



# Disaster Preparedness in Neonatal Intensive Care Units

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Disasters disproportionately affect vulnerable, technology-dependent people, including preterm and critically ill newborn infants. It is important for health care providers to be aware of and prepared for the potential consequences of disasters for the NICU. Neonatal intensive care personnel can provide specialized expertise for their hospital, community, and regional emergency preparedness plans and can help develop institutional surge capacity for mass critical care, including equipment, medications, personnel, and facility resources.

Disasters, whether natural or man-made, are especially threatening to the lives of people who are technology dependent. This is particularly true in the NICU. During a disaster, the provision of highly skilled and specialized care for preterm and critically ill newborn infants can be compromised by the loss of electrical power, physical facilities, specialized equipment, personnel, and other resources that can occur as a result of environmental disruption or large-scale illness, injury, or trauma. There is a paucity of data regarding the effect of disasters on the NICU population and practice implications for providers within the health care system.<sup>1</sup>

This clinical report first briefly reviews disasters that have affected NICUs in the United States and then examines how organizing concepts of mass critical care in pediatrics can be applied to the NICU, including the role of regionalized perinatal systems; disaster-based drills; and training, equipment, medication, and personnel needs. The objective of this report is to help neonatologists and other NICU providers and administrative leaders understand these organizing concepts and develop response plans within their units, hospital institutions, and geographic regions. This report builds on existing American Academy of Pediatrics policies concerning children in disasters, with a focus on the extremely vulnerable NICU population, and also discusses ethical issues related to surge capacity, altered standards, and atypical locations of care, evacuation, triage, and transport.

## abstract

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**TABLE 1** Examples of Disaster Effects on NICU Populations

Disaster Type	General Examples	Potential Effects on NICU Patients
Natural disaster	Hurricane Katrina, Superstorm Sandy	Loss of electrical power and life-sustaining equipment Particulate matter or droplets from debris that can affect skin or airways <sup>a,b</sup> Increased risk of infection or injury during transfer or evacuation to another hospital Exposure to temperature extremes; inability to minimize effects of conduction, convection, evaporation, and radiation Constraints on adequate nutrition/caloric intake Limited medication doses available Increased risk of neonatal conditions related to maternal stress Loss of clean water Possible carbon monoxide poisoning from generators
Industrial disaster	Radiologic disasters, chemical spills	Disruption of fetus'/infant's growing organ systems Radiation/carcinogen exposure that may lead to long-term effects Contamination of water sources
Pandemic infectious diseases	H1N1 influenza, Ebola virus disease, Zika virus	Infection control and medical countermeasure challenges Need for patient isolation Increased maternal illness, preterm birth, or birth defects Risk to first responders, hospital staff, and caregivers
Bioterrorist event	2001 anthrax attacks, aerosol release of smallpox, 1995 sarin attack in Tokyo subway	Nonspecific syndromic symptoms Limited access to postexposure vaccination Selection criteria for administering vaccine Jeopardized safety of first-response team

<sup>a</sup> <http://pediatrics.aappublications.org/content/early/2015/10/13/peds.2015-3112.long>.

<sup>b</sup> [www.fs.fed.us/rm/value/docs/health\\_economic\\_impact\\_wildfire.pdf](http://www.fs.fed.us/rm/value/docs/health_economic_impact_wildfire.pdf).

## BACKGROUND

A disaster is defined as a sudden, calamitous event, natural or man-made, that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources.<sup>2</sup> NICU patients are particularly vulnerable, not only because of their small size and physiologic immaturity, but also because of their baseline dependence on technology for warmth, nutritional supplementation, medication administration, cardiorespiratory monitoring, diagnostic information gathering, and life-sustaining physiologic support. Disasters not only can cause direct danger or injury to NICU patients, but may also affect their caregivers, parents, and families. Disasters may disrupt a NICU patient's protective surroundings, including light, warmth, electricity, oxygen, and air as well as diagnostic and therapeutic resources, such as medications, cardiorespiratory

monitors, incubators, ventilators, blood gas machines, and imaging devices. Different types of disasters may affect NICU operations and capabilities in different ways (Table 1).

