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Neonatal and pediatric regionalized systems in pediatric emergency mass critical care

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Abstract

Introduction—Improved health outcomes are associated with neonatal and pediatric critical care in well-organized, cohesive, regionalized systems that are prepared to support and rehabilitate critically ill victims of a mass casualty event. However, present systems lack adequate surge capacity for neonatal and pediatric mass critical care. In this document, we outline the present reality and suggest alternative approaches.

Methods—In May 2008, the Task Force for Mass Critical Care published guidance on provision of mass critical care to adults. Acknowledging that the critical care needs of children during disasters were unaddressed by this effort, a 17-member Steering Committee, assembled by the Oak Ridge Institute for Science and Education with guidance from members of the American Academy of Pediatrics, convened in April 2009 to determine priority topic areas for pediatric emergency mass critical care recommendations.

Steering Committee members established subcommittees by topic area and performed literature reviews of MEDLINE and Ovid databases. The Steering Committee produced draft outlines through consensus-based study of the literature and convened October 6–7, 2009, in New York, NY, to review and revise each outline. Eight draft documents were subsequently developed from the revised outlines as well as through searches of MEDLINE updated through March 2010.

The Pediatric Emergency Mass Critical Care Task Force, composed of 36 experts from diverse public health, medical, and disaster response fields, convened in Atlanta, GA, on March 29–30,

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2010. Feedback on each manuscript was compiled and the Steering Committee revised each document to reflect expert input in addition to the most current medical literature.

Task Force Recommendations—States and regions (facilitated by federal partners) should review current emergency operations and devise appropriate plans to address the population-based needs of infants and children in large-scale disasters. Action at the state, regional, and federal levels should address legal, operational, and information systems to provide effective pediatric mass critical care through: 1) predisaster/mass casualty planning, management, and assessment with input from child health professionals; 2) close cooperation, agreements, public-private partnerships, and unique delivery systems; and 3) use of existing public health data to assess pediatric populations at risk and to model graded response plans based on increasing patient volume and acuity.

Keywords

emergency mass critical care; influenza pandemic; mass casualty care; pediatric critical care; regional systems of care; surge capacity

In large public health emergencies, such as natural disasters, terrorist attacks, pandemics, and other mass casualty events, population outcomes may depend on our ability to extend intensive care resources to serve unprecedented surges of patients that will overwhelm normal critical care resources. The Task Force on Pediatric Emergency Mass Critical Care (PEMCC) calls for comprehensive plans to provide mass critical care of infants and children in public health emergencies. We endorse and apply the approaches outlined by a similar adult task force (1). In a large public health emergency, critical care resources must be organized to at least triple the numbers of functioning intensive care unit (ICU) beds for infants and children within each region for up to 10 days without outside assistance. Mass critical care would extend essential life-saving interventions, while delaying or forgoing less urgent interventions. All plans must anticipate any type of emergency, whether sudden or sustained.

Pediatric needs in a large public health emergency would exceed the resources of individual facilities and could be served only by using all available resources across a region (2, 3). To facilitate comprehensive planning and to assist decision makers in public health emergencies, this report describes existing resources necessary for PEMCC and the regional organization of these resources. The Task Force recommends improvements that build upon existing regional systems of care.

Regional systems for conventional critical care

Ideally, critical care of infants and children involves a continuum in which prehospital emergency medical service providers respond quickly to a crisis. Resuscitation and stabilization starts at the prehospital site and continues at a nearby emergency department. For low-risk conditions, satisfactory hospital care is often provided at a nearby nonpediatric community hospital. For medically complex children or those with high acuity or high-risk conditions, critical and subspecialty care is provided at a regional pediatric hospital (4–6). In routine circumstances, decisions about the distribution of patients to hospitals are not

determined by clinical criteria only, and may rely on prior or existing specialty care relationships, familiarity, and convenience, especially in children with special healthcare needs. Interests of payers and business affiliations among privately owned healthcare organizations also influence hospital choice (7–10).

