Special Article

Criteria for Critical Care Infants and Children: PICU Admission, Discharge, and Triage Practice Statement and Levels of Care Guidance

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Authors and Voting Panel participants completed Society of Critical Care Medicine conflicts of interest forms. Dr. Frankel disclosed that he provides expert testimony in various medical-legal cases. Dr. Hsu disclosed that he participates in the American Academy of Pediatrics (AAP) and AcademyHealth. Dr. Yeh disclosed that he participates in guidelines with the AAP. Dr. Agus disclosed that he is the immediate past chair for the AAP Section on Critical Care, is part of the organizing committee for Pediatric Academic Societies, and is an expert witness in several cases involving alleged mismanagement of critically ill children (generally those with endocrine diagnoses). Dr. Coss-Bu disclosed that he is on the malnutrition committee for the American Society of Parenteral and Enteral Nutrition and the Young Investigator Research Award Committee for the Society of Pediatric Research. Dr. Gayle disclosed that he participates in AAP and the Air Medical Physician Association. Dr. Hill disclosed that she is on the AAP Committee on Hospital Care. Dr. Kessel disclosed that he is an Extracorporeal Life Support Organization registry member and an Association

of Pediatric Program Directors member. Dr. Moss disclosed that she is the immediate past chair for the AAP Section on Transport. Dr. Papo disclosed that she is the president of the Foundation for Pediatric Acute Care and Quality. Dr. Rice disclosed that he participates in the AAP. Dr. Rosenberg disclosed that he participates in the AAP. Dr. Conway disclosed that he is an AAP member, the Past Chair of Executive Pediatric Critical Care Medicine (PCCM) Committee, and is an expert witness in PCCM cases. The remaining authors have disclosed that they do not have any potential conflicts of interest.

The full Voting Panel is listed in the Acknowledgments.

The American College of Critical Care Medicine (ACCM) Board of Regents is a special body of Society of Critical Care Medicine (SCCM) that emphasizes quality management in the practice and administration of critical care through the development of multiprofessional guidelines and administrative and clinical practice parameters. The ACCM provides SCCM with a consultative body possessing recognized expertise in the practice of critical care. Appreciation is also extended to the American Academy of Pediatrics (AAP) for coauthorship of this practice statement and appointment of representatives from AAP Section on Critical Care, Committee on Hospital Care, and Section on Surgery as liaisons to this body of work. Appreciation is further extended to the staff at AAP and SCCM who provided support and guidance on the processes required to develop this publication.

Objectives: To update the American Academy of Pediatrics and Society of Critical Care Medicine's 2004 Guidelines and levels of care for PICU.

Design: A task force was appointed by the American College of Critical Care Medicine to follow a standardized and systematic review of the literature using an evidence-based approach. The 2004 Admission, Discharge and Triage Guidelines served as the starting point, and searches in Medline (Ovid), Embase (Ovid), and PubMed resulted in 329 articles published from 2004 to 2016. Only 21 pediatric studies evaluating outcomes related to pediatric level of care, specialized PICU, patient volume, or personnel. Of these, 13 studies were large retrospective registry data analyses, six small single-center studies, and two multicenter survey analyses. Limited high-quality evidence was found, and therefore, a modified Delphi process was used. Liaisons from the American Academy of Pediatrics were included in the panel representing critical care, surgical, and hospital medicine expertise for the development of this practice guidance. The title was amended to "practice statement" and "guidance" because Grading of Recommendations, Assessment, Development, and Evaluation methodology was not possible in this administrative work and to align with requirements put forth by the American Academy of Pediatrics.

Methods: The panel consisted of two groups: a voting group and a writing group. The panel used an iterative collaborative approach to formulate statements on the basis of the literature review and common practice of the pediatric critical care bedside experts and administrators on the task force. Statements were then formulated and presented via an online anonymous voting tool to a voting group using a three-cycle interactive forecasting Delphi method. With each cycle of voting, statements were refined on the basis of votes received and on comments. Voting was conducted between the months of January 2017 and March 2017. The consensus was deemed achieved once 80% or higher scores from the voting group were recorded on any given statement or where there was consensus upon review of comments provided by voters. The Voting Panel was required to vote in all three forecasting events for the final evaluation of the data and inclusion in this work. The writing panel developed admission recommendations by level of care on the basis of voting results.

