Chemical-Biological Terrorism and Its Impact on Children

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abstract

Children are potential victims of chemical or biological terrorism. In recent years, children have been victims of terrorist acts such as the chemical attacks (2017–2018) in Syria. Consequently, it is necessary to prepare for and respond to the needs of children after a chemical or biological attack. A broad range of public health initiatives have occurred since the terrorist attacks of September 11, 2001. However, in many cases, these initiatives have not ensured the protection of children. Since 2001, public health preparedness has broadened to an all-hazards approach, in which response plans for terrorism are blended with those for unintentional disasters or outbreaks (eg, natural events such as earthquakes or pandemic influenza or man-made catastrophes such as a hazardous-materials spill). In response to new principles and programs that have evolved over the last decade, this technical report supports the accompanying update of the American Academy of Pediatrics 2006 policy statement “Chemical-Biological Terrorism and its Impact on Children.” The roles of the pediatrician and public health agencies continue to evolve, and only their coordinated readiness and response efforts will ensure that the medical and mental health needs of children will be met successfully. In this document, we will address chemical and biological incidents. Radiation disasters are addressed separately.

BACKGROUND INFORMATION

In 2000, the American Academy of Pediatrics (AAP) published the policy statement “Chemical-Biological Terrorism and its Impact on Children.” Preceding events such as the 1995 sarin attack in Tokyo, Japan, illustrate the reality that acts of domestic chemical terrorism can occur, with significant impact on the health of children. The subsequent 2006 policy statement highlighted the need for increased awareness and preparedness in response to additional acts of chemical and biological terrorism, including the release of anthrax spores through the US postal system, intentional toxic chemical contamination of food in Michigan and California, and the identification of ricin-laden letters in a post office in

abstract

South Carolina. Unfortunately, since the publication of the 2006 policy statement, there have been additional chemical attacks affecting children, such as the 2017 sarin\(^1\) and 2018 chlorine attacks\(^2\) in Syria. These attacks have led to significant pediatric morbidity and mortality. Emerging biological threats, such as Ebola and Zika viruses, have provided opportunities to test the systems of pediatric disaster preparedness nationally and internationally. In the same time frame, there continues to be substantial progress as new chemical and biological medical countermeasures (MCs) are approved by the US Food and Drug Administration (FDA), additional methods for surveillance are in place, and advances in pediatric disaster preparedness and education are available to assist emergency responders with evidence-based best practices.

Since the September 11, 2001, terrorist attacks and subsequent anthrax releases in the United States, the AAP has recognized the need to strategically address the impact of terrorism (i.e., an act designed to frighten, hurt, or kill people) on children at the national, state, and local level. This has led to the appointment of the AAP Disaster Preparedness Advisory Council, which collaborates with federal partners (including the Department of Health and Human Services [DHHS] Office of the Assistant Secretary for Preparedness and Response [ASPR], Centers for Disease Control and Prevention [CDC], Department of Homeland Security [DHS], FDA, Federal Emergency Management Agency, and the National Institute of Child Health and Human Development) as well as more than 70 AAP member disaster preparedness contacts in all AAP chapters who work with their local and state partners to address the needs of children throughout the disaster cycle. The federal government also created the National Commission on Children and Disasters, the National Advisory Committee on Children and Disasters, and the National Biodefense Science Board, all of which included pediatric subject matter experts. The AAP hosts a comprehensive Web site for pediatric health care providers with a page devoted to information on terrorism and its impact on children (www.aap.org/disasters/terrorism). Additional AAP activities to promote pediatric disaster awareness include publication of disaster policy statements such as “Ensuring the Health of Children in Disasters” and “Providing Psychosocial Support to Children and Families in the Aftermath of Disasters and Crises” along with education on specific chemical and biological threats in the AAP manual Pediatric Environmental Health (the “Green Book”) and the AAP manual Red Book: 2018 Report of the Committee on Infectious Diseases.\(^3\)–\(^6\) The AAP has also promoted pediatric preparedness through implementation of a 2016 regional pediatric and public health tabletop exercise and a 2017 virtual tabletop exercise (www.aap.org/disasters/tabletop).\(^7\)

The unfortunate continuing occurrence of chemical and biological terrorism demonstrates the ongoing need to improve public health and health care system preparedness in all respects, including the detection of covert events, establishment of comprehensive response protocols for children, and implementation of plans for rapid resource mobilization to care for children. At the governmental level, the passage of key federal legislation (Table 1) has facilitated these efforts. However, there remains a need for pediatric health care providers to be knowledgeable about the chemical and biological weapons that could be used against a population that includes children and to be able to provide care during the recovery period. Moreover, principles of the care of children after chemical and biological terrorism are evolving, and these approaches will continue to inform future work.

**STATEMENT OF THE PROBLEM**

Pediatricians play a pivotal role in providing care in the medical home and supporting the community before, during, and after a chemical or biological event. It is critical for pediatricians and others who care for children in all care settings to continue to educate themselves regarding the pediatric consequences of a chemical or biological attack. Readiness resources and approaches will vary depending on practice setting, such as community hospitals, pediatric hospitals, emergency departments, and office practices. The role of the pediatrician and others who care for children in ensuring the health of children in disasters has been described.\(^3\)–\(^9\) Specific to chemical and biological terrorism, pediatricians and their staff will need to be prepared to promote and share information on readiness approaches, advise on pediatric decontamination strategies, provide appropriate medical care, offer anticipatory guidance to families, report appearances of unusual disease clusters, and help guide families after events. This technical report summarizes relevant information and evidence. Although the focus of this document is geared toward the US health care system, principles of this technical report can be applied to international health care settings.

**NEW INFORMATION**

This technical report and its accompanying policy statement\(^9\) replace the 2006 policy statement, with an added focus on identifying and resolving system issues that are paramount to minimizing morbidity and mortality in children after their...
TABLE 1 Federal Legislation Enacted Since 2001 To Improve Public Health Response to Bioterrorism and Other Public Health Emergencies

<table>
<thead>
<tr>
<th>Date</th>
<th>Bill</th>
<th>Legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2001</td>
<td>Public Law 107-38</td>
<td>2001 Emergency Supplemental Appropriations Act for Recovery From and Response to Terrorist Attacks on the United States</td>
</tr>
<tr>
<td>August 2002</td>
<td>Public Law 107-206</td>
<td>2002 Supplemental Appropriations Act for Further Recovery From and Response to Terrorist Attacks on the United States</td>
</tr>
<tr>
<td>July 2004</td>
<td>Public Law 108-276</td>
<td>Project BioShield Act of 2004</td>
</tr>
<tr>
<td>December 2004</td>
<td>Public Law 108-484</td>
<td>ENHANCE 911 Act of 2004</td>
</tr>
<tr>
<td>May 2005</td>
<td>Public Law 109-13</td>
<td>Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Tsunami Relief, 2005</td>
</tr>
<tr>
<td>September 2005</td>
<td>Public Law 109-72</td>
<td>Flexibility for Displaced Workers Act</td>
</tr>
<tr>
<td>October 2005</td>
<td>Public Law 109-88</td>
<td>Community Disaster Loan Act of 2005</td>
</tr>
<tr>
<td>December 2006</td>
<td>Public Law 109-417</td>
<td>Pandemic and All-Hazards Preparedness Act</td>
</tr>
<tr>
<td>April 2009</td>
<td>Public Law 111-13</td>
<td>Serve America Act</td>
</tr>
<tr>
<td>January 2011</td>
<td>Public Law 111-351</td>
<td>Predisaster Hazard Mitigation Act of 2010</td>
</tr>
<tr>
<td>March 2013</td>
<td>Public Law 113-5</td>
<td>Pandemic and All-Hazards Preparedness Reauthorization Act of 2013</td>
</tr>
<tr>
<td>November 2015</td>
<td>Public Law 114-80</td>
<td>DHS Social Media Improvement Act of 2015</td>
</tr>
<tr>
<td>December 2015</td>
<td>Public Law 114-111</td>
<td>Emergency Information Improvement Act of 2015</td>
</tr>
<tr>
<td>April 2016</td>
<td>Public Law 114-143</td>
<td>Integrated Public Alert and Warning System Modernization Act of 2015</td>
</tr>
<tr>
<td>December 2016</td>
<td>Public Law 114-268</td>
<td>First Responder Anthrax Preparedness Act</td>
</tr>
<tr>
<td>December 2016</td>
<td>Public Law 114-255</td>
<td>21st Century Cures Act</td>
</tr>
</tbody>
</table>

