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Supplies and equipment for pediatric emergency mass critical care

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Abstract

Introduction—Epidemics of acute respiratory disease, such as severe acute respiratory syndrome in 2003, and natural disasters, such as Hurricane Katrina in 2005, have prompted planning in hospitals that offer adult critical care to increase their capacity and equipment inventory for responding to a major demand surge. However, planning at a national, state, or local level to address the particular medical resource needs of children for mass critical care has yet to occur in any coordinated way. This paper presents the consensus opinion of the Task Force regarding supplies and equipment that would be required during a pediatric mass critical care crisis.

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.

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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, 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—The Task Force endorsed the view that supplies and equipment must be available for a tripling of capacity above the usual peak pediatric intensive care unit capacity for at least 10 days. The recommended size-specific pediatric mass critical care equipment stockpile for two types of patients is presented in terms of equipment needs per ten mass critical care beds, which would serve 26 patients over a 10-day period. Specific recommendations are made regarding ventilator capacity, including the potential use of high-frequency oscillatory ventilation and extracorporeal membrane oxygenation. Other recommendations include inventories for disposable medical equipment, medications, and staffing levels.

Keywords

children; critical illness; disaster; emergency mass critical care; equipment; mass casualties; pandemics; pediatric; supplies

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Epidemics of acute respiratory disease, such as severe acute respiratory syndrome in 2003, and natural disasters, such as Hurricane Katrina in 2005, have prompted planning in hospitals that offer adult critical care to increase their capacity and equipment inventory for responding to a major demand surge. A major surge constitutes the need for mass critical care. Most hospitals can accommodate a minor surge (an increase in admissions of up to 15% above normal capacity) and could probably cope with a moderate surge that requires a regional response. However, in a mass pediatric critical care situation, both local and regional resources would be overwhelmed. Response would entail a major increase in capacity, crisis standards of care with different nurse/patient ratios, and care by personnel not necessarily trained in critical care.

Planning at a national, state, or local level to address the particular medical resource needs of children for mass critical care has yet to occur in any coordinated way. To address this unmet need, an expert panel was convened to consider what would be required in terms of supplies and equipment to deal with mass critical care in children. This manuscript outlines the recommendations that resulted from their deliberations.

Scope of recommendations

Adapting many of the recommendations of a recent task force to address the medical resource needs of adult patients following a disaster (1), the committee endorsed the view that supplies and equipment must be available for a tripling of capacity above the usual peak pediatric intensive care unit (PICU) capacity for at least 10 days. Mass critical care would extend essential lifesaving care to large numbers of patients by restricting elective resource use and focusing on the following:

- Mechanical ventilation

- Intravenous fluid resuscitation
- Vasoactive/inotropic agents
- Antibiotics and antidotes
- Sedation and analgesia
- Select practices to reduce adverse consequences of critical illness and critical care delivery
- Other interventions when possible, such as parenteral nutrition and renal replacement therapy
- Reducing cold stress

Critical care interventions would also be extended by substitution, adaptation, conservation, and reuse. These recommendations apply to all hazards planning, whether the occasion is a sudden-impact event requiring temporary mass critical care, or an event such as an epidemic that develops more gradually but requires a more sustained mass critical care response.

Planning assumptions

The particular medical resource recommendations to care for pediatric patients following a disaster are expressed per bed space and adapted from the Task Force on Mass Critical Care for adult patients (1). They are based on the following assumptions:

1. The supply chain practices of just-in-time delivery and rental from remote locations will not be dependable in a major public health emergency. In a hospital caring for adults and children, it must be anticipated that adults and children will draw from the same inventory. Therefore, planners must also account for sufficient medical resources to address the casualty needs of adult patients at the recommended level triple that of peak capacity.
2. For items listed in excess of one per bed space, it is anticipated that more than one patient will use the bed space during a 10-day period, and/or each patient may need extra replacements of the same item. The basis for pediatric-specific medical resource needs over a 10-day period was derived from several fundamental assumptions. In ordinary circumstances, the mean length of stay in a PICU is 3.9 days, including recovery and death (2). It is assumed that circumstances unique to a public health emergency would result in a PICU population of higher acuity than under usual circumstances, and thus by definition, patients would require more resources and a longer stay. However, this outcome may be offset by higher mortality rates and more liberal criteria for PICU discharge than usual, both of which would conserve resources and mitigate the length of stay. If a PICU length of stay of 3.9 days is assumed, this corresponds to preparations for an average of 2.6 patients occupying each bed space during the 10-day mass critical care period. For example, a hospital that usually provides a peak of 20 PICU beds should plan a mass critical care target of 60 bed spaces each day, allowing for the care of 156 patients over 10 days.

3. For other items, such as ventilators and monitors, one per planned bed space (totaling at least triple the usual peak PICU capacity) would be adequate. These assumptions are *a priori* best estimates. Empirical evidence should be examined from recent mass casualty events around the world to scrutinize these assumptions more rigorously. Using data and modeling of PICU beds in Canada for the 2009 Pandemic Influenza A/H1N1 (based on duration, peak infectivity, and immunization rates), experts felt that the planning assumption for a tripling of PICU admissions was justified (3).

4. Planning for other pediatric equipment needs is more complex than planning for care of adults because of the wide range of age- and weight-specific equipment sizes necessary. At a minimum, equipment must be planned for a surge of PICU patients whose age and size distribution is similar to that in ordinary PICU everyday activity (Tables 1 and 2) (4). This equipment list will be inadequate if one patient age group is overrepresented, such as when a vulnerable group is targeted. A much larger and more complete stockpile would be necessary to meet potential needs for public health emergencies involving patients of any single age group (Table 2).

   Weight ranges of the patients in each age category were assumed to be consistent with data from the National Center for Health Statistics (http://www.cdc.gov/growthcharts,2000). Mass critical care equipment size ranges were then planned for each age group, consistent with American Heart Association recommendations on weight-appropriate equipment sizes (4). Pediatric equipment lists for mass critical care are provided for two types of patients. For purposes of planning, it is arbitrarily assumed that 25% of the patients would have disorders unrelated to the public health emergency and would represent patients across the usual age category distribution, with equipment size distribution as described earlier. However, 75% of the patients would represent a public health emergency surge and would come entirely from any one of the six age categories. Thus, larger equipment stockpiles would be necessary to serve the largest need for each size item, across any of the age groups. This complete list would be more expensive to purchase and would result in some redundant, unused items, but large numbers of patients from any narrow age group would be adequately served (Table 3).

5. For most equipment, it is assumed that a single item per patient will serve throughout the patient's PICU stay. Exceptions include the following: 1.5 endotracheal tubes/patient to account for patients needing reintubation; ten peripheral intravenous catheters/patient to account for unsuccessful attempts and the need for new catheters to replace infiltrated catheters during the PICU stay; one central venous catheter for every two patients; and one chest tube for every four patients.

Equipment recommendations

The recommended size-specific pediatric mass critical care equipment stockpile is expressed as equipment needs per ten mass critical care beds, which would serve 26 patients over a 10-

day period (Tables 2 and 3). Some specific comments should be noted. At a minimum, cardiac, apnea, and oximeter monitoring should be provided. Of course, usual complete PICU monitoring, including invasive pressures and end-tidal CO_2, would be desirable, when available. However, in a mass critical care situation, central venous catheters may be more important for reliable vascular access than for monitoring (5). Pediatric-size self-inflatable ventilation bags should be provided for infants and children, since infant-size bags cannot be used to ventilate a larger infant, toddler, or child. Cuffed endotracheal tubes are recommended to avoid wasting a small tube when it is necessary to upsize the uncuffed tube that has an unacceptably large airleak. Cuffed tubes also allow a reduced inventory of sizes to accommodate all patient ages. Blood pressure cuffs are assumed to be reusable for the next patient after cleaning. Approximately three laryngoscope sets with all sizes of blades would serve each ten beds and allow time for resterilization. It is important to avoid environmental cold stress in burn patients and small infants. Radiant warmers already available at a hospital may be supplemented by ancillary equipment to warm entire rooms serving multiple patients.

