has been successfully used to treat cerebral air emboli from diving decompression injuries by actually causing bubble volume to decrease.

Positive-pressure ventilation (PPV) is a last resort for blast victims because of the risk of further barotrauma. PPV is, therefore, reserved for cases of severe respiratory failure, critical central nervous system injury, or massive hemoptysis or for patients requiring emergency surgery for other reasons. Cardiovascular, respiratory, or neurologic collapse within minutes of PPV being instituted has been reported. In addition, PPV is thought to contribute to the generation of air emboli because of the high airway pressures it causes, and it has been implicated in the reopening of fistulas.

In the spontaneously breathing patient, pulmonary venous pressures are higher than airway pressure, which prevents the passage of emboli into the venous system. During PPV or when pulmonary vascular pressures are low (eg, with hypovolemia), airway pressures are higher, and the gradient is reversed, facilitating the passage of air and debris into the vascular system. Techniques based on experience in ventilating patients with pulmonary contusion and ARDS have been proposed for ventilating victims of blast lung injury who must be intubated. These techniques include low tidal volumes (6 mL/kg), pressure-controlled ventilation with a goal plateau pressure of 25 to 30 mm Hg cm $H_2O$, positive end-expiratory pressures, permissive hypercapnia, and acceptance of oxygenation saturations greater than 90%. As a last heroic attempt, extracorporeal membrane oxygenation has been suggested.

**Gastrointestinal Blast Injury**

After lung injury, gastrointestinal (GI) injury is the second most lethal primary blast injury. Abdominal injuries secondary to open-air blasts are less common than blast lung injury, but they are much more common in underwater blasts.

### *Clinical Findings and Diagnosis*

The signs and symptoms of GI injury may be nonspecific and change over time. Evaluation of the abdomen begins with a physical examination, standard trauma screening laboratory tests, and a high index of suspicion for injury. Making the diagnosis of perforation in an area of trauma is challenging for many reasons. First, the findings can be subtle and masked by other, more critical injuries. Second, the patient may be unconscious, making the value of serial examinations limited. Third, diagnostic examinations such as CT, although useful for detecting hemorrhage, may be misleading or insensitive in the early stages of perforation.

### *Management*

The goals of management are to identify and control internal bleeding and to identify and repair any perforated viscus. In stable patients in whom injury is suspected, the abdominal radiograph and diagnostic peritoneal lavage has largely been replaced by CT scan and ultrasonography. CT scan provides useful information regarding intra-abdominal hemorrhage, organ injury, free intraperitoneal air, and intramural hematoma. However, it has a low sensitivity for identifying a hollow viscus perforation. In hemodynamically stable patients with blast lung injury too severe to be surgical candidates, exploratory abdominal procedures may be delayed. In these patients, broad-spectrum antibiotics are recommended pending confirmation of intact bowel. Exploratory laparotomy may be necessary in hemodynamically unstable patients in whom internal bleeding is suspected. Because surgical outcomes in blast victims are poor, surgery, like intubation, is a last resort and should be weighed against the risk associated with missing a perforation.

## Cardiovascular Effects

The heart and blood vessels can be directly or indirectly injured by a blast wave. Cardiac involvement during a blast usually manifests as coronary vessel embolization and ischemia. Blood vessels within certain organs have a propensity for injury and may contribute to the generation of microthrombi. Cardiac blast injury that manifests as hemorrhage in the epicardium, myocardium, or papillary muscles is quite rare.

Hypotension in blast victims can be caused by blood loss from major musculoskeletal or thoracic injury or from a blast-related, vagally mediated reflex. This reflex, which is seen immediately after a significant blast exposure, causes hypotension and bradycardia. It is the most common effect on the cardiovascular system by the blast wave itself. The hypotension can be profound but is usually self-limiting.

Traditionally, aggressive volume replacement to support circulation is required in trauma victims with cardiovascular collapse. However, excessive volume replacement can be detrimental, particularly to patients with lung injury. A permissive hypotension resuscitation strategy in which a systolic blood pressure of 90 mm Hg is accepted may help limit the use of fluid and blood products. Research in animals has suggested that fluid replacement actually impairs cardiovascular performance in the setting of a blast. However, inadequate pulmonary vascular pressure has been suggested to promote the passage of air into the pulmonary venous system. Therefore, administration of fluids in increments of 5 mL/kg, titrated to clinical response, has been recommended. Either too much or too little fluid can be harmful, and the judicious use of fluids to maintain euvolemia is probably the best approach. As in all trauma patients, a balanced

resuscitation approach that replaces blood loss with similar amounts of red blood cells, plasma, and platelets should be employed.