### Natural Disasters (Hurricanes, Earthquakes, Superstorms, and Wildfires)

Hurricane Katrina was one of the largest threats to NICU patients in US history, because it disabled the health care system's ability to provide adequate care in a large, densely populated area because of the loss of supplies, personnel, communications, and infrastructure.<sup>3</sup> Hurricane Katrina caused extensive flood damage and electrical power loss to hospitals caring for critically ill newborn infants and resulted in mass evacuation efforts that were suboptimally coordinated.<sup>4</sup> Although all neonates in the affected hospitals survived, and many hospitals received evacuated neonates, there was a surge in NICU patients at the hospital receiving the most transports from the affected area, from 55 to 125 patients in 3

days.<sup>4</sup> This event illustrated the need for advance development of systemwide plans for maintenance of neonatal critical care under adverse conditions, local and regional neonatal care coordination and communication, interfacility patient transport, and NICU evacuation because of extensive flood damage and hospital closures.<sup>5</sup>

Hurricane Sandy also affected providers' ability to care for women with high-risk pregnancies and newborn infants in metropolitan New York.<sup>6-8</sup> However, in this instance, when Hurricane Sandy caused a power outage in a New York City medical center, 21 neonates were evacuated to other hospitals in the city in less than 5 hours. These transfers were accomplished with no known mortalities, which may be credited to that medical center's advance planning, with a clear command structure, overall regional coordination, and the availability of backups in the form of personnel, information, and equipment.<sup>6</sup>

## **Infectious Epidemics (H1N1 Pandemic Influenza, Ebola Virus Disease, and Other Emerging Infections)**

Infectious disease outbreaks and pandemics may uniquely and disproportionately affect pregnant women and their fetuses as well as newborn and critically ill infants.<sup>9,10</sup> For example, the H1N1 influenza pandemic in 2009 was associated with significantly increased morbidity and mortality in otherwise healthy pregnant women and their infants. In addition, experts identified a potential risk of transmission from infected health care workers, family members, and mothers of high-risk newborn infants.<sup>11</sup> Most recently, Zika virus, a *Flavivirus* transmitted by *Aedes* mosquitoes, has been associated with significant congenital central nervous system abnormalities, including microcephaly, in some newborn infants of women infected during pregnancy.<sup>12,13</sup> Other emerging infections, such as Ebola, are rare, but can have severe effects; viral hemorrhagic fevers pose significant mortality risks to pregnant, laboring, and postpartum women, who may experience substantial bleeding and multiorgan system failure.<sup>14</sup> To date, the survival of newborn infants delivered to women with confirmed Ebola virus disease is poor; although the mechanism is not well understood, most infants are stillborn or die in the early neonatal period.<sup>15-17</sup> Strict adherence to infection control practices and the use of protective personnel equipment are critical for the safety of patients, family members, hospital staff, and the community.<sup>18</sup>

## **Bioterrorism (Anthrax, Smallpox, Other Biological Weapons, and Chemical Agents)**

Certain biological or chemical agents dispersed by accident or intentionally would leave neonatal populations particularly vulnerable, because signs and symptoms in the

newborn infant may be systemic and nonspecific. For example, anthrax (*Bacillus anthracis* infection) can present in several different ways because of multiple routes of infection (inhalational, cutaneous, and gastrointestinal). Infection can rapidly progress to systemic disease, which has a high mortality rate and requires rapid initiation of postexposure prophylaxis and/or antimicrobial treatment.<sup>19</sup> Data on anthrax in newborn populations are limited.<sup>20-22</sup> Many biologic (eg, plague and smallpox) or radiologic (eg, radioactive iodine) agents target dividing cells; therefore, the mass dispersion of such agents would particularly adversely affect growing children, especially infants.<sup>23,24</sup>

## **Defining Emergency Mass Critical Care for NICUs**

Emergency mass critical care (EMCC) is defined as the immediate need for critical care resources, including staff, medical equipment, supplies, medications, and ICU space, to provide timely, effective care to a large population surge of critically ill victims during a disaster.<sup>25</sup> A mass casualty critical care event affecting the NICU may put many vulnerable patients at risk for limited life-sustaining interventions because of deficiencies in facilities, supplies, or staffing. If disaster events are prolonged, they can also affect the abilities of responders to provide sustained care for those affected. For optimal care of vulnerable NICU patients, specific advance plans for their acute care, stabilization, triage, transfer, and evacuation must be put in place. In 2010, a select pediatric task force developed a framework of pediatric EMCC capable of tripling critical care capabilities for a period of up to 10 days.<sup>26</sup> The unique challenges presented by pregnant women, newborn infants, and NICU patients were acknowledged, including concerns for surge capacity among these vulnerable populations.<sup>1,27</sup> Targeted surge

capacity may be required in hospitals at varying distances from the affected hospital, depending on the nature of the disaster, so community and regional plans should be coordinated if possible.

