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Terrorist Attacks against Children: Vulnerabilities, Management Principles and Capability Gaps

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Abstract

Events such as the 1995 Oklahoma City bombing and the 2004 terrorist attack on the school in Beslan, Russia demonstrate that terrorists are willing and able to attack large numbers of children. Moreover, pediatric casualties are likely when terrorist incidents occur in urban areas even if children are not the primary target. Very little research has been conducted on the management and outcomes of children during and after disasters. This paper discusses the known risks that terrorism brings to children, vulnerabilities in this population, basic principles of pediatric disaster response and current gaps in response capabilities.

KEYWORDS: pediatric disaster preparedness, terrorism, children

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INTRODUCTION

As in many fields of medicine, disaster medicine involves a certain degree of improvisation during crises. However, with diligent pre-event research and planning for unique circumstances such as pediatric mass casualty incidents (MCIs) resulting from terrorist attacks, dramatic improvements in consequence mitigation and management are possible (Peleg et al. 2003, Brandenburg forthcoming). The risk that children might be targeted by terrorists is evidenced by the fact that children who have been placed in danger, injured or killed generate an enormous emotional impact on the community and in the media. Recent events demonstrate that terrorists are willing and able to specifically seek out and attack large numbers of children. On April 19, 1995 domestic terrorists who were aware a children's daycare facility was in the building showed their willingness to kill American children when they attacked the Murrah Federal Building in Oklahoma City with an ammonium nitrate truck bomb (Hogan and Waeckerle 1999). Of the 168 deaths, 19 (11.3%) were children. In addition, 47 children were injured severely enough to be taken to emergency departments (Quintana and Parker 1997). On September 1, 2004, the terrorists deliberately chose children as targets when Chechen militants stormed a grade school in Beslan, Russia (Anonymous 2006). During the four-day siege more than 350 hostages were killed, over half of whom were children. In the aftermath of those and other similarly dramatic events, experts think it plausible that schools, daycare centers, and other locations where children congregate in the United States are just as vulnerable to terrorism (Sawyer 2004).

Moreover, pediatric casualties are likely when terrorist incidents occur in urban areas even if children are not the primary target. The indiscriminate use of explosives or weapons of mass destruction (WMDs) in a highly populated area would likely bring about numerous pediatric casualties (American Academy of Pediatrics Committee on Environmental Health 2000). Trauma data from suicide bombings in Israel shows terror-related injuries in children to be more severe than non-terror-related injuries, increasing the demand for acute care of children (Aharonson-Daniel et al. 2003). Furthermore, injury severity among children injured by explosions is significantly higher than children injured by shootings (Amir et al. 2005, Mintz and Shapira 2002, Waisman et al. 2003). In addition, biological or chemical terrorism can be more detrimental to the pediatric population than to the adult population because these agents concentrate low to the ground and closer to the level of a child's airway (American Academy of Pediatrics Committee on Environmental Health 2000, Bearer 1995). This fact, coupled with the higher minute ventilation of children, exposes them to relatively higher doses of an agent than adults (American Academy of Pediatrics Committee on Environmental Health 2000, Bearer 1995).

Children represent an especially vulnerable population and special considerations are necessary to properly care for them in disasters (Seamen and Maguire 2005). And yet, there is clear and convincing evidence that the United States is not prepared to manage large numbers of injured or displaced children, whether stemming from an act of terrorism, a large-scale accident, or a natural disaster (Keim et al. 2003, Mcfee et al. 2004, Klein et al 2004, Murphy 2004, Webby and Webster 2003, Shapiro 2003). Pediatric preparedness is especially lacking in surge capacity with inattention to the unique vulnerabilities and needs of children (Markenson and Redlener 2004, Gausche-Hill 2006). Larger metropolitan areas in the U.S typically have only one pediatric emergency department capable of handling multiple critically ill or injured pediatric patients, while most U.S. cities have no such facility. A pediatric mass casualty event would overwhelm even the largest and most capable of pediatric emergency departments. And yet, pediatric disaster preparedness has received little attention from the medical and public health communities (Roshal 1999). The National Disaster Medical System (NDMS) oversees an effective network of Disaster Medical Assistance Teams (DMAT's) capable of responding to disasters within 24 hours; some even have the capability to function independently in austere conditions for up to 72 hours. At present, however, the potential of using pediatric response units has not been developed and educational initiatives and preparedness exercises adapted specifically for pediatric WMD events have been lacking. This paper takes an all-hazards approach in discussing the unique vulnerabilities of children in disasters and provides a comprehensive summary of the guiding principles of pediatric preparedness (Table 1).