Traumatic amputations frequently result from a blast. The mechanism for traumatic amputations has been hypothesized to be a combination of the blast wave itself and the effect of propelled fragments on tissues. Tourniquets have been used effectively by the US military and more recently by civilians during the Boston Marathon bombing to limit morbidity and mortality. Uncontrolled hemorrhage is the most preventable form of death in the United States. The "Stop the Bleeding Coalition" has information and kits available to address this issue (https://stopthebleedingcoalition.org/).

**Blast Auditory Injury**

The auditory system is the system most frequently injured during a blast. Auditory injury is more common than lung or GI injury, because the overpressure necessary to perforate tympanic membranes (5 psi) is well below that expected to cause lung or GI injury. Hearing loss, either with or without a ruptured tympanic membrane, is quite common. It can be debilitating and make communication with the victim difficult, if not impossible. Although some sensorineural hearing deficits improve over the first few hours, deficits are permanent in approximately 30% of victims.

***Tympanic Membrane Rupture***

Approximately 80% of tympanic membrane ruptures from PBI heal without the need of surgical intervention. However, with larger perforations, as seen in US troops during Operation Enduring Freedom, only about 50% close without surgical intervention.

***Management***

In general, emergency management of auditory injuries involves clearing the ear canal of debris and minimizing exposure to loud noises or water. Otologic complications such as perilymph fistula and cholesteatoma formation do occur, and all survivors should have an auditory assessment as part of their care.

**Sentinel injuries**

Sentinel injuries are subtle injuries that can increase the risk of having or developing serious blast injury. These patients should be monitored closely, no matter how clinically well they appear. Sentinel injuries include the following:

- Traumatic amputations
- Hypopharyngeal contusion
- Hemoptysis
- Subcutaneous emphysema

## INCENDIARY INJURIES

The chief difficulty in early management of incendiary injuries is that they so frequently coexist with blast injuries. As such, successful fluid management depends on a careful balance between volume resuscitation, needed in severe burns, and volume restriction, needed for blast lung. This is especially problematic in the mass casualty setting, in which numerous patients may require

the intensive care resources normally available in burn and trauma centers, but such resources rapidly become overwhelmed during mass casualty events. In truth, the number of available burn center beds on any given day—even given the relatively resource-rich environment of North America—is extremely limited, especially during winter months, mandating that all health care regions develop flexible surge plans for early burn care, typically in regional trauma centers, as burn beds will be scarce, and the physicians and nurses staffing them will be in very short supply.

Incendiary devices, or "firebombs," are designed to inflict severe burns, and are largely confined to military use because of the high temperatures necessary to ignite them. Historically, white phosphorus was the main component of such bombs, but modern devices rely more often on thermite, a combination of powdered aluminum and ferric oxide, which can burn through, or weld, even heavy armor plate. Their effects on human flesh are obviously devastating. Perhaps the crudest, yet still most commonly employed incendiary device in asymmetric warfare, is the "Molotov cocktail," a liquid petroleum fuel-based firebomb most often enclosed within a glass container and ignited with a cloth wick that is capable of producing severe burns.

Emergency management of victims of incendiary devices involves identifying and treating the following:

- Severe burns (partial- and full-thickness)
- Respiratory compromise (including inhalation injuries)
- Carbon monoxide poisoning
- Dehydration

These burn victims should be managed according to Advanced Trauma Life Support (ATLS) and Advanced Burn Life Support (ABLS) protocols as for any other burn victim, with special attention to identifying coexisting blast injuries and removing the incendiary agent from the skin. Inhalation of superheated gases associated with the explosion can cause severe burns to the upper respiratory tract, leading rapidly to upper airway obstruction as the mucosa of the upper respiratory tract blisters and swells. Although napalm (petroleum fuel mixed with a gelling agent) is chiefly limited to military uses, carbon monoxide poisoning is of particular concern, because carbon monoxide is a byproduct of napalm combustion. Because of the radiant heat emitted from the combustion of these materials, prolonged exposure may lead to severe dehydration.

