
Abstract:

This article is part of a collaborative effort by experts in the field of emergency preparedness to complete an overview begun by the late Michael Shannon, MD, MPH, on the current challenges and future directions in pediatric disaster readiness. This particular article, "Lessons Learned From Disasters Affecting Children," will address pediatric-specific vulnerabilities to disasters and pediatric patient care considerations in various phases of disaster planning and response, as has been learned from recent experiences.

Lessons Learned From Disasters Affecting Children

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Pediatric-specific disaster planning and response are critical to any disaster response initiative. Organized disaster relief systems and plans that address issues specific to children including unique vulnerabilities to disaster, inclusion of pediatric-trained providers, pediatric assessment, and treatment are critical. Comprehensive disaster plans are required for immediate response and management at the disaster site, at hospitals, and in the community with strategies for both short- and long-term postdisaster management and recovery, as well as strategies for personal preparedness. New technologies offer pediatric disaster medicine the promise of better disaster care for children.

PEDIATRIC-SPECIFIC VULNERABILITIES TO DISASTERS

Experience has shown that each disaster has unique elements, many that are predictable, and some that are not. The type, time, and site of a disaster will determine the number and proportion of pediatric victims, the nature and severity of their injuries, and the postdisaster-related events.^{1,2} Children may be disproportionately affected based on the site of a disaster and may even be the intended target, as was the case with the 2004 school hostage crisis in Beslan, Russia. Location within a disaster site may also determine whether and how severely children are affected. In the 1995 bombing of the Murrah Federal Building, 16 of the 19 children who died were near a window in the daycare center, whereas in the 2001 attack on the Pentagon, no children were injured or died because the daycare center was not in the part of the building struck by the aircraft.

The proportion of pediatric patients affected by disaster also depends on the type of disaster. Children are more likely than

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adults to drown, particularly with rapidly rising and moving water, as was the case in the 2004 Indian Ocean Tsunami in which proportionately more children than adults were swept away by the powerful ocean wave. Pediatric casualties were much lower during Hurricane Katrina in which waters rose relatively slowly and caregivers were generally able to keep children safe. Children are less likely to know what to do to protect themselves from fire and smoke. They are more likely than adults to sustain serious head and multisystem organ injury due to blunt trauma from flying and falling debris, such as from earthquakes and explosions, because they are less likely to protect themselves and because of the relatively close proximity of their organs. If trapped within the debris from a disaster, children may be in spaces that are very small and therefore may be more easily overlooked in search and rescue efforts.

Children can be more susceptible to the toxicity of biologic, chemical, and radioactive agents than adults are and, consequently, can be the first to manifest the effects of these agents. Young children exposed to infectious agents often become ill before adults do because their exposure is greater, because their immune systems are less mature, and because they may not yet be fully immunized. Children have also been shown to be more likely to spread infectious diseases given their close proximity to each other in school and daycare and poor hygiene. They are more vulnerable to chemical agents, such as nerve gases, not only because children have a greater surface area to mass ratio and a higher respiratory rate but also because most of these agents are heavier than oxygen, thus are at highest concentration in the air that children breathe.³ Children exposed to ionizing radiation, similar to nerve gases, will inhale relatively higher doses and are more likely to manifest radiation sickness in the short term because these effects correlate directly with the rate of cell division and inversely with the extent of cell differentiation and malignancy in the long-term because of DNA damage that results in malignancy.⁴ They are also more affected by extremes of temperature and more susceptible to dehydration. The presence of a hazardous environment and less adult supervision lead to injury, ingestion, and infection.

DISASTER RESPONSE

Response to disaster by health care providers must include disaster site, hospital, and community-based responses that consider not only pediatric victims but also the facilities to care for them.

Federally coordinated civilian health care provider disaster site response is provided by the National Disaster Medical System in the form of Disaster Medical Assistance Teams (DMATs), pediatric specialty DMATs, and hospitals throughout the country contracted to accept pediatric disaster victims.^{2,5,6} Although most states have several DMATs, there are only 2 pediatric specialty teams, Boston, MA, and Atlanta, GA.

Hospital disaster response poses pediatric-specific challenges regarding care of those who present to the hospital, as well as those who must be discharged or transferred from a hospital that has been compromised by disaster. The number of hospitals equipped and staffed to care for children is limited compared with hospitals for adults, particularly for children with serious and/or complex acute and/or chronic conditions. Furthermore, staffing demands are greater for children than adults. Children require caregivers and/or community providers including emergency medical services, fire, police, or military to get them to the hospital. Caregivers often seek care for children before themselves but understandably do not want to leave their children to obtain care elsewhere. Therefore, hospital personnel at children's hospitals must be prepared to recognize, evaluate, and treat health care needs of adults. Children without caregivers, particularly if they are nonverbal, will provide little or no information regarding past or present medical history. Identification tags must be childproof so that children cannot remove them and must be checked with each intervention to confirm identification. Decontamination, if necessary, requires facilities with special considerations for children. In addition to the usual health care providers required for medical care, children without caregivers will require personnel, potentially volunteers from community agencies and schools, to provide supervision and perform routine caregiver functions. A caregiver or authorized community disaster care provider is also required to discharge a child from the hospital, and if not available, on-site accommodation may be necessary. Critically ill or injured pediatric victims and those with serious and/or rare conditions who must be transferred from a full or compromised hospital will require highly skilled transport, possibly to a distant hospital. Routine drills are essential for training and optimizing the hospital disaster plan. Coordination with local hospitals is essential for efficient use of resources and, for those institutions that are not pediatric centers, should include planning and training for pediatric disaster victims.