Survival is improved when infants and children receive appropriate pediatric critical care (11, 12), neonatal critical care (13, 14), or trauma care at a pediatric or pediatric-capable adult trauma center (15–17). Despite the evidence that specialized pediatric services are beneficial, regional obstacles may interfere with use of existing critical care resources for infants and children even in everyday circumstances (18, 19). Regulation of health care in general and efforts to promote regional systems of care specifically are defined by states in the United States and provinces in Canada. Regulation varies widely, but no comprehensive inventory has been published describing the development or regulation of regional systems of pediatric care across North America.

Regional systems for public health emergencies

Regional systems for responding to public health emergencies are outlined by the U.S. Department of Homeland Security in the National Response Framework and by the Institute of Medicine (20, 21). Emergency operational planning and responses are managed by the immediate jurisdiction. However, events that require consideration of mass critical care would also involve state and federal authority. The Incident Command System provides a decision-making and coordinating process that enables a broad network of agencies to plan and organize emergency responses. The Incident Command System can be scaled to any type or size of event and is compatible with authority at any jurisdictional level. However, the usual chain of command within each participating organization should be maintained, with coordination across organizations and jurisdictions according to the specific emergency. This report considers a “region” in a public health emergency to be a portion of a state functioning under the control of a public health leader. Such local controls are typically located within a county or city department of health operating under the authority of state public health emergency powers (22). Decisions in a public health emergency are made by leaders located at an emergency operations center at a regional, state, or federal level, as discussed in the article, “Pediatric emergency mass critical care: The role of community preparedness.”

Authority is granted by existing laws giving public decision makers temporary emergency power to direct the use of private resources. Authority to implement temporary emergency mass critical care in individual hospitals in a sudden-impact emergency is implied within hospital emergency incident command procedures. However, authority varies from state to state regarding alteration of usual standards of critical care in a sustained emergency mass critical care response. Likewise, at the time of this writing, authority and liability protection in many states is ambiguous with regard to triage allocation (rationing) in emergency mass critical care (see the article, “Legal considerations during pediatric emergency mass critical care events”).

Existing resources for PEMCC

Conventional critical care accommodates seasonal and random variation in ICU occupancy. Normal daily variation in patient volumes, or local seasonal disease outbreak, results in ordinary surges in which ICU needs amount to 110% to 115% of usual peak capacity. An ordinary surge usually is handled within the normal operating procedures of a hospital, and clinical interventions continue as usual. Standards of care during these surges are functionally equivalent to conventional care. In contrast, extending PEMCC to triple the usual numbers of patients requires crisis operating standards as well as crisis standards of care ("altered care standards") that differ from conventional care. Planning for PEMCC must be based on information about existing resources so that they can be organized effectively in a public health emergency. Unfortunately, national information about existing pediatric emergency and critical care resources is limited.

In this section, we provide an overview of published information about existing resources and application of these resources for PEMCC.

Pediatric Prehospital Resources

Performance measures associated with Health Resources and Services Administration Emergency Medical Services for Children grants to states have required improvements in pediatric medical direction for prehospital providers, pediatric equipment in ambulances, identification of hospitals with pediatric emergency capabilities, implementation of interfacility transfer guidelines, and pediatric education of prehospital care providers (23–25). Progress toward these goals varies by state, although systematic reporting has not yet been achieved.

Pediatric Prehospital Resources in Public Health Emergencies

Gaps in pediatric prehospital planning for public health emergencies have been identified (26). Nationwide, 73% of emergency medical service agencies had a written plan for mass casualty responses, but only 13% had plans for a pediatric-specific response, and only 19% had pediatric triage protocols. Although 69% of agencies participated in disaster drills in the previous year, fewer than half of the drills included a pediatric component (26).