**Firearm Injuries**

Although tragedies such as those at the elementary school in Newtown in 2012 or the concert in Las Vegas in 2017 receive most of the attention, more than 60% of mass shootings occur in private residences. The majority of active shooter incidents involve domestic violence, and in 25% of such cases, a child is a victim. Active shooter events are, however, far more common in the United States compared with other industrialized countries.

Data from US forces in Iraq showed that the most common forms of preventable death were from hemorrhage, and more than 30% were hemorrhage from an extremity. These types of injuries can be treated effectively with direct pressure, arterial tourniquets, and gauze impregnated with topical hemostatic agents, methods that are now in use by many emergency

medical services (EMS) systems and police departments and increasingly are being taught to the general public.

Emergency management of victims of firearm injuries should follow Advanced Trauma Life Support (ATLS) protocols. As previously stated, the main difference between routine civilian trauma care and mass casualty trauma care following firearm-related injuries involves the far higher number of both victims and injuries per victim—both of which are facilitated by the use of "assault" weapons that allow both rapid fire and rapid reloading. Because most deaths attributable to gunshot wounds, especially high velocity wounds, result from uncontrolled hemorrhage, the approach to management follows a C-A-B (circulation-airway-breathing) paradigm rather than the more traditional A-B-C (airway-breathing-circulation) model, whereby rapid control of external and junctional (axilla and groin) hemorrhage, employing arterial tourniquets and topical hemostat-impregnated gauze when direct pressure fails to control major bleeding, is addressed first. Otherwise, management is similar to that utilized in routine civilian trauma.

## DISASTER TRIAGE

Disasters are operationally defined as occurrences during which patients' needs exceed available resources. Multiple casualty incidents (MCIs) are occurrences typically involving 5 or more injured patients during which patients' needs exceed but do not overwhelm available resources. Mass casualty events (MCEs) are occurrences typically involving 20 or more injured patients during which patients' needs exceed and overwhelm existing local and even regional resources and require that additional resources be mobilized and deployed.

Standard triage methods apply during MCIs. Under standard triage, patients with actual airway compromise take precedence over those with breathing difficulties, who in turn take precedence over those with circulation instability, in that order. Events caused by improvised explosive devices (IEDs) or active shooters require hemorrhage control as the first priority.

## TRAUMA SYSTEMS

The medical response to blast terrorism is built on the foundation of the regional trauma system. Approximately 75% of all terrorist events worldwide are blast trauma events. Therefore, regional emergency management, public safety, and public health agencies should include not only regional child health care experts but also regional pediatric trauma professionals in planning for mass casualty events that could affect children. Blast terrorism, like all other mass casualty events, needs to be directed with an incident command structure.

### Trauma Hospitals

Most trauma hospitals are full-service general hospitals that provide the highest level of trauma-related health care service in their communities. This includes the timely availability of multiple surgical subspecialties. However, modern trauma system design does not rely solely on such hospitals but integrates all health facilities within the region to the level of their resources and capabilities. Thus, the complete trauma system should consist of an integrated network of health care facilities within a region, designed for safe and rapid transport of injured patients to the

health care facilities that best meet their medical needs (eg, surgical, orthopedic, neurosurgical). Many stand-alone pediatric hospitals also serve as "pediatric trauma centers."

**Trauma Centers**

Trauma centers are general hospitals that are committed, both institutionally and financially, to priority care of injured patients. Trauma center levels are identified in 2 ways—by a designation process and a verification process. The designation process is outlined at the state or local level. Trauma center verification, which is a key element recognized as essential to trauma systems, is an evaluation process conducted through the America College of Surgeons. As of March 2022, there are 578 American College of Surgeons-verified trauma centers. Emergency medicine physicians and emergency trauma surgeons are the primary care providers within the context of the trauma center, and they provide appropriate information and follow-up to each patient's usual primary health care provider. Emergency medicine physicians begin evaluation and management and immediately involve emergency trauma surgeons whenever injuries meet any of the following criteria:

- Are multiple or severe.
- Require support of a full trauma team, based on previously established trauma triage criteria or scores.
- Would benefit from trauma consultation with an emergency trauma surgeon.

Trauma centers should have the following attributes:

- Designated as such by emergency medical and public health authorities within the region, based on self-categorization according to pre-established criteria.
- Followed by on-site peer verification by impartial trauma experts.
- Subject to ongoing review of performance and participation in the regional trauma quality assurance system.