Table 1. All-Hazards Approach to Pediatric Disaster Preparedness

Intentional Human Action	**Unintentional Human Action**	**Natural Disaster ("Act of God")**
CBRNE Terrorism: Chemical Biological Radiological Nuclear Explosives	Accident: Transportation Structural collapse Industrial	Earthquakes Hurricanes Tornadoes Floods Fires

GUIDING PRINCIPLES OF PEDIATRIC PREPAREDNESS

Since the early 1990s, extensive analysis of lessons learned from a variety of terrorist incidents has provided insights into best-practices for preparedness and response. Although these discussions sometimes mention children, preparedness for pediatric disasters requires specific guiding principles that may not apply to the adult population (Table 2).

Table 2. The guiding principles of pediatric preparedness are based upon the unique vulnerabilities faced by children during and after disasters.

Vulnerabilities	Guiding Principles
Anatomy/Physiology	Pediatric Health-Care Professionals
Pharmacology: dosages, side effects, adverse reactions	Pediatric pharmacology
Dependency upon pediatric medical equipment and basic supplies	Pediatric-specific medical equipment and basic supplies
Emotional differences	Pediatric Mental-Health
Unintentional injury susceptibility	Child Injury Prevention
Dependency upon guardians for safety, security and emotional needs	Identification and Reunification
Daycare and educational needs for safety, security and guardians' need to find basic resources	Daycare & Schools
Increased incidence of prenatal complications and premature births	Enhanced Prenatal Care

Pediatric Anatomy and Physiology

The anatomy and physiology of a child differs from that of an adult in several ways. Therefore, diagnosing medical conditions and performing procedures on children requires specialty training that cannot be learned "just-in-time." The inclusion of pediatricians, family physicians, emergency physicians, pediatric nurses and other health-care professionals with pediatric expertise will enhance the likelihood for success of a pediatric disaster response system or team.

The pediatric airway is smaller in length and diameter and unique in position and lie (Rubin and Sadovnikoff 2004). As a result, airway maintenance and protection techniques are very different (American College of Surgeons Committee on Trauma 1997).

A child's cranium relative to the rest of its body is larger than an adult's and the pediatric neck musculature and spinal column are not fully developed. Head injury is the most frequent cause of death among children over the age of one year (Hauda 2004). The severity of the head injury is often the primary determinant of the child's outcome (Holbrook 1991). In the Oklahoma City bombing in 1995, 19 children were killed, 90% of whom suffered head injuries. Of the 47 children with nonfatal injuries, four of the seven (57.1%) requiring hospitalization were admitted for head injuries (Quintana 1997). Although children under the age of 3 years have a less optimistic prognosis after suffering a traumatic brain injury than older children, children overall tend to fair better than adults after sustaining a traumatic head injury (Bruce 1978).

A greater relative body surface area of children places them at risk for more rapid skin absorption of chemical agents or toxins. Children are also at a greater risk of hypothermia due to rapid heat transfer as a result of the greater surface area:body mass ratio, in addition to having minimal subcutaneous fat, thinner epidermis and an immature behavioral response to the colder environment (Hofstrand 1997). Inherent differences in the torso and musculoskeletal system of children also creates unique vulnerabilities to injury and treatment requirements (Cooper and Foltin 1997).

Dehydration is a common issue in the pediatric population, especially with injured children. Poor oral intake may contribute to volume depletion in the child who has been injured or displaced by a disaster. Early and proper fluid resuscitation is central to the management of volume-depleted children (American Academy of Pediatrics and American Heart Association 1997).

Pediatric Pharmacology

All phases of response, pre-hospital, hospital and community, will need to address pediatric pharmacology issues during a disaster response. Each plan will address differences in pediatric dosages, contraindications (relative and absolute), side effects and adverse reactions of the medications. Specific steps can be taken; for example, pediatric auto-injectors for atropine, pralidoxime, valium and other medications can be stockpiled when an attack of certain chemical weapons appears imminent (Food and Drug Administration 2003, Henretig et al. 2002). Some of this need can be met by reliance on the Strategic National Stockpile which is equipped with pediatric-specific pharmaceuticals. When planning for biological agent attacks, chemotherapy, chemoprophylaxis, immunotherapy and immunoprophylaxis represent the four major categories of medications needed.