During large and/or prolonged public health emergencies, crisis standards of care may be necessary. Crisis standards are defined as substantial changes in usual health care operations and the level of care delivered, made necessary by a pervasive or catastrophic disaster.<sup>28</sup> The institution of these standards is intended to optimize population outcomes rather than individual survival. In this scenario, available resources (eg, medications, ventilators, and staff) may become limited and could be substituted, adapted, or reallocated. Preparation for EMCC in NICUs must consider whether the initiation of life-saving interventions can be sustained in the context of a disaster scenario with limited resources as well as the effect on long-term survival. Changes in care and the ways in which such care is delivered may be made necessary by the nature of the disaster. In such circumstances, state and federal governmental entities may take steps to limit or eliminate some legal obligations and liabilities.<sup>28-31</sup> Therefore, coordinated planning with the hospital facility, community, state, and region is essential in preparing for disasters in NICUs.

## **THE ROLE OF NICU PROVIDERS IN EMCC PLANNING**

### **Developing a Plan**

Most NICUs are part of a larger department (eg, pediatrics or obstetrics) within an even larger facility (general or children's hospital). Nevertheless, a 2008 survey of US hospitals found that, although most facilities had memoranda of understanding between hospitals to transfer adult patients during an epidemic,

fewer hospitals had memoranda of understanding for pediatric patients; in 2014, fewer than half of hospitals with an emergency department had a disaster plan for children.<sup>32,33</sup>

Improving disaster preparedness for critically ill newborn infants will require neonatal care providers to participate in the larger plan of emergency preparedness within hospitals, communities, states, and regions. In certain disasters, the personnel and equipment necessary to care for critically ill patients may need to come from other facilities, including those across state lines, which may require plans for shared clinical credentialing within a region. When a governor declares a state of emergency and federal public health and medical resources are activated, licensed providers (physicians, nurses, pharmacists, and respiratory therapists) on emergency medical response teams from other regions can provide care to affected areas.<sup>34</sup> Therefore, regional plans may include a method to determine specific competencies within facilities so patients can be transferred to centers with appropriate capabilities.<sup>35</sup>

Several useful resources are available to help clinicians and hospitals prepare for disasters.

1. The Emergency Medical Services for Children Innovation and Improvement Center (<https://emscimprovement.center/>): This center is supported by the Health Resources and Services Administration of the US Department of Health and Human Services, and provides a comprehensive database of resources for pediatric disaster preparedness.
2. The California Hospital Association's Hospital Preparedness Program ([www.calhospitalprepare.org/](http://www.calhospitalprepare.org/)): This program is funded by the Office of the Assistant Secretary for Preparedness and Response ([www.phe.gov/about/pages/](http://www.phe.gov/about/pages/)

[default.aspx](http://default.aspx)) to support California hospitals and other health systems in an all-hazards disaster planning approach. The Web site contains a large selection of resources for facility, regional, and state planning, including disaster drills, classes, and draft agreements. In addition to an annual conference, California Hospital Association's Hospital Preparedness Program provides classes and technical assistance and warehouses other regional, state, and federal resources.

3. The Pediatric Preparedness Resource Kit of the American Academy of Pediatrics ([www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Children-and-Disasters/Documents/PedPreparednessKit.pdf](http://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Children-and-Disasters/Documents/PedPreparednessKit.pdf)): This kit was developed to encourage partnerships and joint decision-making between pediatricians and state and/or local health department representatives, and includes information and strategies to promote strategic communications and effective messaging in disasters.
4. The New York City Pediatric Disaster Coalition's customizable Neonatal Critical Care Surge Capacity Plan ([www.programinfosite.com/peds/files/2012/12/Pediatric-Disaster-Coalition-Template-NICU-Surge-Plan-docx.pdf](http://www.programinfosite.com/peds/files/2012/12/Pediatric-Disaster-Coalition-Template-NICU-Surge-Plan-docx.pdf)): This plan provides a template for improving disaster-related surge capacity. The document outlines topics such as creating a rapid discharge team, enlisting additional staff, and ensuring availability of medications, code carts, and decontamination operations.
5. The Technical Resources, Assistance Center, and Information Exchange (TRACIE; <https://asprtracie.hhs.gov/>): This program is operated by the US Department of Health and Human Services, Office of the Assistant

Secretary for Preparedness and Response, to address disaster medicine and emergency preparedness inquiries from health care providers and entities.