While little pediatric-specific experience has been reported in prehospital responses to public health emergencies, it is likely that deficiencies reported for care of the general population in sudden-impact events would also pertain to care of children (27). Transportation of patients to hospitals is often performed by private individuals in a variety of nonambulance vehicles, without field triage, stabilization, or decontamination. These often involve the least severe patients, and they tend to arrive at hospitals first. Prehospital responses by emergency units often lack control by a central dispatching authority and have no influence on the appropriate distribution of patients transported independently of emergency medical services. As a result, hospitals lack vital information on numbers and types of anticipated casualties.

Hospital-Based Pediatric Emergency Resources

In 2006, the Institute of Medicine reported on the status of emergency medical services for children in the United States, noting it to be “uneven” (28). In day-to-day emergency care, nearly 90% of children are brought to an emergency department (ED) in a general hospital by virtue of their location within communities. Among 4,800 U.S. hospitals with full-time EDs, 55% serve fewer than 4,000 children annually and 50% of EDs care for fewer than ten children each day. Among EDs, 53% admit children to their own hospital even though no separate pediatric area is available, while 37% admit to a dedicated pediatric ward within their facility; only 10% have a pediatric ICU (PICU). For those hospitals lacking a PICU, 2.5% of EDs admit children to an adult ICU within their hospital, while the others transport these children to another hospital. Fourteen percent of EDs report having a pediatric trauma service; 4% use other services to care for inpatient trauma at their hospital, while the rest transfer children to other hospitals for trauma care (29, 30).

It is imperative that all hospitals be capable of providing effective emergency care for children of all ages (31). This requires advance planning and the presence of appropriate resources (medications, equipment, supplies, policies, staff training, and continuing education). Hospital ED readiness for children may be facilitated by the presence of a physician and nurse coordinator for pediatric emergency care (29). Improving baseline emergency preparedness is important since it likely translates to improved PEMCC preparedness.

Identification of the appropriate coordinators is important because nationally, 1.6 pediatric emergency medicine physicians each serve 100,000 children. Six states have no board-certified pediatric emergency medicine physician, and only 3% of pediatric emergency medicine physicians practice in rural areas (32). The average population-weighted travel distance to a pediatric emergency medicine physician is 35 miles (75^{th} percentile = 44 miles, 90^{th} percentile = 122 miles) (33).

Pediatric Emergency Resources in Public Health Emergencies

In an Arkansas survey, only 13% of ED directors reported having a pediatric mass casualty protocol, and only 28% of hospitals had pediatric issues incorporated into their disaster plans (34). For trauma-intensive public health emergencies, ED surge capacity may be determined more by trauma service capacity than other ED or inpatient resources. It is estimated that a hospital that can provide five trauma teams can manage 30–40 casualties in the first hours after an incident, including five to seven with injuries needing immediate care (35).

Pediatric Hospital Resources

No national classification of hospitals with respect to levels of pediatric services is available. Therefore, it is difficult to describe pediatric hospital resources and their utilization across the United States. In a study of hospitals in New York State, the most comprehensive pediatric hospitals each served regional populations of 1.7 million (all ages), accounting for care of 29% of pediatric (0–14 yrs) hospitalizations (36). In New York, the comprehensive pediatric hospitals share resources with adult services; only one is a free-standing children’s

hospital. Most children receive hospital care at less comprehensive pediatric facilities, or at nonpediatric hospitals (37, 38).

Pediatric Hospital Resources in Public Health Emergencies

Vacant functioning hospital beds to accommodate public health emergency surges may be identified on the basis of historical daily occupancy and empirical peaks in occupancy (39). New York State provides an average of 268 vacant functioning pediatric beds (ICU plus non-ICU) per million age-specific population (0–14 yrs). Vacancies decline to 193 per million during periods of high baseline occupancy on winter weekdays, and increase to 328 per million during periods of low baseline occupancy on summer weekends. Comparable New York statewide available hospital vacancies for adults are 555 per million age-specific population (seasonal range 328–733 per million).