Many other hospital equipment and supply items, including beds, linen, bedpans, and tape, are not detailed here but are essential for care in any hospital location. As recommended by the adult task force, when equipment resources are depleted, it may be necessary to resterilize and reuse equipment that is usually disposable.

Mechanical ventilation

Previously published specifications and guidelines on mechanical ventilation capabilities and oxygen supply requirements to address adult mass critical care needs are equally relevant to pediatric patients and are not repeated here (1). However, several specific concerns related to any equipment planning exercise for pediatric mass critical care must be addressed taking into account the following: 1) whether the pediatric hospital is a stand-alone facility or part of an adult facility with a shared ventilator inventory; 2) mechanical ventilation capability must be technically suitable across the pediatric age and development spectrum, from newborns to adolescents effectively of adult body mass; 3) consideration must also be given to more sophisticated life-sustaining treatment capabilities across the pediatric age and development spectrum, such as the use of high-frequency oscillatory ventilation; and 4) the development of a regional plan to establish reliable communication among tertiary care PICUs for sharing of resources, as needed, including transport facilities and equipment on site to move patients to a higher level of care. Even in a stand-alone pediatric hospital, it may be necessary to adapt transport ventilators, anesthesia ventilators, and bilevel positive pressure breathing devices for use in the PICU. Temporary manual bag ventilation may be necessary if there is a short delay in obtaining a ventilator or in the event of electrical power failure.

Some children’s hospitals have supplies of ventilators with the necessary software and circuits for use in any patient across the entire size and age spectrum. In other hospitals, adult ventilators may have to be adapted for use in infants. The following difficulties may be encountered in using adult ventilators in small infants:

- The inspiratory flow or pressure sensor may be insensitive to an infant's small inspiratory air flow and effort. Thus, triggering of assisted inspiration may fail for synchronized intermittent mandatory ventilation, assist control, or pressure support. Likewise, when inspiratory flow for spontaneous breathing between ventilator breaths requires activation of a demand valve, an infant's small inspiratory air flow and effort may be inadequate to trigger demand flow.
- Ventilator algorithms to terminate pressure support inspiration may fail in the presence of airleaks around an endotracheal tube. Airleaks around an endotracheal tube may activate frequent ventilator alarms for low pressure and/or low exhaled tidal volume.
- In a volume-controlled mode, adult ventilators may be unable to provide small tidal volumes and reduced inspiratory flow rates appropriate for a small infant.
- Pressure-dependent losses of tidal volume in compressible spaces of compliant adult ventilator circuits exaggerate breath-to-breath variation in delivered tidal volume, especially if peak inspiratory pressure varies with patient effort and respiratory mechanics. Effectively providing small tidal volumes may be facilitated by use of time-cycled, pressure-limited mode of ventilation.

Given the relatively small number of PICUs compared to hospitals designed to care for critically ill adult patients, the formalization of a regional pediatric critical care referral system becomes a high priority when planning for mass casualties. A 2007 inventory of U.S. hospitals estimated that there are 62,188 full-feature ventilators owned by acute care hospitals (6). This amounts to 20.5 ventilators per 100,000 total population, or 0.7 ventilators per total intensive care unit beds. However, variation among states is wide (12–78/100,000 population). Forty-six percent of the full-feature ventilators are said to have pediatric-neonatal capability, amounting to 50.7 with age-appropriate capability per 100,000 children younger than 14 yrs (range among states is 22–206/100,000 pediatric population). In addition, an estimated 98,738 other ventilators are owned by acute care hospitals, including transport, older generation, and noninvasive devices. The inventory did not include ventilators owned by rental companies, nursing and rehabilitation facilities, stored in stockpiles, or in chronic home use. The estimated availability of ventilators in the United States is substantially greater than previously published estimates for Australia, New Zealand, and Ontario, Canada. Wide statewide variation in ventilator availability requires regional inventories to enable operational planning for mass critical care. Table 4 is an example of such an inventory developed by the PICUs in New England and could be used as a template for other regions.