Medications to achieve these ends must be stockpiled in a 48-hour supply and ready to dispense in appropriate dosages and forms for children. Medications can be stockpiled and ready to dispense and administer in appropriate dosages and forms for children. State and local health departments can incorporate assets such as the Strategic National Stockpile into pediatric disaster plans (Markenson and Redlener 2004).

Most medications are administered to children in specific weight-based dosages, whether given by mouth, intramuscularly or intravenously. And medications given intravenously must be given in specific volumes at specific rates and require very specialized nursing skills in the process. It is, therefore, necessary to establish pediatric dosages, formulations and administration routes of antibiotics, antivirals and immunizations and to communicate this information to those who respond to pediatric mass casualty incidents.

Moreover, some medications safe for adults are considered unsafe for children, due to unique side effects and adverse reactions; confusion can exist about which medications are safe and effective for children. Contraindications, however, are not always absolute but rather relative to the situation and illness. In disaster settings, the risks of providing a medication to a child may be overridden by the risks of the illness or potential illness created by exposure to the type of injury, chemical or biological agent. For example, doxycycline and ciprofloxacin are both relatively contraindicated in children due to effects of bone development and dental staining; but, the risks of these medications would likely be outweighed by the benefits of giving it. Knowledge of drug indications, contraindications and various hazards to which children might be exposed is a valuable asset to response organizations and teams.

For breaking information such as antimicrobial resistance patterns of infecting organisms, the Centers for Disease Control manages Internet resources such as the Health Alert Network (HAN), Morbidity and Mortality Weekly Review (MMWR) in addition to easily accessible web site materials (US Department of Health and Human Services 2006 a,b,c).

Medical Equipment and Basic Supplies

The ability of a pediatric health-care response will be dependent not only upon physicians, nurses and paramedics skilled in the treatment of children, but also an adequate supply of the necessary medical equipment. It is generally accepted by experts that the current status of the U.S. health care system is characterized by an inadequacy and insufficiency of pediatric-specific medical equipment on ambulances and in emergency departments (Middelton and Burt 2006). The strategic pre-deployment of medical equipment cachets following a major terrorist attack to properly trained personnel will greatly enhance the overall pediatric response capability. In addition, providing such medical equipment to the

emergency medical systems for current, ongoing needs would not only enhance day-to-day operations but would greatly improve pediatric surge capacity.

Children also require basic supplies for daily living, such as infant formulas, baby food, bottles, diapers, cribs, clothes along with many other items. Incorporating a steady flow of these basic supplies into the already existing response system will diminish the likelihood that interruptions in the supply-chain will occur.

Mental Health

Addressing mental health needs is a central component of terrorism response (Vogel and Vernberg 1993). Children need an open, honest, and reassuring approach to understand the events of the disaster on their own terms. Advising and educating caregivers on how to approach children will do much to improve the healing process for both (Madakasira and O'brien 1987). Prior studies of pediatric post-traumatic stress disorder (PTSD) in the aftermath of large-scale disasters witnessed by children further underscore the need for a broad, multidisciplinary mental health and public health approach (Baker 2002). While protecting children from the direct experiences of the disaster is important, it is also essential to avoid overwhelming children with the aftereffects of the event, as much as possible. With the pervasive news coverage by the modern media, the psychological impact of disasters can have adverse effects on children, particularly if exposed to such televised stimulation on a nearly constant basis. Post-traumatic stress disorder in children secondary to repetitive media play after disasters has been well-documented in children up to 100 miles away (Pfefferbaum et al 2003). Protection from post-traumatic stress can be facilitated by quick removal from the impacted environment followed by return to normal life with appropriate counseling as quickly as possible. Schools, churches, media and other community organizations can be used to assist pediatric mental health specialists and identifying the psychiatric or physical signs of stress in children (American Academy of Pediatrics Work Group on Disaster 1999).