Results: The panel voted on 30 statements, five of which were multicomponent statements addressing characteristics specific to PICU level of care including team structure, technology, education and training, academic pursuits, and indications for transfer to tertiary or quaternary PICU. Of the remaining 25 statements, 17 reached consensus cutoff score. Following a review of the Delphi results and consensus, the recommendations were written.

Conclusions: This practice statement and level of care guidance manuscript addresses important specifications for each PICU level of care, including the team structure and resources, technology and equipment, education and training, quality metrics, admission and discharge criteria, and indications for transfer to a higher level of care. The sparse high-quality evidence led the panel to use a modified Delphi process to seek expert opinion to develop consensus-based recommendations where gaps in the evidence exist. Despite this limitation, the members of the Task Force believe that these recommendations will provide guidance to practitioners in making informed decisions regarding pediatric admission or transfer to the appropriate level of care to achieve best outcomes. (*Pediatr Crit Care Med* 2019; 20:847–887)

Key Words: admission; critical care; guidelines; pediatric; practice parameters; triage

PEDIATRIC CRITICAL CARE ADMISSION CRITERIA AND LEVELS OF CARE GUIDANCE

Pediatric critical care medicine has evolved over the last 3 decades into a highly respected board-certified specialty that has become the indispensable service for inpatient programs of most children's hospitals as well as a highly valued resource supporting most community-based programs. The earlier published guidelines (1, 2) for pediatric critical care medicine were used to help establish the basic needs for a state-of-the-art PICU. These guidelines were used by both physician leadership and policymakers to advocate for personnel, supplies, and space that were unique to PICUs. However, there has been a tremendous transformation of pediatric critical care medicine over the past 10 years, with explosive growth in specialized PICUs in pediatric cardiovascular medicine, transplantation, neurology, trauma, and oncology, as well as improvements of care in general PICUs. This has led to the evolution in both human and material resources and training in more highly specialized areas, such as cardiovascular medicine, neurosurgical ICU, and trauma care.

This article will review the current evidence and explore expert opinions regarding the state of PICUs throughout the country, attempt to stratify these PICUs, and stratify the personnel and equipment needs for the various levels of ICU care. Using both literature review and a modified Delphi technique seeking expert opinion, we have created a new practice statement and guidance that will enable hospitals, institutions, and individuals to develop the appropriate PICU for their

community needs. In addition, recognition of the value that different PICUs bring to their respective organizations and local or regional communities is reflected in the new practice statement and guidance. Although PICU characteristics are described in this document as unit based, we recognize that, in institutions with multiple PICUs (e.g., cardiac ICU, PICU), certain therapies may be only offered in one or a subset of those PICUs—in this scenario, the unit characterizations described may be considered to apply at the institutional level.

The previous guidelines emphasized a uniform set of standards for the PICU that reflected both the scientific and technical advances made in this emerging field of pediatrics. A specialty Board in Pediatric Critical Care Medicine was created in the late 1980s with requisite board examinations of the subspecialty. In addition, the American Boards of Medicine, Surgery, and Anesthesiology recognized the subspecialty of pediatric critical care medicine. Following this, the Residency Review Committee of the Accreditation Council for Graduate Medical Education (ACGME) began its accreditation of pediatric critical care medicine training programs in 1990. There also existed a parallel process established by the American Association of Critical Care Nurses (AACN) to develop a certification program for pediatric critical care and the initiation of a certification program for clinical nurse specialists in pediatric critical care. There has also been a rapid evolution of the concept of level I and level II PICUs. We intend to expand on this and add subspecialized PICUs to the mix. Although individual states may have their own PICU guidelines, it is not the intent of this report to supersede already established state regulations. However, we will use both the existing body of literature and expert opinion to help craft the new practice statement and guidance that will further stratify the PICUs into specialized or quaternary PICUs (e.g., cardiac, transplant related, neurologic, burns), tertiary PICUs, and community-based PICUs.

It is expected that critically ill or injured pediatric patients will be cared for in an environment that is focused on the care of the child and family through a multidisciplinary approach addressing a wide range of complex, progressive, and physiologic unstable medical, surgical, and traumatic disorders that may occur. Newborns are not included in the practice statement and guidance unless they require complex cardiovascular surgical interventions because there are American Academy of Pediatrics (AAP) guidelines for levels of neonatal care.