exposure to a chemical or biological weapon.

**REVIEW OF EVIDENCE**

**Exposure Sources for Chemical and Biological Weapons**

Exposure to chemical and biological weapons can occur through several potential sources. Airborne releases of agents have remained the primary concern because large populations can be exposed by this route. Potential mechanisms of exposure include crop-dusting airplanes, tainted letters, and release of agents into confined spaces (eg, subway tunnels, office buildings, theaters). Contamination of the water supply is also a potential source for exposure, although dilution of chemical and biological agents in water is mitigating, and few chemical or biological agents are both water stable and resistant to water-purification techniques that decrease the risk. Finally, the contamination of food that is either unprocessed (eg, uncultivated grain) or processed (eg, a consumer product) is considered a potential means of exposure to chemical or biological weapons.

**Specific Vulnerabilities in Children**

After events of chemical or biological terrorism, children have a greater risk of both exposure and harm, the result of key developmental, anatomic, and physiologic vulnerabilities. Children have greater life expectancy than adults and, therefore, have more time in which to develop sequelae such as cancer from a variety of sources of exposure (air, water, or food) to chemical or biological weapons. For each source of exposure, children possess a significantly greater likelihood of exposure because of their intake patterns. Children inhale considerably more air on a per-weight basis than adults (400 vs 140 mL/kg per minute, respectively). Consequently, for any concentration of an airborne toxicant, a child will inhale more of the substance on a per-kilogram basis than an adult. Also, substances that are heavier than

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air have their highest concentration near the ground, closer to the breathing zone of the child. Because of a proportionately greater body-surface area, children have both greater exposure and an increased likelihood of systemic toxicity to agents that contact their skin. Children have fluid and food intakes that differ significantly from adults. For example, children ingest approximately 100 mL/kg of water per day, whereas adults ingest 40 to 60 mL/kg per day. Children drink more milk than adults, placing them at risk for exposure to agents that can enter the milk supply through contamination of the grass on which cows feed. In the Chernobyl radiation disaster, cows grazed in contaminated pastures, leading to excess radioactivity in their milk. Children drinking this milk sustained significant exposure to radioisotopes, including iodine and strontium. Finally, children not only eat more food on a per-kilogram basis but also have diets that are distinctly different from adults (eg, greater consumption of fruits). Once exposed to a chemical or biological agent, children have numerous physiologic vulnerabilities that could lead to a greater risk of harm. These vulnerabilities include undeveloped self-preservation skills that make them less able to flee danger; an immature immune system that makes them less able to contain infection (eg, plague); less fluid reserve, which can result in a greater risk of severe dehydration after exposure to agents that produce excess gastrointestinal fluid loss (eg, Ebola virus disease); and a greater risk of anxiety reactions and posttraumatic stress disorder after witnessing or being victim to a terrorist act. Additionally, with the advent of technology, there is increased availability of social media to children and adolescents, allowing for access to online terrorist information or suggestive material on how to terrorize.

**Public Health Preparedness**

**The All-Hazards Approach**

In past years, resources have been provided to public health authorities, including the network of state and regional poison control centers, and first responders (fire officials, police officers, and emergency medical services personnel) to create systems capable of responding to a possible chemical attack. Similarly, emerging and reemerging infections as well as highly contagious organisms such as Ebola have led to a massive public health effort to improve response capability to future acts of biological terrorism. The initiation of these response campaigns revealed large-scale weaknesses in state and local public health infrastructure. Moreover, it became evident that intense effort was being directed toward events that might never occur rather than toward public health threats of much greater likelihood (eg, an unintentional hazardous chemical release). Finally, it became clear that a fragmented and reactive public health response plan is more expensive and inefficient than a single, comprehensive plan. As a result, disaster response agencies and public health authorities have increasingly embraced the concept of the “all-hazards approach.” Representing a dramatic paradigm shift in the preparation for chemical and biological terrorism, the all-hazards approach is designed to augment the public health infrastructure, using an integrated model of disaster response. The creation of all-hazards response systems has led to improvements in public health response capabilities. For example, an effective public health response protocol for a sarin release would be equally effective for a hazardous-materials (hazmat) release in the community, such as the 2017 chemical fires in Texas that followed massive flooding and power losses in the wake of Hurricane Harvey. Similarly, the same protocol created to respond to the appearance of smallpox can be modified easily to contain an outbreak of severe acute respiratory syndrome. However, as threats increase and local and state budgets fluctuate, there will continue to be challenges to achieve adequate responses.

**Pediatric Disaster Preparedness and Education**

Several investigators have studied disaster preparedness and education specific to the needs of children. In 2008, Schobitz et al conducted a study of pediatric and emergency medicine residents at a single institution to assess their baseline knowledge of management of pediatric victims of chemical and biological terrorism. Using an expert-developed, validated test, the investigators determined that the residents of this era were unprepared to manage these victims. The 2010 Pediatric Emergency Mass Critical Care Task Force concluded that mass events place unusual stresses on health care providers, many of whom must provide care outside of their scope of practice, and that education and educational resources can mitigate anxiety and chaos in these contexts. Subsequent research in pediatric disaster triage has demonstrated that a multiplesimulation curriculum can improve prehospital care providers’ assessment skills. In addition, studies have revealed an increase in clinical staff’s knowledge and confidence with pediatric disaster skills with short, topic-focused educational interventions. There are also review articles of pediatric disaster courses to educate health care professionals.

**Agents of Concern**

**Chemicals**

Three traditional assumptions specific to chemical terrorism have proven simplistic. These include the narrow concepts that (1) such weapons were intentionally and specifically manufactured as instruments of mass destruction; (2) chemical terrorism was dramatic and recognized immediately (eg, the sarin...
Act of chemical terrorism involving children illustrate these expanded concepts. In 1999, patrons of a restaurant in Fresno, California, developed severe gastroenteritis. An investigation by public health authorities discovered that the carbamate insecticide methomyl had been added maliciously to the salt. More than 100 adults and children became ill with nausea, vomiting, and diarrhea; a perpetrator was never identified. In 2003, in Grand Rapids, Michigan, a disgruntled grocery store worker placed a nicotine-containing insecticide into ground beef, making it available for purchase by unsuspecting customers. It was not until widespread illness (nausea, mouth burning, vomiting) was reported and there was a recall and analysis of the meat, revealing the presence of nicotine, that this was recognized as an act of terrorism. Ultimately, more than 100 people became ill, including more than 40 children, in what is now considered the largest act of chemical terrorism in US history.