Alternative modes of ventilation

In many tertiary care pediatric centers, alternative ventilation strategies, such as high-frequency oscillatory ventilation and extracorporeal membrane oxygenation (ECMO), are used as rescue therapies in children with acute hypoxic respiratory failure that cannot be reversed with conventional ventilation and positive end-expiratory pressure. Planning in these centers should include a regional stockpile of oscillators that could be accessed during a major surge. High-frequency oscillatory ventilation is a technique that could be learned and adopted in a crisis requiring a surge in capacity to care for critically ill children with the guidance of regional experts in this mode of ventilation. However, in the event of a pandemic of respiratory illness, the use of conventional ventilators allows for a greater number of patients to be treated.

The use of ECMO in a mass critical care setting is more problematic given that, as currently structured, it requires more resource utilization above and beyond the amount needed for conventional mechanical ventilation or high-frequency oscillatory ventilation. ECMO has been used in the ordinary surge circumstances of the 2009 Influenza A/H1N1 Pandemic, although the adult task force did not address the use of ECMO as an option for severe acute respiratory distress syndrome/hypoxic respiratory failure during a mass critical care situation. Despite this, it was extensively used in adults during the 2009 Influenza A/H1N1 epidemic in Australasia (7). ECMO is offered in the treatment of single-system pulmonary disease, unresponsive to conventional treatment, in many tertiary care pediatric centers. The overall survival of 48% where it was used in pediatric patients during the 2009 pandemic will continue to make this a controversial issue (www.elso.med.umich.edu/H1N1Registry). The accepted standard for staffing of one ECMO patient is one nurse and one ECMO specialist per patient, as well as the immediate availability of a senior specialist in pediatric critical care. This could be altered to a single-caregiver model in the event of a surge situation. However, unlike the 2009 pandemic surge, mass critical care involves a tripling of PICU capacity with altered levels of care, which would involve one PICU nurse supervising non-PICU supplement providers caring for perhaps three to six patients. It is therefore unlikely that ECMO would be available as a therapeutic option. A model of decision making for pandemics of acute respiratory illness based on available resources is provided in Figure 1.

Lessons from the 2009 Influenza A/H1N1 Pandemic

Pediatric mass critical care crises are more likely to arise from pandemics of acute respiratory illness. However, there is little experience of mass critical care during pandemics of respiratory illness in children on which to base planning assumptions for equipment and supplies. The severe acute respiratory syndrome pandemic in 2003 resulted in very few seriously ill children admitted to intensive care units (8). The 2009 Influenza A/H1N1 pandemics of April to June 2009 in the northern and southern hemispheres revealed that the highest age-specific incidence of the disease was in children younger than 4 yrs. Approximately 10% to 20% of children admitted to pediatric hospitals were transferred to intensive care, and the majority of these required positive-pressure ventilation (9–16). Many PICUs experienced a doubling of children admitted with respiratory failure, and a significant number also had hemodynamic compromise compared with the usual numbers of patients with seasonal flu. The experience in the second wave of the disease seen in North America in October and November 2009 was similar and in no instance invoked a mass critical care response.

Medications

Medications necessary to provide mass critical care have been suggested by the adult Mass Critical Care Task Force (17), but we lack evidence to guide quantitative recommendations. Essential categories include sedatives, analgesics, paralytics, bronchodilators, crystalloids, vasopressors, antimicrobials, selected antidotes, insulin, and glucocorticoids. Experience suggests that the need for analgesics may quickly exhaust usual stockpiles even in modest and temporary public health emergencies (18).