The American College of Surgeons Committee on Trauma publication, *Resources for Optimal Care of the Injured Patient*, offers further detail on the characteristics of trauma systems and trauma centers. The latest edition, released in 2022, includes information on optimal emergency readiness for children.

**Treatment**

There should be preapproved prehospital triage, treatment, and transportation protocols in place that both represent the consensus of the medical community and are consistent with national recommendations. Treatment of blast trauma involves full integration of the regional EMS system and the regional trauma system, in accordance with plans developed in collaboration with regional public safety and emergency management agencies. Although most blast trauma is caused by explosive or incendiary agents, the possibility of other weapons of mass destruction (WMD), such as biological, chemical, or nuclear weapons, should always be considered.

**Trauma and Burn Treatment**

The treatment of victims of major trauma, including blast trauma, follows well-established protocols. The American College of Surgeons Committee on Trauma has developed and disseminated such protocols through its support of the *Advanced Trauma Life Support for Doctors Course*. The Emergency Nurses Association and the Society of Trauma Nurses have

undertaken like responsibilities for nurses through the *Trauma Nursing Core Course* and the *Advanced Trauma Care for Nurses Course*. All 3 courses focus on a practical approach to the initial care and management of the injured patient, assuming no special knowledge of trauma care, including the steps to be taken during the "golden hour" of trauma care—the critical first hour after injury has occurred.

Major burns and major trauma are often seen together in victims with injuries caused by explosive or incendiary devices. The treatment of victims of major burns also follows well-established protocols. Specific education on the initial resuscitation of these victims is included in both the *Advanced Trauma Life Support for Doctors Course* (American College of Surgeons Committee on Trauma) and the *Advanced Burn Life Support Course* (American Burn Association).

**Multiple Casualties**

The strict definition of an MCI is an incident involving more than one casualty that overwhelms the capacity of emergency medical providers at the scene. In general, this happens when a local EMS system must care for 5 or more victims who have the same illness or injury at the same place and time. Because local hospital emergency departments may also be overwhelmed by such events, either because of patient self-referrals or ambulance transport, EMS systems usually attempt to transport multiple victims to several hospitals in the vicinity of the event when feasible. Generally, the closest facilities will receive the more critical patients, while the more stable patients will be transported a longer distance to a facility that has the appropriate resources to care for children. In such circumstances, attempts are usually made to transport members of the same family to the same hospital, particularly if ill or injured children are involved. However, the availability of specialized pediatric health care resources, such as children's hospitals, may justify preferential transport of pediatric victims of multiple casualty incidents to these facilities.

**Mass Casualties**

The strict definition of an MCE is an event involving large numbers of casualties, generally 20 or more, that overwhelms and disrupts the resources and capabilities of the entire regional trauma and EMS systems to provide immediate care for all ill or injured victims. This situation develops when the need for ambulances, hospitals, or both exceeds the emergency resources of the regional health care system. The definition further implies the following:

- The need to activate regional disaster plans that mobilize all available ancillary resources to assist with providing emergency medical care. This includes using the surge capability of both the regional EMS system to deploy extra ambulances (via mutual aid agreements) and of the regional hospital system to maximize the number of victims who can be cared for by opening spare beds, discharging stable patients, canceling elective procedures, and conscripting off-duty staff.
- The need to prioritize care such that those at greatest risk of loss of life or limb are treated first (unless they are unlikely to survive). Switching practice philosophy of doing the most for one patient, to attempting the best possible care for many patients when limited resources are available, is a difficult paradigm to adopt. The standard of care also changes. The most widely used pediatric resource for triage and immediate treatment is JumpSTART,

modified by Romig from the Simple Triage and Rapid Treatment (START) triage system used for adults.

## PLANNING AND MITIGATION

The approach to planning for the possibility of blast injury after a terrorist attack should combine knowledge of the epidemiology of blast injury with awareness of the resources available to the regional trauma system. The federal government has adopted a similar approach for routine trauma system planning that allies the regional public health system with the regional health care system to form regional partnerships for the purpose of developing and implementing comprehensive injury control strategies at the community level.

Medical disaster planning should fully integrate regional public health agencies, regional health care organizations and coalitions, EMS, emergency departments, and trauma centers before a disaster occurs. Public health officials and trauma care professionals should collaborate to evaluate, and redesign if needed, each system component for optimal performance.