Research in the past decade specific to chemical exposures has focused on antidotes and resultant injury after exposure. For nerve-agent exposure, 3 classes of medication are used in the treatment of nerve-agent exposure: (1) anticholinergics, usually first-line atropine, to block excess acetylcholine at peripheral muscarinic receptors; (2) oximes, such as pralidoxime, to reactivate inhibited acetylcholinesterase; and (3) anticonvulsants (please refer to the Nerve Agents section for further discussion of clinical effects). Some studies have explored the problem of antidote dosing in children, particularly with respect to prepackaged autoinjectors. Baker noted that adult doses of atropine are well tolerated, even in young children, and recommended the use of the atropine (0.5 or 2 mg) autoinjector for children younger than 1 year after nerve-agent exposures when weight dosing is impractical or not possible to control excessive bronchorrhea and to prevent respiratory failure. In a 2009 review of research on atropine dosing, Sandilands et al considered pharmacokinetic data to balance sufficient and timely dosing of atropine versus the risk of overdose; the authors recommended relatively large initial doses of atropine in children, who are relatively resistant to its adverse effects. Droste et al used a pharmacokinetic model to analyze current CDC and US Army treatment protocols and found that in general, oxime therapy alone was ineffective in alleviating symptoms. The atropine and pralidoxime combination autoinjector can, in theory, be used in children older than 1 year; as of 2018, however, the combination autoinjector was not FDA approved for pediatric patients weighing less than 41 kg. However, authors of an extensive review of antidotes for a variety of chemical agents concluded that the strength of evidence supporting the use of these antidotes is generally weak and that more research is needed.

Other investigators have studied injury related to chemical exposures. Custer et al used an in vitro test lung to simulate pediatric lung injury; the goal was to assess the efficacy of transport and/or emergency ventilators in the setting of mass-casualty respiratory failure. These investigators found that few of the ventilators, chosen from a range of manufacturers, were capable of the minimum alarm and tidal volume function necessary to support the ventilation of pediatric victims.

Additional efforts have focused on improving access to information after chemical exposures. The ASPR, in cooperation with the National Library of Medicine, has developed a Web site that is intended to enable health care professionals to respond to mass-casualty events involving chemicals (https://chem.nlm.nih.gov/). The resource can be downloaded to a computer or mobile device in advance of an event that might limit or interrupt Internet access.

The analysis of a mass-casualty event may identify 1 or more specific chemicals. The World Health Organization considers the following 6 categories of chemicals to be the most likely threats: nerve agents, blistering agents (vesicants), irritants (corrosives), choking agents, asphyxiants (cyanogens and carbon monoxide), and disabling (incapacitating) agents, including lacrimators (Table 2).

**Nerve Agents**

Nerve agents are well absorbed through intact skin and even through examination gloves used in clinical settings. All nerve agents act as acetylcholinesterase inhibitors, producing the same symptoms and signs associated with organophosphate poisoning. Manifestations can range from mild (miosis, nausea, diarrhea) to severe (muscle weakness, fasciculations, respiratory failure, coma, and seizures).

In the 1995 sarin episode in Tokyo, the most unanticipated sequela was the degree of injury to health care professionals. Several hundred physicians, nurses, and other health care professionals became ill as a result of 2 factors: handling of sarin-contaminated victims without wearing personal protective equipment (PPE) and entry of contaminated victims into health care facilities, allowing sarin vapor to
enter the ventilation system.27,29 This event firmly demonstrated the importance of using PPE to protect health care professionals, decontaminating victims before building entry to maintain office or hospital safety, and using environmental controls such as airborne infection isolation rooms (negative-pressure rooms).

Management of nerve-agent exposure includes supportive care and, when indicated, prompt administration of the antidotes atropine and pralidoxime (see the introduction to the previous section, Chemicals, for recent research regarding atropine, pralidoxime, and autoinjectors).30 Autoinjectors are particularly important in mass-casualty incidents when there is a need to treat large numbers of victims as quickly and efficiently as possible. Until recently, the absence of pediatric autoinjectors complicated the rapid administration of atropine and pralidoxime to children; only the devices approved for adults, containing 2 mg of atropine and 600 mg of pralidoxime, were available. In 2003, the FDA approved new dosage forms of atropine sulfate, approved since 1973 for adults, for use in children and adolescents after nerve-agent exposure.31 However, the continued absence of a combination pediatric autoinjector in the United States, which is critical to the successful treatment of central nervous system and muscular toxicity from nerve agents, leaves the use of standard, multidose vials as the only therapeutic option. To address this issue, consensus guidelines now recommend that children weighing 13 kg or more (2–3 years of age or older) receive a 600-mg dose of pralidoxime from an autoinjector because this pralidoxime dose falls within the range of safety for the drug.32 Children weighing less than 13 kg can receive the customary weight-based (20–50 mg/kg) dose, administered from a multidose vial; if the multidose vial is unavailable, an autoinjector could be used. Repeat dosing of atropine may be necessary to mitigate secretions.

Other aspects of care to children who have been exposed to nerve agents are found in recent reviews.29,33

**Blistering Agents (Vesicants)**

Vesicants include sulfur mustard and lewisite, an arsenic-based blistering agent first used in World War I. British antilewisite (dimercaprol) was developed in subsequent years and mitigated the risk to allied soldiers in World War II; it remains useful today as an antidote in some cases of heavy-metal poisoning.34 The vesicants, released as aerosols, produce erythema, burning, vesiculation, and then desquamation of the skin. Victims of blistering-agent exposure typically develop skin tingling, then burning; within 24 hours, skin sloughing begins to occur, with wounds having the appearance of partial-thickness burns. These agents -are also immunosuppressive, further increasing the risk of severe infection. Treatment is largely supportive. Important principles of management include topical decontamination and PPE use to protect health care professionals.35

### TABLE 2 Chemical Weapons of Concern

<table>
<thead>
<tr>
<th>Agent Classification</th>
<th>Built Weapon</th>
<th>NATO Codes</th>
<th>Weapon of Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve agents</td>
<td>Tabun</td>
<td>GA</td>
<td>Pesticides</td>
</tr>
<tr>
<td></td>
<td>Sarin</td>
<td>GB</td>
<td>Nicotine</td>
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<tr>
<td></td>
<td>Soman</td>
<td>GD</td>
<td>Organophosphates</td>
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<tr>
<td></td>
<td>VX gas</td>
<td>VX</td>
<td>Carbamates</td>
</tr>
<tr>
<td>Blistering agents (vesicants)</td>
<td>Lewiste</td>
<td>L</td>
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</tr>
<tr>
<td></td>
<td>Mustard gas</td>
<td>HD</td>
<td>—</td>
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<tr>
<td></td>
<td>Nitrogen mustard</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Irritants (corrosives)</td>
<td>—</td>
<td>—</td>
<td>Ammonia</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>Bromine</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>Chlorine</td>
</tr>
<tr>
<td>Choking agents</td>
<td>Phosgene</td>
<td>CG</td>
<td>Perfluoroisobutylene (Teflon) and other chemical polymers</td>
</tr>
<tr>
<td></td>
<td>Nitrogen oxides</td>
<td>NOx</td>
<td>Smoke, products of combustion</td>
</tr>
<tr>
<td>Asphyxiants</td>
<td>Hydrogen cyanide</td>
<td>AC</td>
<td>Industrial cyanide</td>
</tr>
<tr>
<td>Disabling agents (incapacitators)</td>
<td>5-quiniuclidinyl benzilate</td>
<td>BZ</td>
<td>Anticholinergics</td>
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<tr>
<td></td>
<td>Cannabinoids</td>
<td>—</td>
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<tr>
<td></td>
<td>Barbiturates</td>
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<tr>
<td></td>
<td>Fentanyl derivatives</td>
<td>—</td>
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</tr>
<tr>
<td></td>
<td>Lacrimators: Chloroacetophenone</td>
<td>CN</td>
<td>Lacrimators</td>
</tr>
<tr>
<td></td>
<td>Chlorobenzylidene</td>
<td>CS</td>
<td>Capsaicin</td>
</tr>
</tbody>
</table>