Pediatric Critical Care Resources

A national survey revealed a peak capacity of 54 PICU beds per million age-specific population (0–17 yrs) (40). Among 349 PICUs reported in 2001, half had no more than eight beds each. Nationally, an average of 1.6 pediatric intensivists serves each 100,000 children, but state-by-state variation is wide (41). No pediatric intensivist was available in Montana or Wyoming, and an additional seven states had less than one intensivist per 100,000 children. Their national distribution results in an average population-weighted travel distance of 26 miles to a pediatric intensivist (75th percentile = 33 miles, 90th percentile = 90 miles) (32).

One hundred seventy verified trauma centers with pediatric capabilities are distributed nationally among 41 states (42). Ground travel distance is no more than 1 hr for 43% of the population, and 72% of the population can reach one of the trauma centers by air within an hour. One-hour access varies from 23% of the population in rural areas to 94% in urban areas. Even with distance as a barrier, outcomes for the youngest and most severely injured children appear to be maximized in pediatric trauma centers (43).

While the number of burn centers dedicated to pediatric care is negligible (40), 128 self-reported and 51 verified burn center hospitals are available nationally (44). Ground transport access is 1 or 2 hrs to a verified burn center for 25% or 46% of the population, respectively. Air transport access is 1 or 2 hrs to a verified burn center for 54% or 79% of the population, respectively. Access tends to be better in the northeastern United States, and worst in the southern United States.

Pediatric Critical Care Resources for Public Health Emergencies

Since the average occupancy for PICUs is 61% (40), fewer than 30 vacant PICU beds per million age-specific population would be available in a sudden-impact public health emergency. Given that pediatric critical care resources are limited, any aspect of a public health emergency that reduces the capabilities at any of the few pediatric facilities may severely degrade pediatric critical care services throughout a region.

Quantitative modeling studies of hypothetical sudden-impact public health emergencies suggest that many more children could be accommodated with better survival if regional

distribution of patients could be controlled to take advantage of all available regional resources instead of overloading facilities near the scene of a sudden-impact incident (45). Regardless of the ability to control patient distribution, PEMCC approaches would increase the probability that large pediatric patient surges could be accommodated, with better population outcomes, in sudden-impact events or in a sustained crisis such as a pandemic (45–47).

Neonatal Critical Care Resources

Regional systems for neonatal critical care were developed decades earlier than pediatric emergency and critical care services. However, regulation of neonatal ICU (NICU) services still varies substantially across states (48). In general, neonatal critical care is provided in units at three levels of care. Units providing the most advanced technology and specialized personnel often share resources with PICUs in the same institution. Among >4.3 million annual births, 6% of newborns receive NICU care because of prematurity, birth defects, or complex maternal conditions requiring urgent delivery (49).

Accurate national counts of NICU bed capacity have not been published. A voluntary report of neonatal beds submitted to the American Academy of Pediatrics, Perinatal Section, estimates 809 level III centers (24,907 beds) and 148 level II centers (1,417 beds) nationally (communication with Dhilip Bhatt, MD, FAAP, American Academy of Pediatrics, Section on Perinatal Pediatrics, December 2009). These estimates indicate wide national variation from <1 NICU bed per 1000 live births in some rural states, to >13 NICU beds per 1000 live births in some urban areas.

The neonatology physician workforce is larger than that for pediatric emergency and critical care, with most states having between three and eight neonatologists per 100,000 children (50). The population-weighted travel distance to a board-certified neonatologist is less than that to other pediatric emergency and critical care services, averaging 15 miles (75th percentile = 44 miles, 90th percentile = 58 miles) (33).