Current regional trauma system design maintains an artificial separation between the pre-event, event, and post-event phases of injury control. The comprehensive public health approach to regional trauma system design integrates all phases of injury control into a single system. Regional injury control systems that have adopted such an approach (eg, San Diego County, CA) have seen steady improvement in the quality of their injury prevention programs and the outcomes of their trauma patient care.

Public health reasons to apply this approach to blast terrorism include the documented lack of public health preparedness of most regions for terrorist attacks, despite excellent resources that describe the necessary elements for triage, transportation, and treatment of victims.

### *Planning*

The enormous variability in the following characteristics hinders comparative analysis and, hence, accurate prediction of needs and resources for victims of blast terrorism:

- Type, quality, quantity, force, and delivery of explosive
- Environment (closed space versus open air)
- Time (day versus night)
- Distance (proximate versus distant)
- Circumstances (weather conditions, presence of hazardous materials, etc)
- Protection (clothes, barriers, etc)
- Sequelae (structural collapse, structural fire, etc)
- Victims (ages, number, density)

In general, small blasts in open air usually result in less serious injury than large blasts in closed spaces, which historically have resulted in life-threatening injuries.

Regional trauma system planning should also consider the special needs of children who are injured in blast terrorism events and the special resources needed to care for them. Children and young adults are at higher risk of serious injury than adults for several reasons. Specific to blast trauma is that, although blast tolerances in children are poorly defined, there is good reason to

believe that children may absorb more blast energy per unit of body mass than adults after blast trauma. This predisposes children to morbidity and mortality rates higher than those of adults as compressive shock waves passing through the body are compacted into a smaller total body mass.

***Mitigation***

In recent years, many children have been victims of terrorist events, if not physically, then psychologically. Significant personal experience has been gained with pediatric disaster and emergency preparedness and management by child health professionals. Reports in the literature (summarized below) point out many gaps in the state of emergency preparedness for disasters that involve children. They also describe the common problems in pediatric disaster planning and management such that pediatric professionals involved in disaster planning will be knowledgeable about these problems and thus can seek to anticipate and thereby avoid them in future disasters.

Trauma system resources do not always meet the potential needs of the victims. Had the bomb detonated in front of the Times Square Theater where the Lion King was playing in 2010, a study indicated that the bed census in New York City would have been inadequate, even after surge plans were enacted. With only 5 hospitals at the time having operationally ready pediatric surge plans, the total number of beds could have been increased from 29 to 121, certainly insufficient to meet the needs of the number of potential injuries from an explosive event in close proximity to a theater heavily populated by children. The April 1995 bombing at the Alfred P. Murrah Federal Building in Oklahoma City impacted a child care center located on the second floor within that facility directly above the blast site. Nineteen children died and another 47 sustained injuries.

No children were injured in the terrorist airliner attack on the Pentagon on September 11, 2001, because the Pentagon child care center was located on the opposite side of the building from the location of attack. However, as a result of the attack, issues were raised about the regional children's hospital's disaster preparedness. Immediately after the event, the hospital disaster plan was activated, resulting in the discharge of more than 50 patients and the cessation of all nonurgent activities. Although hospital staff had conducted disaster drills, hospital leaders continued to question their actual state of readiness. Emergency preparations were complicated by the fact that all of their news came not from official sources, but from local television, leaving hospital leaders unsure about what to expect.

Experiences highlight a number of vitally important issues regarding blast terrorism mitigation in children.

- After a blast, injuries in children are to be expected with most children injured in closed or confined spaces, which greatly increases the magnitude of forces of injury.
- As with blast injuries in adults, most children will either die at the scene or sustain minor injuries. Only a small number of children in the "penumbra" of the blast wind who sustain major injuries will survive to require hospital care, but typically they will not begin to arrive at the trauma center until 30 to 60 minutes after the blast event.
- Most surviving children with major injuries will require early surgery and subsequent care in a pediatric critical care unit, followed by lengthy hospitalization and rehabilitation, both

physical and psychosocial.
- Pediatric victims may be unaccompanied by a parent or guardian when they present for care and may be unable to self-identify. Systems for the timely identification and reunification of children with family must be in place.
- As has been documented with all disaster types, preparation must also include mitigation and response planning for the mental health impact on children.

Although all of the above can overwhelm even the best prepared systems, optimal outcomes for children and families will be achieved through preparation for all disaster mechanisms, including blast injuries, the concurrent consideration for the unique needs of children of all ages, and the inclusion of pediatric readiness into local planning.