**Irritants (Corrosives)**

The irritants and corrosives include common chemicals such as ammonia, bromine, and chlorine, which can affect the skin, eyes, mucous membranes, gastrointestinal tract, and predominantly, the upper and lower respiratory tracts. Decontamination includes copious water irrigation of the skin and eyes; management is mainly supportive, but the risk of delayed pulmonary injury remains for 24 hours. The Assad regime in Syria has used chlorine gas against civilians, causing at least 1 pediatric death.\(^2,3,7\)

**Choking Agents**

Choking agents are created to produce, usually in delayed fashion, pulmonary injury: bronchospasm, pulmonary edema, and respiratory failure. Immediate symptoms include eye burning, tearing, and laryngospasm. The major agent of this group is phosgene; however, common industrial chemicals, including polytef (Teflon) and other chemical polymers, act as choking agents depending on their ambient concentration. Most choking agents are heavier than air; which could produce higher concentrations at the breathing level of the child. Treatment is supportive.

**Asphyxiants (Cyanogens and Carbon Monoxide)**

The asphyxiants include the cyanogens and carbon monoxide, often generated in fires. Victims of asphyxiant exposure must be recognized promptly to remove them from the source and to administer life-saving antidotes. The cyanogens (cyanide salts and sodium azide) interrupt cellular use of oxygen, producing respiratory distress, coma, metabolic acidosis, and lactic acidosis. In the United States, the traditional cyanide antidote “kit” was amyl nitrite inhalation or sodium nitrite injection—which generates methemoglobin—followed by sodium thiosulfate, which reacts with methemoglobin and converts the potentially lethal cyanide ion to the stable thiocyanate ion. Hydroxocobalamin is a newer option that acts more rapidly than thiosulfate and avoids the additional hazard of the methemoglobin intermediate.\(^3,8\)

Carbon monoxide, a potential weapon of opportunity, binds avidly to hemoglobin and other hemoproteins, interfering with oxygen transport and tissue delivery, and may lead to nonspecific symptoms that mimic viral infections. After immediate removal from carbon monoxide exposure, victims will benefit from receiving 100% oxygen administered via a nonrebreather mask. The degree of illness rather than specific carboxyhemoglobin levels can guide treatment; some experts recommend consultation with a hyperbaric oxygen facility for more severe cases.\(^3,9\)

**Disabling (Incapacitating) Agents**

Disabling or incapacitating agents include several different chemical classes (eg, anticholinergic agents, hallucinogens, cannabinoids, and fentanyl derivatives). In the 2002 Russian theater hostage incident, a fentanyl-based disabling agent may have been released during the rescue effort. The agent, although successful in overwhelming the hostage-takers, also killed 127 hostages.\(^4,0\)

Many disabling agents are weapons of opportunity, easily acquired pharmaceutical agents, or substances of abuse that are added surreptitiously to common sources of food or drink. Included among disabling agents are lacrimators. Often referred to collectively as Mace or “tear gas,” lacrimators include the chemicals chloroacetophenone and chlorobenzylidene as well as capsaicin (“pepper spray”). Lacrimators are designed to produce incapacitation from irritation of the eye and other mucous membranes. Exposure to lacrimators leads to eye burning, tearing, and blepharospasm; victims may become temporarily blind. Inhalation produces mouth pain, shortness of breath, and, in rare cases, laryngospasm. Because capsaicin is widely sold as a nonlethal weapon, episodes of capsaicin release into the ventilation system of schools and buildings are a relatively common prank, although such incidents meet the definition of terrorism.\(^4,1\)

**Biological Agents**

Most of the biological agents that could be used as weapons are now discussed in the *AAP Red Book*;\(^6\) although some agents (eg, ricin) are not discussed in detail. Ricin is discussed in a subsequent section of this report.

The biological agents of concern are listed in Table 3. These agents have been placed by the CDC into categories A, B, or C. Thirty-nine agents are included in these 3 categories. 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. Currently, there are 6 agents in this group, including the pathogens that cause anthrax, botulism, plague, smallpox, tularemia, and the viral hemorrhagic fevers, specifically filoviruses (Ebola and Marburg viruses) and arenaviruses (Lassa and Machupo viruses). Detailed descriptions of these agents have been published in the *AAP Red Book* and elsewhere.\(^6,4,2\) 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 (Table 3). 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. Mycotoxins are toxins produced by fungi. Agents of primary concern, trichotheccenes and aflatoxins, have properties of both chemical weapons and biological weapons and could be used in chemical warfare (Tables 1 and 2).43,44

Smallpox (Variola)

Until the Ebola virus epidemic in 2013–2016, the most widely discussed category A agent was Variola major, the agent that causes smallpox. Initial CDC smallpox immunization efforts initiated in 2002 included a “ring immunization” (surveillance and containment) strategy in the United States.45,46 Subsequently, the CDC recommended a 3-phase plan for smallpox immunization of health care professionals and other individuals, although the program met with only limited success in the first phase of vaccination of health care professionals in acute-care facilities.42 A high rate of vaccine refusal by health care professionals, concerns about the safety of the vaccine, extensive contraindications to the vaccine, and the appearance of unrecognized adverse effects from the vaccine (eg, fatal cardiac disease)47,48 hampered the program.49,50 In 2015, the CDC and AAP published updated clinical guidance for use of the 3 smallpox vaccines in the US Strategic National Stockpile (SNS) for people at risk for smallpox infection after an intentional or accidental release of the virus.13

Ricin

Although it is a category B agent, ricin has become a major biological weapon of concern because it is 1 of the most toxic biological agents known. A plant-derived, heat-stable toxin, ricin is an extract of the castor bean (Ricinus communis). Ricin acts by inhibition of protein synthesis of cells, ultimately resulting in cell death. Rapidly dividing tissues, particularly the gastrointestinal epithelium, are most susceptible to ricin actions. With these effects, ricin produces severe morbidity and mortality.

Ricin is a versatile agent that can be administered by ingestion, inhalation, or injection. When ingested, it can produce a syndrome of severe gastrointestinal upset, vomiting, hemorrhagic gastroenteritis, shock, and cardiovascular collapse. After inhalation, respiratory distress with a necrotizing pneumonitis may occur. Injection produces rapid shock and cardiovascular collapse. Treatment is supportive. A vaccine against ricin is currently under development.