6. The National Library of Medicine Disaster Information Management Research Center (<https://disaster.nlm.nih.gov>): This site provides the most recent research regarding disaster impact and preparedness, emergency readiness tools, and research resources.
7. The Centers for Disease Control and Prevention (CDC) ([www.cdc.gov](http://www.cdc.gov)): In addition to Web resources, the CDC provides technical assistance in response to public inquiries and clinician outreach calls as well as direct technical assistance for outbreak investigation and reporting and surveillance of disasters.

### **NICU Emergency Preparedness Plans**

Developing and maintaining NICU emergency preparedness plans that include consideration of the total hospital patient populations, as well as community and regional resources, can improve the capacity to care for critically ill newborn infants during a disaster. Given the need of many NICU patients for intense technology support, planning for sufficient power during a disaster is critical, including backup generators. Backup power sources must be located in safe locations (protected by appropriate construction in earthquake-prone areas and high enough off the ground in flood-prone areas). Planning can also include discharge of relatively healthy newborn infants to the mother and family, with follow-up with a primary care provider, or transfer of convalescent patients to lower-level facilities.<sup>35</sup> In some circumstances, complete NICU evacuation may be indicated.

Certain epidemics (eg, H1N1) may disproportionately affect the population of pregnant women and may increase preterm deliveries and the need for NICU care.<sup>36</sup> Disasters may also increase demand for specialized equipment, such as ventilators, to care for all critically ill patients and may limit equipment and staffing available to newborn infants.<sup>37</sup> Because NICU bed capacity is not necessarily determined by a regional need-based formula, the strain of a major disaster could affect NICU resources in an unpredictable manner.<sup>38</sup>

### **Staffing Support for Safe and Effective Operations During a Disaster**

Planning for a sustained disaster event involves calculating potential surge capacity, usually considered to be the ability to handle up to 3 times a facility's maximum capacity for a period of 10 days.<sup>26,27</sup> Because staff with highly specialized skills may be particularly limited during prolonged disaster situations, it is important to consider cross-training staff for the care of recovering preterm or critically ill infants. These care providers may include staff from other areas of the hospital who have either received training in advance or "just in time" to provide EMCC.<sup>39</sup> Cross-training of primary care pediatric, surgical, or ICU staff also may help to build surge capacity and institutional resilience. Clinical staff from other hospitals, including local volunteer groups or the Medical Reserve Corps, may be available.<sup>34</sup> Patient-provider ratios in disasters may need to be altered from the usual standards to address the needs of a larger number of patients. Depending on the type of disaster, alternative provider configurations (eg, non-NICU staff) may need to be considered.

Several hospitals have developed and tested disaster preparedness systems.<sup>40</sup> The Good Samaritan

Hospital in Northern California developed a series of templates to assist in emergency operations, including staffing, bedside backpacks, mobile disaster boxes, and premade forms (eg, "go-kits") to document patient care (available at: [www.calhospitalprepare.org/continuity-planning](http://www.calhospitalprepare.org/continuity-planning)). These hospitals also provide resources for testing equipment, rotating inventory, and training staff in developing response protocols. The St Louis Children's Hospital has improved communication among physicians and families concerning bed availability and patient transport and has piloted a new computer-based bed management system to accelerate patient placement and service (BJC HealthCare, St. Louis Children's Hospital; available at: [www.stlouischildrens.org/health-care-professionals/publications/doctors-digest/january-2012/surge-plan-readies-hospital-perio](http://www.stlouischildrens.org/health-care-professionals/publications/doctors-digest/january-2012/surge-plan-readies-hospital-perio).)