Staffing

The usual numbers of critical care staff may be insufficient to meet the needs of a mass critical care surge. If available, supplemental providers with skills in nonpediatric critical care, or noncritical care pediatrics, may bring invaluable assistance to pediatric mass critical care. These may include physicians, nurse practitioners, physician assistants, nurses, respiratory therapists, pharmacists, and emergency medical technicians, particularly those having backgrounds in certain surgical subspecialties, anesthesia, and emergency medicine. Residents, medical students, and veterinary practitioners should also be considered in the event of a national pandemic situation. An altered or “crisis” standard of care would need to be adopted. Rapid credentialing procedures, just-in-time training, and close supervision by experienced PICU clinicians would promote the effective role of supplemental providers. The regulations governing work hours for physicians would need to be suspended. The Accreditation Council for Graduate Medical Education should consider the relaxation of duty hour restrictions during a national pandemic.

Optional interventions

As suggested by the adult task force (19), some therapeutic interventions that are routine in ordinary, everyday critical care must be considered optional in mass critical care, either because they are not immediately lifesaving, or because they are so resource intensive. The adult task force identified renal replacement therapy and enteral nutrition as optional for mass critical care. Local leaders may decide to attempt optional therapies in a public health emergency if resources are available. However, mass critical care goals to maximize population outcomes require that optional therapy must not limit evidence-based care of patients who would benefit from simpler interventions.

Other considerations

Since infants and children have a large surface-area-to-mass ratio, they are far more prone to the deleterious effects of environmental hypothermia than adult patients. Thus, it is imperative to avoid environmental cold stress in burn patients and infants and small children. As such, radiant warmers already available at a hospital may need to be supplemented by ancillary equipment to warm entire rooms serving multiple patients.

CONCLUSION

While many of the recent and comprehensive plans for mass adult casualties can be directly adapted to surge capacity plans to care for critically ill infants and children, comprehensive planning (Table 5) also requires collaboration within healthcare systems and within regions to meet the peculiar and essential equipment and supply needs of pediatric patients.

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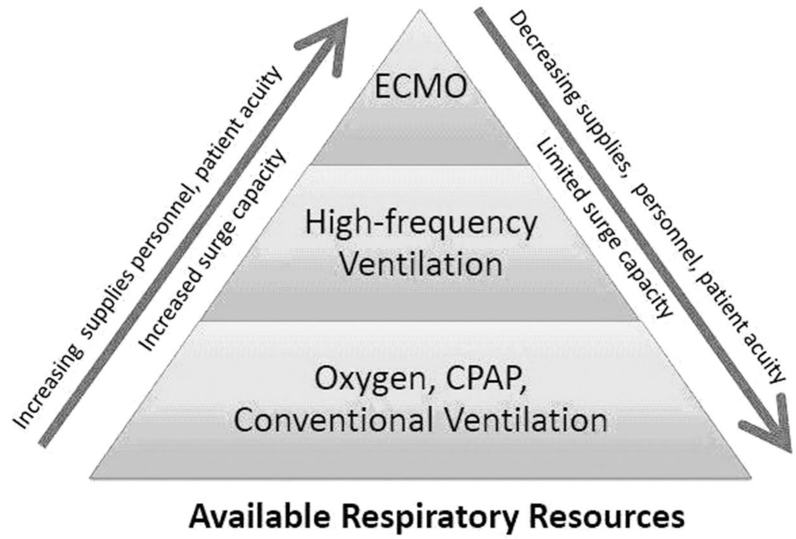

Figure 1.

Model of decision making based on available supplies, personnel, patient acuity, and surge capacity for pediatric emergency mass critical care. *CPAP*, continuous positive airway pressure; *ECMO*, extracorporeal membrane oxygenation.

Table 1

The proportion of patients in indicated age categories in ordinary everyday pediatric intensive care unit care

Age	Percent
<1 month	5%
1 to 12 months	25%
1 to <3 yrs	21%
3 to <6 yrs	14%
6 to <12 yrs	18%
>12 yrs	17%

From Pollack MM, Patel KM, Ruttimann UE. PRISM III: An updated Pediatric Risk of Mortality score. *Crit Care Med* 1996; 24:743–752.