Ricin has been associated with terrorist activity in the United States on multiple occasions, particularly as an agent sent through the mail. In October 2003, 2 ricin-containing letters were found in the US postal system.51 In a third incident, ricin was found in the mail sorter of a congressional post office in January 2004. In June 2006, the CDC developed a comprehensive guideline for public health and medical officials in response to a ricin incident.52 As recently as 2013, the Federal Bureau of Investigation responded to reports of suspicious letters received at mail facilities that contained ricin.53

Syndromic Surveillance

Overt acts of chemical and biological terrorism such as the sarin release in Tokyo present the challenge of rapidly identifying the agent and mobilizing the proper interventions. However, acts of chemical and biological terrorism may also be covert. Examples include the cyanide contamination of Tylenol (1982),54 the release of anthrax (2001), and the nicotine contamination of ground beef (2003).18 Covert incidents pose a significantly greater public health challenge and are more likely to induce widespread fear than overt events. Mechanisms for early recognition of a covert chemical or biological event, therefore, are necessary to contain the incident and minimize its impact.

TABLE 3 Biological Weapons of Concern

<table>
<thead>
<tr>
<th>Weapon Category</th>
<th>Weapon</th>
<th>Category</th>
<th>Weapon</th>
<th>Category</th>
<th>Weapon</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weapon Category</strong></td>
<td><strong>Anthrax</strong> (Bacillus anthracis)</td>
<td>Category A</td>
<td><strong>Botulinum</strong> (Clostridium botulinum toxin)</td>
<td>Category A</td>
<td><strong>Plague</strong> (Yersinia pestis)</td>
<td>Category A</td>
</tr>
<tr>
<td><strong>Mycotoxins</strong></td>
<td><strong>Tularemia</strong> (Francisella tularensis)</td>
<td>Category A</td>
<td><strong>Viral hemorrhagic fevers</strong> (filoviruses [eg, Ebola, Marburg] and arenaviruses [eg, Lassa, Machupo])</td>
<td>Category A</td>
<td><strong>Brucellosis</strong> (Brucella species)</td>
<td>Category B</td>
</tr>
<tr>
<td></td>
<td><strong>Epsilon toxin of Clostridium perfringens</strong></td>
<td>Category A</td>
<td><strong>Food-safety threats</strong> (eg, Salmonella species, Escherichia coli O157:H7)</td>
<td>Category A</td>
<td><strong>Glanders</strong> (Burkholderia mallei)</td>
<td>Category A</td>
</tr>
<tr>
<td><strong>Food-safety threats</strong></td>
<td><strong>Meliodosis</strong> (Burkholderia pseudomallei)</td>
<td>Category A</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Psittacosis</strong> (Chlamydia psittaci)</td>
<td>Category A</td>
<td></td>
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<tr>
<td><strong>Viral hemorrhagic fevers</strong></td>
<td><strong>Q fever</strong> (Coxiella burnetii)</td>
<td>Category A</td>
<td></td>
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<tr>
<td></td>
<td><strong>Ricin toxin from Ricinus communis</strong> (castor beans)</td>
<td>Category A</td>
<td></td>
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<tr>
<td><strong>Mycotoxins</strong></td>
<td><strong>Staphylococcal enterotoxin B</strong></td>
<td>Category A</td>
<td></td>
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<tr>
<td></td>
<td><strong>Typhus</strong> (Rickettsia prowazekii)</td>
<td>Category A</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Viral hemorrhagic fevers</strong></td>
<td><strong>Viral encephalitis</strong> (alphaviruses [VEE, EEE, WEE])</td>
<td>Category A</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Water safety threats</strong> (eg, Vibrio cholerae, Cryptosporidium parvum)</td>
<td>Category A</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Emerging threat agents</strong></td>
<td><strong>Emerging threat agents</strong> (eg, Nipah virus, hantavirus)</td>
<td>Category C</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

EEE, eastern equine encephalomyelitis; VEE, Venezuelan equine encephalomyelitis; WEE, western equine encephalomyelitis.
Syndromic surveillance, a specialized type of outbreak detection, is a term used to describe mechanisms for monitoring health indices or events that reflect the early stages of a chemical release or of an infection or disease of public health importance to minimize consequences.\textsuperscript{55,56} Syndromic surveillance is considered an important means of identifying public health emergencies in their initial stages. Syndromic surveillance techniques, summarized below, can be clinician based or automated. Many syndromic surveillance systems are based in hospital emergency departments.

Astute Clinician

The traditional mechanism of detection of an unusual occurrence has been the clinician who recognizes atypical patterns of symptoms, signs, or disease and reports them to public health authorities. The “astute clinician” principle places all health care professionals (including physicians, advanced practice providers, nurses, paramedics, emergency medical technicians, infection preventionists, laboratorians, pharmacists, epidemiologists, and health educators) in the role of sentinels for the appearance of disease clusters or other clinical abnormalities. It is important to identify and work with those who may already have a defined role in syndromic surveillance. For example, school nurses have an established or particular role in this area, and there are other professionals with these capabilities. The pivotal role of physicians and other health care professionals in surveillance, particularly for acts of terrorism, has led the CDC and other agencies to educate clinicians about chemical and biological weapons release and the diseases they produce. Clinical cues, case definitions, and syndromes for chemical weapons exposure have been published (Table 4) along with numerous resources to expand clinicians’ ability to recognize covert terrorist incidents.\textsuperscript{25,50,57}

To facilitate uniform reporting among local, state, and federal authorities after unintentional or intentional releases of chemical agents, the CDC has developed case definitions for illness.\textsuperscript{51}

Automated Systems

Recently, there has been a rapid increase in the development of real-time, automated syndromic surveillance tools. Such automated decision support uses software to identify sentinel events such as an unusual amount of work or school absenteeism, changes in consumer purchase of over-the-counter products (eg, antipyretics or cough syrups), and changes in the chief-complaint profile among those who visit primary care physicians or hospital emergency departments.\textsuperscript{58–60}

The CDC BioSense Platform (www.cdc.gov/nssp/biosense/index.html) is an integrated, national surveillance system that gathers data from diagnosis codes included in electronic medical records to enhance situational awareness for an all-hazards approach. The DHS BioWatch Program (www.dhs.gov/biowatch-program) provides early warning of a bioterrorist attack in more than 30 major metropolitan areas across the country.