In addition to serving as important resources to the community in preparing for such events, pediatricians and other professionals with pediatric mental health expertise can participate in the response to mitigate the psychological impact to children when a disaster occurs (American Academy of Pediatircs Community of Psychosocial Aspects of Child and Family Health 1999). The roles of primary care physicians in pediatric disasters involves assisting medical personnel during triage and treatment processes, as well as teaching parents about the common post-disaster mental health needs of children. Using the fundamental principles of disaster triage, first responders can implement basic psychological consequence management for children. For example, establishing a cross-organizational psychosocial response program with

an Incident Command structure can serve as the framework for preparedness training as well as a response team to provide psychological first aid and PTSD prevention during a disaster (National Disaster Life Support Foundation 2004a).

Post-Event Injury Prevention

Current evidence indicates that injuries from child abuse increase after major disasters (Curtis et al 2000). In addition, they are susceptible to unintentional injuries that adults are unlikely to suffer, such as drowning, auto-pedestrian injuries, electrical injuries, etc. Unique injuries can also occur in certain scenarios where children are exposed to secondary hazards. In Israel, atropine auto-injectors and gas masks that were passed out to the civilian population during the first Gulf War were linked to unintentional injuries to children (Amitai et al. 1994, Hiss and Arensburg 1994). Depending on the magnitude and type of specific event, health care personnel in a pediatric ED can also expect to see an increased census, with more diagnoses of open wounds, gastroenteritis, and skin infections. Alerting parents to the potential for injury and accidental poisoning in children after a terrorist event may help prevent the reported morbidity (Quinn et al. 1994). Incorporating established child safety programs by partnering with regional injury prevention experts and organizations (i.e., Safe Kids Worldwide) into a pediatric disaster response can be effective in minimizing the incidence of injuries in children (Brandenburg and Ogle 2006).

Parent/Guardian Issues

Recognizing the importance of keeping families together and reuniting children with their usual guardians is a key element in the management of pediatrics in mass casualty incidents. The dependent nature of children places them at higher risk of psycho-emotional problems if their sense of security is disrupted following a disaster (North and Smith 1990, MacIntyre et al. 2000, Stewart 1986). By reuniting children with parents or guardians, the acute emotional effects of the separation can be minimized. When over 2,000 children were reported missing by the National Center for Missing and Exploited Children (NCMEC) during the aftermath of Hurricane Katrina, work with displaced Louisiana children exemplified the importance of planning for displaced children (Brandenburg 2005, Brandenburg and Watkins forthcoming). A better post-disaster individual identification system will help prioritize the identification and reunification of children with guardians, regardless of the type of mass casualty incident.

Day Care & Schools

Establishing day care facilities, including early back-to-school programs, and criteria for making school closure decisions is another key element in community disaster planning (Neuzil et al. 2002, World Health Organization Writing Group 2006). Moreover, in large scale disasters involving mass casualties, children can survive their parents and other family members; in order to deal with this eventuality, developing plans for large numbers of homeless and orphaned children is also essential for timely and effective preparedness and management.

Enhanced Prenatal Care

Prenatal and neonatal medicine has received almost no attention in the literature of disaster medicine. Evidence supports the contention that in utero fetal growth is adversely affected in the weeks following a major disaster (Lederman et al. 2004). It has been shown that an earthquake experienced early in pregnancy is associated with shorter gestational length, presumably a result of the emotional stress of the event (Glynn et al. 2001). One study reviewed the perinatal medical problems in pregnant women during the flood disaster of July 1997 in the Klodzko Region of Poland. Of 47 pregnant women injured from the flood disaster, researchers observed adversely affected reproductive outcomes that included: pregnancy loss in 26 of the women (55.3%), premature delivery, missed abortion, birth asphyxia, premature rupture of membranes and intrauterine growth retardation (Neuberg et al. 1998). An increase in the number of pregnant women seeking medical attention for contractions can be expected, too (Seidman and Hourvitz 1994).

Ensuring surge capacity in labor and delivery, newborn nursery and neonatal intensive care wards in community hospital preparedness efforts is a primary strategy in addressing these needs. Better understanding of third trimester pregnancy-related complications and premature births following disasters might lead to the mitigation of these illnesses and an overall better prognosis for the pediatric population after a disaster.

ALL-HAZARDS APPROACH

The unique vulnerabilities and guiding principles of pediatric preparedness will vary depending upon the type and scope of terrorist attack. The following sections discuss these vulnerabilities and principles in light of various hazards, conventional terrorist attacks and weapons of mass construction (WMD).