Community-based pediatricians, physician assistants, nurse practitioners, and nurses are critical, yet at this time underinvolved constituencies with an essential role in family disaster preparedness and immediate and long-term management of pediatric disaster victims.⁷ Disaster preparedness plans are necessary for all children and should be personalized for those with special needs and/or chronic medical problems. Immediately postdisaster, pediatric health care professionals, as part of a disaster plan, can evaluate and treat less seriously injured or ill pediatric victims at local hospitals and/or community facilities converted into disaster response centers, as well as provide follow-up for victims cared for and released from hospitals. Providers may be called upon to take care of children who have been temporarily or permanently relocated from their homes, some without medical records and/or medical insurance, as was the case after Hurricanes Katrina and Rita in 2005 and Ike in 2007.

Optimal pediatric disaster planning and response requires a private and public partnership of all provider groups at local, state, and national levels and should include all professional organizations, government agencies, and advocacy groups that have a role in the welfare of children and the training of health care personnel, first responders, and volunteers.

PEDIATRIC CONSIDERATIONS REGARDING INJURY AND ILLNESS

Unique aspects of pediatric injury and illness must be recognized and anticipated.⁸ For distant disasters, response teams will not be on-site soon enough to take care of critically injured victims. For disasters, triage must be based on doing the most good for the greatest number of patients. Recognition of anatomic and physiologic differences in children is essential for appropriate evaluation and management. Training and preparation must include decision making and clinical skills support for rare, serious events. After the first few days, needs shift from patients who require care for injuries sustained during the disaster to injury and illness secondary to the hazardous and unsanitary, crowded conditions resulting from the disaster. Lack of basic supplies, such as formula and diapers, may lead to dehydration and skin rashes in infants. Chronic medical conditions may go untreated and become more acute. Births are not only ongoing, but the stress of disaster may result in an increase rate of premature births. Psychologic stress and psychiatric decompensation resulting from injury, illness, fear, disruption of the physical and psychosocial

environment, as well as perceived threats to safety may manifest in ways that are subtle and may go unrecognized in children.⁹ Reuniting children with relatives, not leaving them alone, providing basic needs, and attempting to address their fears are an important part of their care.

FUTURE PROMISES

The future of pediatric disaster medicine will benefit by technological advances, many of which are in development and/or early use. Search and rescue devices, such as microrobots or radio-frequency ID tags with optical, audio, thermal, and/or vibration sensors able to locate disaster victims, including those trapped in small spaces, will make children easier to detect amidst debris. Electronic tracking devices and networked communication between hospitals and emergency medical services to coordinate pediatric transport and facility availability can optimize efficient use of these limited resources.

Electronic medical records will be particularly beneficial for pediatric patients whose identity can be established but are brought to care by individuals unfamiliar with their medical history. Use of electronic medical records to detail evaluation and management at the disaster site, during transport, and at the hospital will improve the quality, safety, and efficiency of care. Electronic triage and non-invasive continuous physiologic monitoring with electronic reporting will facilitate, expedite, and improve the accuracy of triage assessment and allow ongoing monitoring and prioritization of the appropriate resources for the appropriate patient at the appropriate time. Bedside laboratory devices and ultrasound will greatly enhance diagnosis and guide treatment and disposition.

Computer decision support, such as the Children's Hospital of Los Angeles virtual disaster program, is being developed to provide real-time expert consultation to disaster site providers regarding situation and patient management.¹⁰ Surveillance systems that detect trends will pick up early signs of an infectious, chemical, and radioactive agent, which is particularly important for pediatric providers because effects usually manifest in children before they do in adults. Computerized facial recognition and online reunification resources will dramatically expedite bringing families together, which, for children, is critical to minimizing short- and long-term medical and psychosocial effects.

Online pediatric disaster resources, such as those being developed by Children's Hospital of Los

Angeles, include software that guides hospital disaster response planners through best practices for disaster planning as well as training modules on planning, disaster preparedness, and response; patient care; and disaster management for pediatric victims.^{10,11} The American Academy of Pediatrics resources include disaster preparedness information and training for pediatricians,^{12,13} and pre-hospital professionals.¹⁴ Simulation training, available at many major centers, provides opportunities to teach complex decision making, procedures, and teamwork. It is particularly valuable for rare event training and to cross-train personnel with limited pediatric experience.

Research in pediatric transport, emergency, and critical care that elucidates pathophysiology and evaluates approaches to evaluation and management is crucial for to improving care of pediatric disaster victims. Important areas for research include effectiveness of devices such as the laryngeal mask airway and laryngoscope videography for endotracheal tube placement, effective cardiopulmonary resuscitation, appropriate fluid management, management of specific disaster related injury and illness, and systems operational issues.

Perhaps the most important lesson learned from disasters affecting children is that each lesson provides an opportunity to improve disaster response, optimize approaches to evaluation and management of pediatric disaster victims, mitigate the short- and long-term effects of disaster, and prevent future disasters. ☒

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