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# RESOURCES

**AAP Children & Disasters Web Site**
www.aap.org/disasters

**AAP Clinical Report: Providing Psychosocial Support to Children and Families in the Aftermath of Disasters and Crises**
http://pediatrics.aappublications.org/content/136/4/e1120

**AAP Clinical Report: Disaster Preparedness in Neonatal Intensive Care Units**
http://pediatrics.aappublications.org/content/139/5/e20170507

**AAP Establishing Pediatric Advisory Councils or Children's Preparedness Coalitions**
www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Children-and-Disasters/Pages/Establishing-Pediatric-Advisory-Councils-or-Childrens-Preparedness-Coalitions.aspx

**AAP Family Readiness Kit**
www.aap.org/en-us/Documents/disasters_family_readiness_kit.pdf

**AAP Family Reunification Following Disasters: A Planning Tool for Health Care Facilities**
https://www.aap.org/en-us/Documents/AAP-Reunification-Toolkit.pdf

**AAP Pediatric Preparedness Resource Kit**
www.aap.org/disasters/resourcekit

**AAP Policy Statement: Emergency Information Forms and Emergency Preparedness for Children with Special Health Care Needs**
http://pediatrics.aappublications.org/content/125/4/829

**AAP Policy Statement: Ensuring the Health of Children and Disasters**
http://pediatrics.aappublications.org/content/early/2015/10/13/peds.2015-3112

**AAP Policy Statement: Pediatric Readiness in the Emergency Department**
http://pediatrics.aappublications.org/content/142/5/e20182459

**AAP Policy Statement: Medical Countermeasures for Children in Public Health Emergencies, Disasters, or Terrorism**
http://pediatrics.aappublications.org/content/early/2015/12/31/peds.2015-4273

**AAP Policy Statement: Pediatric Care Recommendations for Freestanding Urgent Care Facilities**
http://pediatrics.aappublications.org/content/133/5/950

**AAP Preparedness Checklist for Pediatric Practices**
www.aap.org/disasters/checklist

**CDC Disaster Planning Guide for Healthcare Facilities**
www.cdc.gov/phpr/readiness/healthcare/planning.htm

**CDC Framework for Expanding EMS System Capacity During Medical Surge**
www.cdc.gov/phpr/readiness/healthcare/Expanding-EMS-Systems.htm

**CDC Planning Resources by Setting: Pediatric Offices and Hospitals**
www.cdc.gov/phpr/readiness/healthcare/pediatric.htm

**CDC Resources for Emergency Health Professionals**
https://emergency.cdc.gov/health-professionals.asp

**EMSC Innovation and Improvement Center, Disaster Domain**
https://emscimprovement.center/ or https://emscimprovement.center/categories/disaster/

**FEMA Homeland Security Exercise and Evaluation Program (HSEEP)**
www.fema.gov/media-library/assets/documents/32326

**FEMA National Response Framework**
www.fema.gov/media-library/assets/documents/32230

**FEMA Post-Disaster Reunification of Children: A Nationwide Approach**
www.fema.gov/media-library-data/1384376663394-eef4a1b4269de14faff40390e4e2f2d3/Post+Disaster+Reunification+of+Children+-+A+Nationwide+Approach.pdf

**National Center for School Crisis and Bereavement**
www.schoolcrisiscenter.org/

**National Advisory Committee on Children and Disasters**
www.phe.gov/Preparedness/legal/boards/naccd/Pages/default.aspx

**New York State Health Emergency Preparedness Coalition**
https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/pediatric.aspx

**Office of the Assistant Secretary for Preparedness and Response Technical Resources, Assistance Center, and Information Exchange Pediatric Topical Collection**
https://asprtracie.hhs.gov/technical-resources/31/Pediatric/27

**Society for Critical Care Medicine Pediatric Fundamental Critical Care Support**
https://ssc.sccm.org/Fundamentals/PFCCS/Pages/default.aspx

**Texas A&M Engineering Extension Service Pediatric Disaster Response and Emergency Preparedness Course**

https://teex.org/Pages/Class.aspx?course=MGT439&courseTitle=Pediatric+Disaster+Response+and+Emergency+Preparedness

**US Food and Drug Administration Pediatric Medical Countermeasures**
www.fda.gov/EmergencyPreparedness/Counterterrorism/MedicalCountermeasures/MCMIssues/ucm470308.htm