Conventional Terrorist Acts

A conventional terror attack with explosives typically involves bombing, building collapse, or shooting. Terrorist bombings inflict injury of a distinctly different pattern than other means of trauma. The injuries are usually penetrating or blunt trauma to the victims. In conventional terrorist attacks where firearms or explosives are used, medical personnel and other first responders can expect to see children with serious trauma including high velocity, penetrating injuries, amputations, fractures, head injuries, organ injuries and contusions. The simultaneous combination of different injury mechanisms in explosions results in a multi-system injury pattern and a complicated clinical course (Kluger et al. 2004).

Fundamental differences in the various injury patterns of injured children exist from one mechanism to another (Peleg et al. 2004). For example, in the setting of high velocity, penetrating injuries that typically result from conventional terrorist acts, the medical response to mass pediatric casualties requires properly diagnosing and managing pediatric hemorrhagic shock, head injury, and know the indications, contraindications and proper dosages and formulations of the relevant pharmacological agents. Pediatric pharmacology requirements will include antibiotics, pain medication, tetanus immunization and medications of various classes that will be used for standard resuscitative medications, sedation and chemical paralytics for children requiring mechanical ventilation. It is recommended that hospitals keep a 48-hour supply of pediatric equipment and pharmaceuticals on hand for the average daily number of patients plus an additional 100 patients (Markenson and Redlener 2004).

Weapons of Mass Destruction

Detonation of a nuclear device falls into a special category due to the combination of both immediate and delayed morbidity and mortality attributable to blast, thermal, and radiation effects. The potential release of biological pathogens, chemical warfare agents, toxic industrial chemicals, or non-fissile radiological material constitutes the other unconventional threats posed by terrorism.

BIOTERRORISM

The threats posed by biological weapons are likely to continue into the future (Christopher et al. 1997). In a bioterrorism attack, the healthcare system will be responsible for providing diagnostic and treatment information efficiently and expeditiously (Platt and Feigin 2002). The current model for handling BT and communicable MCI's is substantially different from other types of disasters (Petrosillo et al. 2005). "Population Triage," the process of moving large numbers of patients to appropriate healthcare facilities for evaluation and treatment during

a disaster, for bioterrorism events is vastly different than for conventional or even chemical terrorism attacks. With conventional or chemical incidents, triage is a process involving EMS and hospital-transfer principles with modifications for mass casualty incidents (National Disaster Life Support Foundation 2004b). In a BT incident, however, it is likely that the first-responders for these patients will not be paramedics, firemen and police as is typically the case with other MCI's. Rather, the first-responders will be the nurses and physicians in clinics, offices and emergency departments (National Disaster Life Support Foundation 2004c).

The clinical presentations of biological agents in the pediatric population often mimic common illnesses and are likely to result in diagnosis and treatment delays. A high index of suspicion by clinicians combined with active environmental, diagnosis and syndromic surveillance programs, usually managed by public health departments, will improve the detection of such attacks in the general population, including children (Centers for Disease Control 2006). Chemotherapy, chemoprophylaxis, immunotherapy and immunoprophylaxis are the four basic categories of medications required to be prepared for biological events. Specific therapeutic choices for children exposed to biological agents may vary from adults due to potential side effects and complications. In addition, dosage forms suitable for children may not be readily available and will require some clinical improvisation.

The community triage response to bioterrorism depends upon whether the agent is highly toxic or communicable (Kortepeter et al. 2002). When a pathogen is communicable, a multi-agency, community-wide management strategy is necessary for the proper triage, treatment, isolation and quarantine (if necessary) of children and hospitalized victims. Strategies for isolation and quarantine, thought out well in advance of an event, would ideally preserve parent/guardian togetherness whenever possible. In the case of influenza pandemic, for example, directing patients to emergency departments of major hospitals can threaten the functioning of those facilities (Chaovavanich et al. 2004, Connolly et al. 2004).

Current recommendations by the U.S. Department of Health and Human Services (2006) include limiting admission of pandemic influenza patients to those with severe complications of influenza who cannot be cared for outside the hospital setting. This recommendation reflects the fact that the emergency care system in the U.S. now functions in a constant state of crisis with serious overcrowding and routine ambulance diversions (Institute of Medicine 2006). Clearly, unlimited patient access to hospital emergency departments during a disaster is unacceptable, especially when considering this lack of emergency medicine surge capacity. Participation by key city leaders and media personnel in pre-event drills and communication planning is necessary to maximize effectiveness of the communication and information dissemination that will provide triage instructions to the citizenry during a pandemic event.