A number of surveillance studies have attempted to use the massive volume of data on the Internet to inform rapid epidemic detection. Various surveillance tools, such as the Program for Monitoring Emerging Diseases–Mail (available at www.promedmail.org; International Society for Infectious Diseases) and HealthMap (available at www.healthmap.org; Boston Children’s Hospital), which aggregates content from the Program for Monitoring Emerging Diseases–Mail and other sources, are capable of providing alleged outbreak signals ranging from days to months before official reports.\textsuperscript{61,62}

Crowdsourcing

An unconventional and unplanned type of syndromic surveillance has arisen in recent years with the advent of mobile devices and social media applications. For example, in the 2013 intentional release of sarin gas near Damascus, Syria, many individuals recorded videos of the atrocity that killed 1400 civilians; Rosman et al\textsuperscript{63} searched the YouTube Web site for videos that had been uploaded in the weeks after the release. Many of these videos documented significant clinical signs—including dyspnea, diaphoresis, and syncope—and also revealed problems with the use of PPE, decontamination strategies, and antidote administration. Nonclinicians contributed “crowdsourced” data, in effect, to syndromic surveillance. Although there were no chemical or biological releases at the 2013 Boston Marathon bombings, investigators were able to identify specific keywords that were posted within minutes of the explosions on the social media site Twitter before any reports were issued from public safety officials or traditional news media outlets.\textsuperscript{64}

Governmental Roles in Emergency Preparedness

Although emergency preparedness legislation existed before 2001, the passage of additional rules has resulted in efforts by the federal government to improve public health readiness across the nation (Table 1) despite federal budgets remaining flat for more than a decade and state and local budgets declining for public health and emergency response. In contrast, there has been an escalating need to ensure the safety of all US citizens. Established in 2002, the DHS is the main federal agency that leads efforts to protect the US population against chemical, biological, and
The ASPR has led the development of the National Health Security Strategy and oversees implementation of the National Biodefense Strategy. The ASPR continuously identifies and addresses gaps in coordinating patient care and transportation in disasters, especially for coalitions and states. 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. The potential benefits of regional disaster health response systems are also being explored. The ASPR also leads the disaster medical assistance teams (DMATs), which provide medical assistance to regions after a large-scale disaster. Although there are individuals on DMATs who have pediatric expertise, personnel on DMATs are trained to provide initial care for both adults and children. The Medical Reserve Corps, another federal effort designed to create community "medical strike teams," has no clearly established pediatric capability or standards (https://mrc.hhs.gov/HomePage).

Other DHHS agencies have undergone change; these include the CDC, FDA, and National Institutes of Health, all of which have reorganized practice, regulatory, and research priorities to include chemical and biological terrorism, along with other public health threats. In 2002, the CDC established the Coordinating Office for Terrorism Preparedness and Emergency Response (later referred to as the Office of Public Health Preparedness and Response and now renamed the Center for Preparedness and Response), and in 2012, the CDC launched the Children’s Preparedness Unit to address children’s needs in the context of infectious disease outbreaks and other public health emergencies. The CDC also integrated a children’s health team into its Emergency Operations Center structure, beginning in 2009 with the H1N1 influenza pandemic and continuing through the responses to the Ebola virus epidemic (2013–2016); the Zika virus outbreak in 2016–2018; the Flint, Michigan, water contamination in 2016; Hurricanes Harvey, Irma, and Maria in 2017; and Hurricane Michael in 2018. At state and local levels, planning for chemical and biological terrorism is now coordinated by multiple agencies, including departments of health, emergency management agencies, poison control centers, and law enforcement authorities. Because there is variability across states, pediatricians can inquire as to which agencies are in charge of planning for and responding to chemical and biological attacks in their local communities.

### Poison Control Centers

The network of regional and state poison control centers, funded by federal, state, and local sources, may be the first point of contact for health care providers and members of the public concerned about possible terrorist attacks. Callers can reach poison centers 24 hours a day via a national toll-free number (800-222-1222), and call data are uploaded automatically in nearly real time (currently a median of 9.5 minutes to upload data from all centers) to the National Poison Data System, maintained at the American Association of Poison Control Centers.

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**TABLE 4 Clinical Syndromes Associated With Chemical and Biological Agents**

<table>
<thead>
<tr>
<th>Category</th>
<th>Clinical Syndrome</th>
<th>Potential Etiologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular hypoxia</td>
<td>Altered mental status, dyspnea, seizures, and/or metabolic acidosis</td>
<td>Cyanide, carbon monoxide, hydrogen sulfide, and/or sodium azide</td>
</tr>
<tr>
<td>Cholinergic crisis</td>
<td>Salivation, diarrhea, lacrimation, bronchorrhea, diaphoresis, miosis, fasciation,</td>
<td>Nicotine, nerve agents, and/or organophosphates</td>
</tr>
<tr>
<td>Gastrointestinal illness</td>
<td>Abdominal pain, vomiting, profuse diarrhea, hypotension, and/or cardiovascular</td>
<td>Ricin, staphylococcal enterotoxin E, arsenic, and/or Ebola</td>
</tr>
<tr>
<td>Lacrimation</td>
<td>Tearing, blepharospasm, and/or incapacitation</td>
<td>Lacrimators (Mace), ammonia, and/or halogens (chlorine, bromine)</td>
</tr>
<tr>
<td>Mucosal irritation</td>
<td>Tearing, nose and mouth burning, and/or sore throat</td>
<td>Ammonia and/or halogens</td>
</tr>
<tr>
<td>Muscle rigidity</td>
<td>Generalized muscle contractions, painful neck and/or limb spasm, and/or seizure</td>
<td>Strychnine</td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>Generalized muscle weakness, ptosis, and/or respiratory embarrassment</td>
<td>Botulism</td>
</tr>
<tr>
<td>Peripheral neuropathy</td>
<td>Muscle weakness or atrophy, &quot;stocking-glove&quot; sensory loss, and/or depressed or</td>
<td>Arsenic and/or thallium</td>
</tr>
<tr>
<td>Respiratory distress, acute onset</td>
<td>Cough, wheeze, shortness of breath, and/or generalized mucosal irritation</td>
<td>Ammonia and/or halogens</td>
</tr>
<tr>
<td>Respiratory distress, delayed</td>
<td>Cough, respiratory distress, wheeze, hypoxia, and/or pulmonary edema</td>
<td>Phosgene and/or sulfur mustard</td>
</tr>
</tbody>
</table>

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**Radiation Threats.** Specifically, the DHS strives to secure the nation from many threats (eg, 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. Within the DHHS, the ASPR was established in 2006 to minimize the adverse health consequences from disasters. The ASPR has led the development of the National Health Security Strategy and oversees implementation of the National Biodefense Strategy. The ASPR continuously identifies and addresses gaps in coordinating patient care and transportation in disasters, especially for coalitions and states. 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. The potential benefits of regional disaster health response systems are also being explored. The ASPR also leads the disaster medical assistance teams (DMATs), which provide medical assistance to regions after a large-scale disaster.
**SNS and Pediatric MCMs**

The SNS has become 1 of the most important initiatives in mass-casualty disaster response. Designed to respond to disasters that overwhelm state and local resources, the SNS includes such capabilities as the delivery of medications and medical supplies to areas of need within a clinically relevant time frame. The SNS supplies include pediatric dosage forms and pediatric sizes of medical supplies as well as instructions for compounding certain tablets and capsules into liquid formulations for some but not all MCMs. Unfortunately, not all MCMs are licensed for use in children, and not all MCMs are available in ideal formulations that are appropriate for younger children. According to the 2013 US Government Accountability Office, 40% of the MCMs in the SNS have not been approved for pediatric use. Of the 60% of MCMs that are approved for children, there are many instances when use is limited to people of specific ages. Currently, unapproved MCMs may be distributed under FDA emergency use authorization or investigational new drug application. If an MCM is considered under the investigational new drug application, additional consent would be needed, which would be challenging to explain to frightened parents and would likely prolong MCM mass distribution efforts during a public health emergency. Ongoing efforts continue within the ASPR to address the MCM needs of pediatric populations in relation to the current medications within the SNS and make prioritized recommendations for formulary additions or changes. The AAP has identified several concerns and recommendations in its policy, “Medical Countermeasures for Children in Public Health Emergencies, Disasters, or Terrorism.” Even with an increased awareness of the need, significant barriers remain to developing, testing, procuring, and distributing medications in doses and formulations appropriate for children. In addition, state and local plans for medication distribution need to be developed in collaboration with pediatric experts and consider children’s needs for maximum effectiveness and efficiency.