METHODOLOGY

Task Force

The pediatric admission guideline task force comprised a group of nationally and internationally recognized clinical experts in pediatric critical care medicine. The members agreed on the structure and function of the task force, reviewed the work of the previous Pediatric Society of Critical Care Medicine (SCCM) Admission Discharge and Transfer Guideline Task Forces, and made decisions regarding the scope, timeline, methodology, and support needs. The work of the group was conducted through teleconferences, e-mails, and meetings during the SCCM Annual Congress.

Objective

The objective of this task force was to update the AAP/SCCM guidelines for PICU admission, discharge, and transfer, specifically identifying admission criteria by PICU level of care.

Topic Refinement

The population considered for the practice statement and guidance includes pediatric critically ill patients who are candidates for critical care services or admission to the PICU. Although the patient population is defined as people younger than 18 years old, those 18 years old and older may be admitted to a PICU because of the disease process that is deemed best cared for by pediatric subspecialists and critical care experts.

Topic selection and organization were determined by the task force chair (L.R.F.) and agreed by all guideline panel members and authors. The broad sections for the practice statement and guidance addressed PICU characteristics and interventions by the PICU level of care, including quaternary or specialized, tertiary, and community. Interventions addressed include PICU admission, team structure, transport and transfer mechanisms, outreach programs, and quality metrics.

Significant care and thoughtful discussion went into the decision to determine the upper age limit for this review. The task force recognized that although there were many empiric limits imposed on this definition, the SCCM guidelines for adult critical care units defined the lower limit of adult patients as 18 years old, thus making this age the upper limit for this review.

Search and Review of the Literature

The task force, in consultation with a librarian, refined the topics and identified specific questions to be addressed. After group discussion and agreement, these questions served as a basis for conducting comprehensive literature searches in selected biomedical databases to identify relevant publications for each section of the practice statement and guidance. The 2004 guidelines and levels of care for PICUs served as the starting point, and searches in Medline (Ovid), Embase (Ovid), and PubMed resulted in 329 articles published from 2004 to 2016.

Members of the task force received the set of citations and abstracts relevant to the section of the practice statement and guidance; references not directly related to the content area were excluded from the review. The full-text articles were retrieved and reviewed to determine appropriate inclusion for appraisal.

The key ICU admission questions to be answered included:

- Do patients cared for in a pediatric specialty ICU have better/improved outcomes versus those cared for in a general PICU?
- Does the level of PICU have an impact on patient outcomes and quality of care?
- Does annual patient volume in PICU impact patient outcomes?

- Does the volume of the mechanically ventilated patient in PICU have an impact on patient outcomes?
- Does surgical volume (e.g., cardiothoracic, neurosurgery, trauma) impact patient outcomes?
- Which admission criteria, diseases, and severity of illness requiring higher level of PICU care are associated with improved patient outcomes?
- Does ICU structure/care delivery model have an impact on patient outcomes?
- Does immediately available (e.g., being in-house) care by an intensivist and/or subspecialist lead to improved patient outcomes?
- Does a dedicated multidisciplinary care team in the ICU improve patient outcomes?

Admission literature searches included:

- Level of PICU and patient outcomes (limited to 0 mo to 18 yr)
- Admission process/severity of illness for specific types of PICUs
- Specialized PICU and patient outcomes (limited to 0 mo to 18 yr)
- Pediatric cardiac/neurosurgery/trauma ICU and patient outcomes
- Annual volume in PICU and patient outcomes
- Annual volume of mechanically ventilated patients and patient outcomes
- ICU staffing/personnel (intensivist, nurse practitioners [NPs], physician assistants [PAs], hospitalists, nurses, etc) and patient outcomes

Discharge literature searches included:

- PICU discharge criteria or standards
- PICU unplanned readmissions and patient outcomes
- Rapid response team/medical emergency response team and unplanned PICU transfer
- Pediatric Early Warning Scores and unplanned PICU readmissions

Literature search flowcharts are presented in **Supplemental File 1** (Supplemental Digital Content 1, http://links.lww.com/PCC/A989).