Neonatal Critical Care Resources and Public Health Emergencies

Far less attention has been given to planning for neonatal care than for pediatric and adult critical care in public health emergencies. However, recent experience with the 2009 Influenza A/H1N1 pandemic indicates that conditions involving pregnant women may result in a surge of newborns needing critical care (51). Among 94 pregnant women with influenza A/H1N1 hospitalized in California in 2009, 12 delivered 13 infants during the hospitalization. Eleven of these infants were delivered prematurely, and all 11 were admitted to the NICU, primarily for management of medical complications of preterm birth. Although none of the infants had evidence of influenza, their critical care needs were attributable to maternal illness. In addition, the 2009 Influenza A/H1N1 Pandemic raised important infection control concerns, due to exposure of neonatal care providers to influenza A/H1N1 and spread of the virus in the nursery. Highly contagious infections can affect hospital personnel in PEMCC, and the use of neonatal beds and providers for older children with infectious disorders requires careful planning.

Other Resources

Inventories for many other resources necessary for PEMCC would be helpful to planners and decision makers, but data are not available. Stockpiles of ventilators appropriate for adults and older children have been considered by the adult task force (1), but supplies of ventilators specifically designed for infants are not known (see the article, “Supplies and equipment for pediatric emergency mass critical care”). Likewise, we lack information on a wide variety of other important resources, such as negative pressure isolation beds and resources for interhospital transport.

Pediatric-specific challenges in public health emergencies

Historically, as many as 30% of hospitalized victims of all ages in public health emergencies have required intensive care (52–54). Critical care needs projected by the Department of Homeland Security National Planning Scenarios could exceed the entire national ICU capacity (1). Children account for 6.9%, 6.6%, 6.6%, and 7.1% of the population in age categories of birth to 4 yrs, 5 to 9 yrs, 10 to 14 yrs, and 15 to 19 yrs, respectively (55). In a public health emergency affecting all ages proportionately, pediatric patients would account for 20% or 27% of all patients, if pediatric patients were classified as 14 yrs and younger, or 19 yrs and younger, respectively. No evidence is available to define age-specific limits for which specialized pediatric services are beneficial. However, the benefit is probably most important for infants and young children, and children of all age groups with special healthcare needs. These groups are physiologically and behaviorally vulnerable and may be overrepresented in public health emergencies, such as those involving a pathogen targeting infants, children, or pregnant women (e.g., 2009 Pandemic Influenza A/H1N1) (51, 56). A natural disaster involving schools or other pediatric-specific activities, or terrorism specifically targeting children, would result in surges of children disproportionate to the overall population (57, 58). Whatever proportion of a surge is made up of children, planners should anticipate that a disproportionate number of the children needing intensive care are vulnerable by virtue of chronic health conditions and special healthcare needs. In ordinary daily PICU activity, children with chronic health conditions account for 41% of admissions (59). In the 2009 Influenza A/H1N1 Pandemic, among children with severe illness who died, 67% had one or more high-risk medical conditions, especially neurodevelopmental disorders (56).

Task force suggestions

All preparations for pediatric mass critical care must build on a foundation of effective conventional services for critically ill or injured children. All preparations for mass critical care for the general population must include pediatric aspects. For this to occur, pediatric experts must be involved in all aspects of emergency and disaster planning.

States and Regions

1. States should reaffirm ethical norms in PEMCC (see the article, “Ethical issues in pediatric mass critical care”).

2. States should ensure that all hospitals are prepared to provide care for children in a mass casualty scenario, including a level or scope of care beyond what they might ordinarily provide during normal operating conditions. This would include inpatient care for children that would otherwise be transferred to a regional pediatric resource center during normal operations.

3. States and regions should facilitate PEMCC by providing the legal protections for those involved in PEMCC. A more complete discussion has been reported by the Institute of Medicine (21) and in the article, “Legal considerations during pediatric emergency mass critical care events.”

4. All hospitals with a PICU or NICU must prepare for and provide PEMCC in a large public health emergency when authorized by state public health officials (see “Treatment and triage recommendations for pediatric emergency mass critical care”).