Drills and exercises are important components of maintaining disaster readiness among NICU providers and staff, modifying scenarios and objectives for specific situations. The Federal Emergency Management Agency's Community Emergency Response Team drills and exercises ([www.fema.gov/media-library/assets/documents/27997](http://www.fema.gov/media-library/assets/documents/27997)) are an excellent resource. These full-scale exercises include a sample scenario, the use of volunteers from outside agencies to fill various victim roles, altered site logistics, and postexercise feedback for participants. These exercises could be tailored to include NICU patients.

### **Family Care During Disasters**

During major disasters, providers may need to identify and address additional psychosocial needs of family members beyond what may be anticipated in nondisaster settings.<sup>41-46</sup> Providers should consider and plan for the possibility that either the disaster itself or

medical necessity will result in infants being separated from their mothers and/or other family members. Lessons learned from previous disasters include challenges because of forced relocation or evacuation, staffing shortages, and security concerns. Keeping mother and baby together is important to support bonding and breastfeeding. Opportunities to incorporate family-centered care principles should be considered because family members could assist in routine care and feeding of their infants during critical staff shortages.<sup>41</sup> When keeping the maternal-infant dyad together is not possible, a tracking system for patients who have been transferred should be in place. Safety and security should also be considered in disasters because standard modes of patient visitation may be compromised. In infectious outbreaks, if isolation is necessary, a postpartum mother and her newborn should be placed in isolation together if medically feasible. If separation is unavoidable, parents should receive written documentation of where their infant will be and how to contact their child's care providers.<sup>42</sup> Multiple family contact numbers should be obtained and kept with the infant's record, and efforts should be made to maintain contact with the parents and keep them as involved as possible in decision-making around the care of the infant.<sup>43</sup> Disaster planning should also include consideration of the psychosocial needs of families, who likely are already considerably stressed as a result of their critically ill child. Primary care providers should be considered as a potential resource for supporting affected families.<sup>44-46</sup>

### **Transfer/Evacuation**

Because transfer of patients to unaffected locations or evacuation of both patients and personnel may be necessary in disasters, such plans should be arranged in advance

whenever possible. NICU evacuation planning should ensure coordinated communication with transport teams and receiving hospitals. Planning may also include the use of specialized equipment (eg, moveable incubators or multiinfant carriers) for difficult terrain (eg, stairs). Planning should also prepare for possible separation of infants from their parents, families, or guardians. Evacuation plans should include a mechanism to identify and track NICU patients and caregivers during and after the disaster. Examples of evacuations plans specific to newborn infants include:

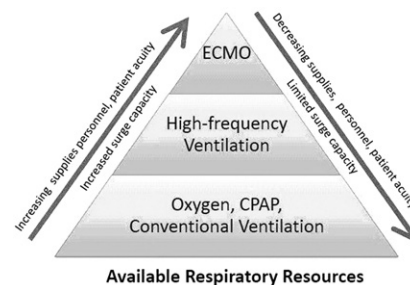
1. The New York City Pediatric Disaster Coalition NICU Evacuation Plan: This plan can be tailored to any institution (New York City Pediatric Disaster Coalition: A Plan Outline for NICU Evacuation [www.programinfosite.com/peds/files/2012/12/Pediatric-Disaster-Coalition-Template-NICU-Evacuation-Plan.pdf]). The plan outline includes maintaining emergency equipment, establishing a chain of command for urgent and nonurgent evacuations, assigning staff roles, and establishing designated evacuation areas.
2. A NICU/nursery evacuation tabletop exercise toolkit, created by Illinois Emergency Medical Services for Children, based on the Homeland Security Exercise and Evaluation Program (Illinois Emergency Medical Services for Children: NICU/Nursery Evacuation Tabletop Exercise Toolkit. 2013 [www.luhs.org/depts/emsc/NICU\_Nursery\_EvacuationTTX\_Toolkit\_FINAL.pdf]). These tabletop exercises are designed for training staff, gathering information to educate and improve emergency plans and responses, and identifying weaknesses in existing plans.