Moreover, general hospitals have limited pediatric capabilities and children's hospitals are often geographically spaced hundreds of miles apart. Therefore, security at pediatric healthcare facilities is necessary in community disaster plans. In the case of a children's hospital, emergency department access control is necessary because disabling such a facility by post-event contamination or direct terrorist attack can have a crippling impact on the provision of pediatric health care throughout that region.

When looking specifically at hospital security during a bioterrorism attack, most facilities will need to gain access control in a timely and efficient manner in order to protect patients and hospital staff. Specific security measures will prevent patients with potentially deadly, highly communicable infections from breaching the entrance of hospital emergency departments (United States Department of Health and Human Services 2006). The degree to which access control is implemented will depend upon the agent in question, the pharmaceuticals available, personal protective equipment at the hospital and the overall biopreparedness of the hospital. The more prepared and able a facility is to prevent secondary exposure of healthcare workers, the less access control needed.

CHEMICAL TERRORISM

Intentional releases of chemical warfare agents or toxic industrial chemicals pose a threat to adults and children, especially in urban areas. Over 5,000 individuals were injured when sarin was intentionally released in the Tokyo subway in 1995, resulting in 12 deaths. Sixteen of the surviving victims were children less then 14 years of age, and five were pregnant women (American Academy of Pediatrics Committee on Environmental Health 2000). In the event of a chemical attack, the greatest challenge for hospitals will be the surge of large numbers of contaminated individuals (Macintyre and Christopher 2000). Expertise in hazardous materials exposure, decontamination and personal protective equipment use will be necessary in these events.

The skin of very young children is less able to resist chemical agent absorption and less able to heal after injury from vesicant exposure (Slater and Trunkey 1997). Also, because of poor regulation of body heat due to the increased body surface to mass ratio, children are more prone to changes in environmental temperatures. As such, hypothermia in children is a concern when mass decontamination is required. Dose issues for chemical agent antidotes must also be considered for children.

RADIOLOGICAL TERRORISM

Unlike a nuclear device, a radiological dispersion device (RDD), commonly called a dirty bomb, does not involve fission or fusion. Relatively few, if any,

people would die immediately after exposure to the ionizing radiation from a typical RDD using non-fissile material. As a result, pharmacological preparedness for pediatric victims of RDD events differs significantly from a nuclear event. The type of pharmaceutical needed will vary with the type of radionuclide released (Hogan and Kellison 2002, Hogan et al. 2003, Guilmette and Muggenberg 1993). Familiarity with chelating agents and medications such as the potassium iodide (KI) dosages, including preparation, guidelines, and limitations of this therapy in the pediatric population will enable health-care workers to better treat exposed children.

CONCLUSIONS

Fortunately, there have been very few pediatric MCIs involving terrorism; however, this has created a deficiency in practice models that integrate the well-accepted principles of disaster management with guiding principles for treating pediatric patients. Medical and trauma protocols obviously exist for the evaluation and treatment of children on a daily basis, but the application of these practices under conditions of resource-constrained triage and treatment have not been systematically evaluated. A review of existing practice reveals that medical care and pharmacology for children are key elements in pediatric preparedness.

Addressing other unique vulnerabilities of children, such as mental health, separation issues, injury susceptibility and day care needs, provide the basis for the guiding principles of pediatric preparedness discussed in this paper. The dearth of pediatric disaster expertise and management standards extends into all phases of response, pre-hospital, hospital and community coordination, as well as in all hazards of terrorism, Conventional, BT, Chemical and Radiological.

By applying the guiding principles of pediatric preparedness (i.e., medical care, pharmacology, mental health, child identification, child:guardian reunification, injury prevention, daycare services and enhanced pre-natal care) in all phases of response hazards, a more comprehensive plan will be realized. The integration of these principles into already existing disaster plans and response infrastructure (DMATs, Medical Reserve Corps units and community disaster preparedness entities) will require a concerted effort by pediatric specialists, ideally working as a team both in planning and response.

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