**The Primary Care Provider and Community Response**

Pediatricians play a pivotal role in providing care in the medical home and supporting the community before, during, and after a chemical or biological attack. Most families will seek medical advice from a trusted source such as their pediatrician. Pediatricians can emphasize the need for family disaster preparedness planning before an event and provide resources such as the AAP Family Readiness Kit. After an attack or outbreak, pediatricians and their staff will need to be knowledgeable about the medical course for the agent of concern and provide anticipatory guidance to the families. Although victims of a chemical or biological attack may be treated initially in hospital emergency department settings, victims may also seek care from the medical home. Thus, pediatricians will need to be prepared for a surge in communications with patients and families, have the appropriate PPE (and related training on how to use the equipment), and have developed isolation procedures. Pediatricians will also need to be prepared to help families care for the long-term physical and emotional sequelae. Additional information on the role of the pediatrician in disaster preparedness and response is available.

**Prehospital and Hospital Preparedness**

Hospital protocols for pediatric victims of chemical or biological terrorism must be established in all hospitals. These disaster protocols require an integrated response from the emergency department, ICU, 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 (milligrams of medication per kilogram of body weight) to minimize morbidity and mortality. The needs of children with chronic health conditions as well as physical and intellectual disabilities need to be considered in the disaster plan. All hospitals should have disaster protocols for pediatric patients, including mobilization of child-life specialists, volunteers, and others such as behavioral health professionals who can provide comfort to and minimize the stress of children, particularly if those children are separated from their parents. For hospitals that do not treat large numbers of children, telehealth and telementoring technologies offer access to information and to pediatric subspecialists to facilitate the care of children. In addition, hospitals participating in a regional coalition may be asked to provide care for victims far away from the affected site.

To be fully prepared for chemical or biological terrorism, pediatric and general hospitals must also have an evacuation plan for times when the hospital environment becomes uninhabitable. Although protocols for “vertical evacuation” (ie, the removal of patients to other areas or floors within the same building) are well established in hospital-based disaster response, comprehensive plans for complete building evacuation are less well developed. Pediatric hospitals requiring full evacuation may have the additional challenge of transporting pediatric patients to health care facilities with relatively few pediatric resources. Nonetheless, memoranda of agreement with
nearby or affiliated institutions and regional alliances are a key part of a comprehensive pediatric hospital disaster plan.

**Decontamination**

Several investigators have focused on the logistics of prehospital and hospital preparedness. In a study of 2 mass decontamination field exercises, investigators in the United Kingdom used radio-frequency identification tags and detection mats to examine bottlenecks in the process. Computer analysis revealed that bottlenecks occurred at specific phases of the process (eg, the redressing or “rerobing” that followed decontamination showers), and subsequent simulations revealed that shortening the duration of showers and adding capacity in the rerobing area could improve throughput of casualties.77

After exposure to a chemical or biological weapon, children may become covered by toxic material that can produce skin injury or be absorbed, producing systemic toxicity. In the case of infectious material, the contamination of skin could be sufficient to represent a threat to health care professionals as well as the victim. When children are covered with unknown but potentially dangerous chemical or infectious material, immediate decontamination is required.78 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 regulations—before entering the ambulance or building, with attention to prevention of hypothermia, as noted below. Plans should address the collection of contaminated water. Disrobing alone accounts for more than 85% of topical decontamination and is an extremely effective means of ending exposure. In the Tokyo sarin experience, it was determined that removal of clothing can eliminate pockets of trapped gas.79 When possible, the victim should disrobe himself or herself to minimize exposure to others. Health care professionals should not assist in disrobing unless they are wearing appropriate PPE.60 60

There is some debate about the merits of dry decontamination (removal of clothing, scraping, absorbent or adsorbent materials, vacuuming, pressurized air, provision of replacement clothing) alone versus wet decontamination, which adds showering to topical decontamination. The decision to use dry versus wet decontamination may depend, for example, on the presence of clearly visible contamination or evidence of a blistering agent.66

Showering further removes chemicals, microbes, and debris. As with disrobing, showering usually happens outdoors. However, some institutions may have specially designed indoor hazmat decontamination facilities. Protocols should include strategies for using warm water and low-pressure showers (to avoid trauma to the skin), etc, to prevent hypothermia in children, as well as methods for the collection of contaminated water. 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 lb psi, and containment of the wastewater. If the toxic material is oily or firmly adherent to the child’s skin, a mild soap or shampoo should be used; solutions such as mild bleach should not be used on children because of the risk of skin injury.31 If an outdoor shower is not available, the child can be simply disrobed before being brought into the health care facility for further care. Decontamination can be a frightening procedure for children, exacerbated by the identity-concealing PPE that clinicians are wearing. Efforts can be made to keep parents nearby and families intact; when possible, parents should remain with their child to offer psychological support and assist with their child’s decontamination.80

A number of studies have explored various materials—including water—for decontamination. One preliminary study of water-only decontamination of an oil-based, mock chemical-biological agent suggested that 100% of subjects could be decontaminated within 90 seconds.81 Although proprietary agents are available for specific types of exposures, a review of corrosive dermal exposures found that water is efficacious, widely available, and inexpensive.82 In specific, known exposures, other decontamination agents may be more effective: a study of the molecular tracer 4-cyanophenol found that decontamination efficiency from porcine skin was 54% with water, up to 70% with dry fuller’s earth, and around 90% with a suspension of fuller’s earth.83 In terms of wet versus dry decontamination, another study of absorbent materials in an ex vivo model indicated that dry decontamination was superior to wet methods for removing liquid contaminants but was not effective against particulate matter.84

The consensus among investigators, however, is that time is the single most important factor in successful decontamination.85 In most cases, decontamination is most successful if performed within minutes of exposure, which has the added benefit of mitigating the demand on health care facilities. This has introduced the concept of self-care decontamination and the mnemonic MADE: move and assist, disrobe and decontaminate, evaluate and evacuate.86
All health care professionals who assist in decontamination must protect themselves by wearing appropriate PPE. Currently, there are 4 levels of PPE, ranging from level A, which is the highest level of protection, to level D, which consists of a simple gown, gloves, and surgical mask. Many exposed subjects self-present to health care facilities. For hospital personnel, level C PPE (a chemical-resistant suit and gloves, with an air-purifying respirator) is considered adequate for hospital-based management of most contaminated victims. Health care facilities can develop plans for rapid access to PPE equipment and train staff on its use. Other recently published principles of decontamination and PPE are outlined in Table 5.

**Isolation and Containment**

In the current era, hospitals and health clinics need to develop protocols to be vigilant in screening, isolating, and starting treatment of patients with highly contagious emerging infectious diseases. Ideally, integrated communication systems will be in place to help clinicians identify pediatric patients with concerning travel history and possible exposures to an emerging infectious disease. Clinicians can become better prepared by knowing how to contact local and state public health officials if there is concern of a highly contagious pathogen, an emerging infection, or a cluster of illness.