Table 2

Minimal mass critical care equipment needs for a surge population whose age distribution is similar to ordinary everyday pediatric intensive care unit care

Item	Size	Number of Items per Ten Mass Critical Care Beds Over 10 Days
Respiratory		
Oral airway	Infant	7
	Small child	3
	Child	8
	Small adult	5
	Adult	3
Self-inflatable bag	Child	17
	Adult	9
Resuscitation mask	Infant	7
	Small child	6
	Child	5
	Small adult	5
	Adult	3
Oxygen mask	Infant	5
	Child	16
	Adult	5
Endotracheal tube (cuffed)	3.0 mm	2
	3.5 mm	7
	4.0 mm	6
	5.0 mm	7
	6.0 mm	8
	7.0 mm	2
Stylette	Pediatric	14
	Adult	12
Closed-circuit suction catheter	6F	2
	8F	5
	10F	14
	12F	5
Yankauer suction device	Standard Size	26
Ventilator circuit	Infant	8
	Adult	18
Other		
Peripheral intravenous catheters	24 gauge	39
	22 gauge	112
	20 gauge	61
	18 gauge	36
	16 gauge	9
Central venous catheters	4F/8 cm	1

Item	Size	Number of Items per Ten Mass Critical Care Beds Over 10 Days
	5F/15 cm	11
	7F/30 cm	1
Nasogastric tube	5F	2
	8F	9
	10F	3
	12F	4
	14F	5
	18F	3
Urinary catheter	5F	2
	8F	6
	10F	6
	12F	12
Chest tube	10F	1
	16F	1
	20F	1
	24F	1
	28F	2
	38F	1
Blood pressure cuff	Neonate	1
	Infant	2
	Child	6
	Small adult	1
	Adult	1

Table 3

Complete mass critical care equipment needs for a surge population that includes 75% from any single age group and 25% from the usual age distribution

Item	Size	Number of Items per Ten Mass Critical Care Beds Over 10 Days
Respiratory		
Oral airway	Infant	21
	Small child	7
	Child	18
	Small adult	13
	Adult	9
Self-inflatable bag	Child	24
	Adult	22
Resuscitation mask	Infant	21
	Small child	17
	Child	13
	Small adult	13
	Adult	9
Oxygen mask	Infant	21
	Child	24
	Adult	21
Endotracheal tube (cuffed)	3.0 mm	26
	3.5 mm	22
	4.0 mm	13
	5.0 mm	17
	6.0 mm	22
	7.0 mm	6
Stylette	Pediatric	23
	Adult	23
Closed-circuit suction catheter	6F	20
	8F	17
	10F	23
	12F	5
Yankauer suction device	Standard size	26
Ventilator circuit	Infant	22
	Adult	24
Other		
Peripheral intravenous catheters	24 gauge	107
	22 gauge	184
	20 gauge	132
	18 gauge	126
	16 gauge	41
Central venous catheters	4F/8 cm	10

Item	Size	Number of Items per Ten Mass Critical Care Beds Over 10 Days
	5F/15 cm	13
	7F/30 cm	4
Nasogastric tube	5F	20
	8F	22
	10F	11
	12F	13
	14F	13
	18F	9
Urinary catheter	5F	20
	8F	11
	10F	11
	12F	22
Chest tube	10F	5
	16F	3
	20F	3
	24F	3
	28F	3
	38F	1
Blood pressure cuff	Neonate	8
	Infant	5
	Child	9
	Small adult	4
	Adult	4