### Sharing Resources With Hospital and Community

A mass critical care event may require a shift or reallocation of technology resources (Fig 1). Pooling resources from other departments and hospitals may also enable the provision of a more sustained response to an emergency. In the event of a major loss or depletion of medical countermeasures (MCMs), such as vaccines, antidotes, medications, and equipment, regional authorities can request support from the US Department of Health and Human Services, including support for the care of critically ill newborn infants. A national cache of medical supplies for use in disasters, the “Strategic National Stockpile,” is maintained and can be dispersed as authorized by the CDC.<sup>47</sup>

### Medical Countermeasures

In addition to maintaining surge capacity, there may be situations in which MCMs are warranted. MCMs are defined as medications, antitoxins, vaccines, immunoglobulins, medical devices, and age-appropriate life-saving medical equipment required to protect or treat children for possible chemical, biological, radiologic, nuclear, or explosive threats.<sup>48</sup> For example, during the H1N1 pandemic, the US Food and Drug Administration (FDA) provided emergency use authorization of oseltamivir for infants younger than 1 year of age.<sup>49</sup> In addition, in December 2012, the FDA approved raxibacumab to prevent and treat inhalational anthrax in adult and pediatric populations, using human safety and animal efficacy study results.<sup>50</sup> Although such emergency dosing may be warranted in disasters, additional research is needed to appropriately measure antimicrobial concentrations and assess the efficacy and safety of MCMs in newborn infants, including preterm infants. Agencies, such as the FDA,



**FIGURE 1**

Model of decision-making based on available supplies: example using respiratory support. The figure shows a model of decision-making based on available supplies, personnel, patient acuity, and surge capacity for pediatric EMCC. CPAP, continuous positive airway pressure; ECMO, extracorporeal membrane oxygenation. Reproduced with permission from Bohn D, Kanter RK, Burns J, Barfield WD, Kissoon N. Supplies and equipment for pediatric emergency mass critical care. *Pediatr Crit Care Med*. 2011;12(suppl 6):S120–S127. Copyright © 2011 Wolters Kluwer Health.

the CDC, and the National Institutes of Health, can collaborate to make specific medications available as needed during disasters, through state public health agencies. The Biomedical Advanced Research and Development Authority develops and procures needed MCMs against a broad array of public health threats, whether natural or intentional in origin. To meet the needs of neonates and children exposed to public health emergencies, sufficient amounts of MCMs appropriate for children of all ages should be present in caches, such as the Strategic National Stockpile.<sup>37,47</sup>

### Nutrition and Human Milk

Nutritional supplies for NICU patients may become strained in disasters because of limited supplies of parenteral and enteral nutrition, including infant formula, supplemental vitamins, and trace elements. Agencies, such as the Supplemental Nutrition Program for Women, Infants, and Children, state health departments through the Maternal Child Health Bureau’s Title V programs, milk banks, and private organizations, can assist with the provision of nutritional supplies.

Whenever feasible, a mother's own milk should be made available to infants, particularly those who are critically ill, because it is the safest form of nutrition in a disaster.

### **Ethical Considerations**

Ethical dilemmas exist in the routine care of extremely preterm and medically complex infants,<sup>51,52</sup> but additional challenges occur during disasters. Ethics in medical practice include 4 key principles: (1) respect for autonomy; (2) nonmaleficence ("do no harm"); (3) beneficence; and (4) justice. During a disaster, the principle of justice becomes dominant, with 2 ethical theories mostly considered. The first theory, utilitarianism, states that actions are correct if they provide the greatest good for the greatest number of people. The second theory, egalitarianism, stresses equal distribution of resources for all individuals. These theories can be considered for a hospital's decision matrix to guide ethical questions and resolutions during a disaster.<sup>53-55</sup>

Providing a specific approach to ethical decision-making during disasters has been challenging. In 2010, the Pediatric Emergency Mass Critical Care Task Force met to discuss recommendations for US pediatric surge planning and allocation of resources.<sup>56</sup> The Task Force acknowledged the need for an objective tool to help predict the benefit of resource use. However, it noted that developing a reliable tool was challenging given the dependence of many tools on the use of technology for assessment (eg, response to ventilator support). The Task Force was reluctant to recommend expert opinion as a way to allocate limited resources and instead suggested either a system of queuing (eg, first come, first served) or lottery.