Preparation for the 2013–2016 Ebola virus outbreak has led to federally identified biocontainment treatment centers in each US region, including, in some cases, tertiary care pediatric hospitals. Institutions caring for a child with a high-consequence pathogen require policies that include and recognize the developmental and psychological needs of children as well as policies that address parental presence and the use of age-appropriate equipment and supplies.

**Surge Capacity**

An effective response to large-scale chemical or biological terrorism (ie, an incident with more casualties than routine operations can accommodate) requires the creation of surge capacity protocols. Federal, state, and local public health authorities are essential in assisting health facilities during crises of large magnitude. Crisis standards of care have been reviewed and established at all levels. Definitive care of pediatric patients is increasingly dependent on interhospital transfers and referral centers. Lack of disaster planning for children in local health care facilities will impede and complicate the care of children. Because disasters happen locally, all health care systems must consult with pediatric experts and plan for the needs of children during a disaster. Plans for such an event might include (1) the creation of additional bed spaces through cohorting; (2) mechanisms for the rapid discharge of inpatients to increase capacity; (3) an inventory of all sites in the hospital where critical care can be provided; (4) establishment of a site for patient triage, ideally outside of the hospital; (5) identification of care sites for those whose injuries are minor; (6) mechanisms for labeling and tracking patients, particularly children who arrive without personal identification and may not be able to identify their parents; and (7) plans for maintaining hospital security by preventing the entry of contaminated victims and other unauthorized individuals. For nonpediatric hospitals, surge capacity plans for a mass-casualty chemical or biological incident involving children can include mechanisms for mobilizing health care professionals with pediatric expertise, including telemedicine. Surge capacity principles are summarized in Table 6.

**Pediatric Mental Health**

Given that the primary intent of terrorist attacks is to cause psychological distress among victims, witnesses, and the general population, it is to be expected that adjustment reactions will be a major challenge—if not the primary challenge—after chemical and biological terrorism, for both children and adults. Children are among those most at risk for psychological trauma and behavioral difficulties after

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### TABLE 5 Principles of Decontamination

<table>
<thead>
<tr>
<th>Principles</th>
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<tbody>
<tr>
<td>All decontamination should occur outside of the health care facility.</td>
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<tr>
<td>All health care professionals should wear appropriate PPE, as determined by their safety officer and occupational health specialist.</td>
</tr>
<tr>
<td>All levels of health care professionals should be trained to quickly access and use PPE, including physicians, nurses, clinical assistants, security, and environmental services.</td>
</tr>
<tr>
<td>Remove clothing from the victims as quickly as possible. Victims should disrobe themselves when possible.</td>
</tr>
<tr>
<td>Discarded clothing should be placed in a labeled plastic bag and stored for possible use by law enforcement.</td>
</tr>
<tr>
<td>Consider dry (removal of clothing, scraping, absorbent or adsorbent materials, vacuuming, pressurized air, and/or provision of replacement clothing) versus wet decontamination (addition of showers).</td>
</tr>
<tr>
<td>If showering is used, ensure the following: The water should have a temperature of approximately 100°F and a pressure of 60 psi. Water alone is used routinely. If the material is oily, a mild soap or shampoo should be added. Victims should shower for 5 min unless specific alternative recommendations are given. When possible, water effluent should be contained rather than placing it in the local wastewater stream. Use heat lamps, blankets, and other mechanisms to prevent hypothermia. Cover hands, feet, and other exposed areas of the victim if there is evidence of gross contamination. If there are multiple victims, anticipate the need to perform out-of-hospital triage.</td>
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</tbody>
</table>
a disaster and will also be influenced by their parents’ reactions and by coverage in social and public media. Children may experience short- and long-term effects on their psychological functioning, emotional adjustment, and developmental trajectory. Adjustment reactions may include anxiety, worries, or fears; sadness or depression; difficulties with concentration and learning; developmental or social regression; sleep or eating problems; substance abuse or other risk-taking behavior; posttraumatic reactions and disorders; bereavement when deaths have occurred; and somatization. These reactions may be seen even among children in the community who have had no direct or indirect exposure to the chemical or biological agents. These reactions may persist long after an event, which should be a consideration for those children who have escaped countries where such terrorist attacks are known or believed to have occurred in the past.

Emotional distress may interfere with accurate reporting of symptoms or instead mimic physical responses to the chemical or biological agents. Primary and subspecialty care pediatricians will often be the first to see children experiencing psychological distress in this setting, whether it presents as physical complaints, an adjustment reaction to the terrorist attack, or a combination. Given that virtually all children in a community affected by a terrorist attack are likely to experience some degree of emotional distress and anxiety, it is critical that pediatricians become comfortable in the assessment and acute management of adjustment reactions and mental health problems that may be seen. Pediatricians should be prepared to provide psychosocial support, psychological first aid, and psychoeducation in addition to evaluation and referral to mental health specialists when indicated and resources allow.5

Pediatricians who live in communities affected by terrorist attacks are likely to be worried about the health of family, friends, and themselves. They may find the delivery of care exhausting and emotionally draining given the surge in health care needs (in most cases predominantly because of the large number of individuals with psychological distress), the uncertainty of providing care during an evolving crisis for which the pediatrician has limited information and experience, and the distress that results from delivering compassionate care and witnessing the suffering of children and their families, pediatric colleagues, and the pediatrician’s own family and friends. Attention to self-care and support of professional colleagues is an important component of the response to the crisis throughout the long-term recovery period.5

**CONCLUSIONS**

The threat of a chemical or biological attack remains high. Children can be the intended target or part of the targeted group. Although advances have been made in surveillance, pediatric disaster education, decontamination, and awareness, there continue to be gaps in incorporating children into disaster planning, especially with respect to the use of pediatric MCMs. Pediatric health care providers will need to be knowledgeable of possible agents and sequelae to provide optimal medical and mental health management for children exposed to chemical or biological terrorism. Pediatric health care providers will need to be trained on pediatric decontamination strategies as well as the use of PPE. Pediatric health providers can also help their communities with chemical and biological preparedness and response activities.

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**TABLE 6 Surge Capacity Principles for Hospitals**

<table>
<thead>
<tr>
<th>Principles</th>
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<tbody>
<tr>
<td>Preparation</td>
</tr>
<tr>
<td>Obtain PPE, showers, and other emergency-response equipment</td>
</tr>
<tr>
<td>Stockpile pediatric supplies</td>
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<tr>
<td>Stockpile or plan for additional pediatric pharmaceuticals</td>
</tr>
<tr>
<td>Perform drills; consider tabletop exercises using pediatric victims</td>
</tr>
<tr>
<td>Familiarize with wt-based dosing (eg, milligrams of medication per kilogram of body wt) for pediatric emergency medicines</td>
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<tr>
<td>Response</td>
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<tr>
<td>Anticipate a 1.5:1 ratio of critically ill/urgently ill (“walking wounded”)/well (“worried well”) casualties96,97</td>
</tr>
<tr>
<td>Anticipate the “second-wave” phenomenon98</td>
</tr>
<tr>
<td>Reserve the emergency department for critically ill patients</td>
</tr>
<tr>
<td>Perform triage and decontamination outside of the hospital</td>
</tr>
<tr>
<td>Put protocols in place to prevent campus security from unauthorized intrusion</td>
</tr>
<tr>
<td>Identify and use alternate sites of care; identify transportation options</td>
</tr>
</tbody>
</table>

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