Table 4

Ventilator inventory template

HOSPITAL CORPORATION NAME:		**TOTAL**
SITE NAME:		
SECTION A: HOSPITAL DETAILS:		
Site Contact:	*Name:* *Title:* *Telephone:* *E-mail:* *Fax:*	-
Single room (isolated) critical care beds with negative pressure in hospital:		
On 9/1/09, the total number of ventilators in use in your hospital:		
On 9/1/09, the total number of ventilators in storage in your hospital:		
SECTION B: VENTILATOR CAPACITY AS OF 8/10/09:		
Total number of INVASIVE MECHANICAL ventilators:		
Quantity/Manufacturer/Type/Model:		
Can ventilate adults ONLY:		
Can ventilate pediatric ONLY:		
Can ventilate neonates ONLY:		
Can ventilate neonates AND pediatric:		
Can ventilate adults AND pediatric:		
Can ventilate adults AND pediatric AND neonates:		
Total number of HFO ventilators:		
Quantity/Manufacturer/Type/Model:		
Can ventilate adults ONLY:		
Can ventilate pediatric ONLY:		
Can ventilate adults AND pediatric:		
Total number of OR INVASIVE MECHANICAL ventilators:		
Quantity/Manufacturer/Type/Model:		
Total number of MOBILE/PORTABLE INVASIVE MECHANICAL ventilators:		
Quantity/Manufacturer/Type/Model:		
Total number of NON-INVASIVE ventilators:		
Quantity/Manufacturer/Type/Model:		
BIPAP ONLY:		
CPAP ONLY:		
CPAP AND BIPAP:		
SECTION C: RESPIRATORY THERAPY FAILING CONVENTIONAL VENTILATION:		
Does hospital have the capacity to deliver inhaled nitric oxide?		
How many patients can you simultaneously provide inhaled nitric oxide?		
Does your hospital have the ability to provide ECMO?		
For how many patients can you simultaneously provide ECMO?		

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Does your hospital have the ability to provide inhaled prostacyclin?		
For how many patients can you simultaneously provide inhaled prostacyclin?		

HFO, high-frequency oscillation; OR, operating room; BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; ECMO, extracorporeal membrane oxygenation.

Table 5

Summary of recommendations

1	Mechanical Ventilators[a]
	One ventilator per patient
	Volume and pressure ventilation options
	Inspiratory flow/pressure sensor sensitive enough to ventilate infants
	Appropriate high- and low-pressure alarms
	End-tidal CO_2 monitoring
2	Ventilation Ancillary Equipment
	Pediatric ventilator circuits[b]
	Humidifiers
	Age/size-appropriate endotracheal and tracheostomy tubes (cuffed and uncuffed)[b]
	Oxygen masks[b]
	Manual ventilation circuits, bag-mask ventilation apparatus with different size masks[b]
	Chest drains[b]
	Suctioning equipment[b]
	Pulse oximeters
3	Other Options to be Considered for Assisted Ventilation
	Anesthesia ventilators
	Transport ventilators
	Noninvasive ventilator systems
4	Nonconventional Respiratory Support Modalities in Tertiary Care Centers Acting as a Regional/State Resource
	High-frequency oscillators in a ratio of one oscillator per six conventional ventilators
	The use of extracorporeal membrane oxygenation to be considered in tertiary care centers using a crisis level of care model (one caregiver per patient)
5	Ventilator Inventory
	Each state/region should develop a ventilator inventory, updated annually, that includes the number of conventional and high-frequency ventilators. The inventory should also include noninvasive transport and anesthesia ventilators, capability to deliver inhaled nitric oxide, and the number of operational extracorporeal membrane oxygenation circuits. This should become part of the Joint Commission standards for emergency management
6	Equipment for Hemodynamic Management
	Size-appropriate blood pressure cuffs, noninvasive blood pressure monitoring equipment and pressure transducers
	Bedside cardiac and pressure monitors
	Central venous line insertion kits
	Intraosseous needles
	Broselow resuscitation tapes
	Infusion pumps
	Intravenous fluids and vasoactive drugs
7	Sedation, Analgesic, Antimicrobials, and Nutrition
	Narcotics, ketamine, benzodiazepines
	Antibiotics, antifungals, and antitoxins
	Supplies of age-appropriate enteral feeding solutions
8	Pediatric Intensive Care Unit Staffing in Pandemic Situations

Pediatric intensive care units should develop alternate (crisis) standards of care to optimize staffing in pandemic situations. This would include the use of nurse practitioners, respiratory therapists, emergency medical technicians, physician assistants, and veterinarians

[a]See reference 1 for further details;

[b]denotes equipment that could be disinfected or sterilized between patient uses in a pandemic situation.