Nevertheless, NICU teams have a duty and opportunity to plan and anticipate ethical considerations

before disasters. Because hospital ethics committees serve as advisory boards during dilemmas in neonatal care under standard operating conditions, these committees should become more familiar with potential disaster scenarios and assist with decisions in mass critical care, including altered standards of care and withholding or withdrawing life-sustaining treatment.<sup>28,57</sup> In disaster conditions, decisions for initiation or continuation of medical care may shift from the needs of the individual to the needs of the wider community, because decision-makers must determine how to allocate resources in a way that is substantial to all in need.<sup>54,56</sup> If decisions are made not to initiate or to withdraw support, families should be counseled and infants should be provided comfort care.<sup>57</sup>

### **Recovery From Prolonged Disaster Events**

A disaster is a significant stressor, not only for patients and families, but also for NICU staff. In addition to the personal and family impact of a disaster, staff may be affected by their prolonged efforts and by the anguish of not being able to deliver usual intensive care and the resulting influence on patient outcomes. There are unique aspects that confront providers in an ICU setting in the context of a disaster. Altered standards of care include triage; decisions made because of limited resources may result in the death or disability of critically ill infants who might have otherwise survived under usual circumstances. Facing these difficult decisions may be extremely stressful to providers. It is important to consider the length of shifts, the length of response, incorporation of breaks, and psychosocial support of staff and their families. After a disaster event, the need for staff debriefing and counseling should be anticipated. Self-care, both during and after the event, is an important aspect of maintaining resilience in

disasters.<sup>58,59</sup> When possible in a prolonged disaster, relief teams can be brought in to allow respite for the on-site caretakers. Lastly, NICU providers will benefit from family preparedness planning before a disaster event because they will be better able to address the needs of patients and be aware of the well-being of loved ones.

### **CONCLUSIONS**

Infants in the NICU are highly vulnerable in a disaster because of their need for specialized and highly technical support. As such, NICU preparedness is required for optimal disaster response.

1. Preparation before a disaster event is critical to optimizing outcomes of NICU patients during public health emergencies and disasters. Health care institutions and providers are strongly encouraged to know and prepare for the most likely disaster scenarios in their communities (eg, hurricane, earthquake, or flood) and also to consider unanticipated events (eg, bioterrorism) that could create a mass casualty event and similarly affect surge capacity and capabilities.
2. It is important for NICU teams to fully participate in the emergency- and disaster-planning activities of their facility, health care system, or regional, state, and local emergency management agency. Teams should be part of the periodic disaster simulation drills that are now required in every hospital. NICU teams should actively participate in the design of hospital drills to address the unique needs of NICU patients in situations involving "shelter-in-place," relocation, and/or evacuation. The use of an incident command structure within the NICU, facility, and community is

important to maintain structure and an organized response.

3. Neonatal care systems (providers, administration, information technology, and equipment) can develop appropriate staffing support for safe and effective operations during disasters. NICU care providers, in collaboration with their hospital facility, community practitioners, network, and region, need to identify the surge capacity to provide 3 times the baseline critical care resources and sustain this for 10 days during a major public health disaster. An effective response to specific disaster threats, including maintenance of adequate surge capacity, relies on sufficient supplies of age- and size-appropriate MCMs.
4. During a disaster, neonatal care providers can maintain situational awareness for decision-making, including patient volume and severity of illness, available equipment, medication, and staffing, transport, evacuation, recovery, and crisis standards of care. Maintaining flexibility is important in adjusting to new situations. Advance planning and coordination with local and state public health and emergency management agencies will additionally support situational awareness and timely decision-making. A process of ethical decision-making and altered standards of care needs to be included in disaster planning.
5. In addition to the needs of patients, NICU providers may need to consider the medical and psychosocial needs of postpartum

mothers and families. To the extent it is feasible, parents and families should remain in contact with patients. Families may have unique needs and/or require assistance in unusual ways during a large-scale disaster. In addition, plans should be made to recognize and respond to the needs of NICU staff, including self-care and support.

6. Although some guidance in this report is based on systematic reviews (eg, H1N1 and mass critical care), much is based on lessons learned from previous disaster events. Preparedness is an ongoing process that changes on the basis of learned experience and evidence. NICU providers should continue to research best practices, neonatal medications and dosing, and the effects of altered standards of care in disasters.

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#### ABBREVIATIONS

CDC: Centers for Disease Control and Prevention  
EMCC: emergency mass critical care  
FDA: Food and Drug Administration  
MCM: medical countermeasure

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