5. States should plan to share scarce resources with neighboring states to meet the needs of a pediatric patient surge and optimize pediatric critical care capacity in a mass casualty event. Relationships such as these may already exist for regional pediatric resource hospitals during normal operating conditions, but further planning is required to accommodate crisis operating situations.

    5a) Since nearly all of the care resources for pediatric (and neonatal) tertiary, subspecialty, and critical care reside in the private sector, there should be an effective public-private collaboration at the local, state/regional, and federal levels for such planning.

6. States should develop pediatric-specific performance criteria to hold regional systems accountable for PEMCC preparations and responses.

7. At all jurisdictional levels, practice is essential to develop and maintain proficiency in PEMCC. Federal agencies can provide resources and coordination of these efforts (see the article, “Education in a pediatric emergency mass critical care setting”).

    7a) Exercises may include full-scale simulations, tabletop exercises, and aspects of responses that are embedded in everyday practice. Responses should be practiced within, as well as across, responding organizations and agencies.

    7b) State guidance is necessary to specify required types and frequencies of these exercises.

    7c) All mass casualty practice exercises must include pediatric components. All planning jurisdictions should include at least one pediatric mass casualty event per year.

8. Hazard vulnerability analyses should estimate anticipated pediatric mass critical care needs, including especially vulnerable populations (children with chronic health conditions, non-English speaking, uninsured) and facilities that serve large numbers of children (schools, day care, recreational facilities).

9. Inventories of functional resources (staff, stuff [equipment, supplies], and space) for mass critical care must be performed at every hospital with an ICU. Counts of administratively certified beds may overestimate functional capabilities. Pediatric resources must be specifically identified.

10. Regional and state information systems should be developed to track critical care needs and resources in real time during public health emergencies to direct the distribution of patients and resources. Needs and resources for children must be specifically tracked since age-specific critical care may be warranted.

11. Operational plans for mass critical care and triage allocation (rationing) must be integrated across all jurisdictional levels and all response agencies, and must be integrated with all aspects of emergency preparedness planning. Operational plans must be graded according to the size of the public health emergency, with criteria triggering specified aspects of mass critical care and triage allocation (rationing), and associated crisis standards of care (see “Treatment and triage recommendations for pediatric emergency mass critical care”).

12. Regional mechanisms should be defined to direct the distribution of patients and resources in a public health emergency (see “Treatment and triage recommendations for pediatric emergency mass critical care” and “Supplies and equipment for pediatric emergency mass critical care”).

    12a) Since pediatric resources may be very scarce, public health decision makers may need to reserve the highest level pediatric resources for the youngest or sickest patients, while older and less severe patients may be directed/ redistributed to adult facilities.

    12b) In some cases, the resources of PICUs and NICUs may be shared to care for either a large number of infants or a large number of older children, adolescents, or young adults.

    12c) In some cases, interhospital transport of critically ill patients may be prohibitive, requiring transport of staff and supplies to an overloaded hospital rather than transporting patients to another ICU.

Federal

1. In very large or sustained public health emergencies, federal assistance and coordination will be necessary (60). Plans for federal involvement should be consistent with state plans for mass critical care and triage allocation (rationing).

2. Federal expertise and guidance should promote consistency in informing state laws and regulations regarding mass critical care and triage allocation (rationing) in public health emergencies.

    2a) Federal expertise should assist states in planning for pediatric mass critical care and triage allocation (rationing).

3. Federal incentives, specific readiness requirements, readiness, and performance measures germane to pediatric care capabilities and capacity are necessary to

ensure that all states prepare sufficiently for mass critical care and triage allocation (rationing).

4. Federal support for research on best practices ahead of time, as well as real-time surveillance, epidemiologic research, and clinical trials during a public health emergency, will result in better evidence-based practices at the level of regional systems of care, and better clinical care.

    4a) Since effectiveness of systems, as well as clinical interventions, may be age specific, research on pediatric aspects of care is especially important.

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APPENDIX

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