The admission literature search identified 832 articles. The review of article titles resulted in 299 relevant articles, of which all abstracts were reviewed. The full text of 75 articles and 12 additional articles obtained by hand-searching reference lists were reviewed. Only 21 relevant pediatric studies evaluating outcomes related to pediatric level of care, specialized PICU, patient volume, or personnel were found. Of these, 13 studies were large retrospective registry data analyses, six were small single-center studies, and two were multicenter survey studies. The registry data analyses included evaluation of outcomes in specialized ICUs, including cardiac surgery, trauma, transplant, and burn ICUs. Of the 13 registry data analyses studies, one study evaluated outcomes in freestanding children's hospitals and two evaluated outcomes in general PICUs. The discharge and unplanned readmission literature search identified 68 articles. The full text of 24 articles and six additional articles obtained by hand-searching reference lists were reviewed. No articles were found evaluating PICU discharge criteria, and only 14 relevant studies were found evaluating outcomes related to unplanned PICU readmissions, including impact of rapid response teams and Pediatric Early Warning Score. Of these, three were large retrospective registry data analyses, eight were single-center PICU studies, and three were single-center pediatric cardiac ICUs. Since the publication of the 2004 revised guidelines, evidence evaluating the impact of the level of PICU care on patient outcomes remains limited. The task force intended to use the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system methodology; however, after much deliberation, the task force determined that the strength and quality of the current pediatric evidence for the selected topics were insufficient to use the GRADE system in supporting evidence-based recommendations. The sparse literature and the nature of the questions under review did not lend themselves to the use of the P - patient, problem or population, I - intervention, C – comparison, control or comparator, and O – outcome format. Therefore, a modified Delphi process was undertaken, seeking expert opinion to develop consensus-based recommendations where gaps in the evidence exist.

Modified Delphi Methodology

Panel Selection. Members of the panel were selected on the basis of their experience as PICU directors, administrators, or other leadership roles and were chosen to represent a variety of hospital settings, from academic centers to community hospitals. The AAP also appointed a hospitalist and critical care physician liaison to serve on the panel and to assist in the development of the practice statement and guidance. An American College of Critical Care Medicine Board of Regents member served as a liaison to the committee to support its work.

Methods. The panel consisted of two groups: a voting group and a writing group. The Voting Panel used an iterative collaborative approach to formulate statements based on the literature review and common practice of the pediatric critical care bedside experts and administrators on the task force. Statements were then formulated and presented via an online anonymous voting tool to a voting group using a three-cycle interactive forecasting Delphi method. With each cycle of voting, statements were refined on the basis of votes received and on comments. Voting was conducted between the months of January 2017 and March 2017. The consensus was deemed achieved once 80% or higher scores from the voting group were recorded on any given statement or where there was consensus on review of comments provided by voters. The Voting Panel was required to vote in all three forecasting events for the final evaluation of the data and inclusion in this work. The writing panel evaluated the survey data and, together with literature findings, formulated admission recommendations.

Delphi Voting Results. The panel voted on 30 statements, five of which were multicomponent statements addressing characteristics specific to PICU level of care, including team structure, technology, education and training, academic

pursuits, and indications for transfer to tertiary or quaternary PICU. Of the remaining 25 statements, 17 reached consensus cutoff score. Following a review of the Delphi results and consensus, the recommendations were written. The Delphi voting results are available in **Supplemental File 2** (Supplemental Digital Content 2, http://links.lww.com/PCC/A990).

Limitations

The limited high-quality evidence since the 2004 guidelines resulted in the task force's decision to use a modified Delphi process. The intent of the task force was to support updated recommendations with current evidence and expert opinion.

Target Audiences

The target audiences of the practice statement and guidance are broad and include critical care professionals, pediatricians, pediatric subspecialists, allied healthcare providers, and hospital administrators who make daily administrative and clinical decisions in all PICU levels of care. The audience also includes pediatric surgeons, pediatric surgical subspecialists, pediatric imaging physicians, and other members of the patient care team such as nurses, therapists, dieticians, pharmacists, social workers, and care coordinators. However, these recommendations may not be applicable to regions outside the United States. Although the literature search was not restricted to the United States, the ponderance of evidence is specific to the United States.

Conflicts of Interest

The practice statement and guidance were developed with no direct influence, either direct or indirect, from industry. All members of the task force indicated that they had no significant financial or nonfinancial conflicts of interest with participation in this project and submitted the standard SCCM conflicts of interest disclosure forms, which were evaluated and cleared by the SCCM Guidelines Management Committee for potential conflicts.

SUMMARY STATEMENT

Table 1 summarizes the task force's recommendations for PICU admission based on the level of care. The evidence, Delphi results, and rationale for each recommendation, as well as suggestions for future research, are described in the proceeding sections of this document.

ICU ADMISSION BY LEVEL OF CARE

In this section, we describe the general specifications for quaternary or specialized PICU care, tertiary, and community levels of PICU care, including purpose, populations and disease entities served, providers, support services, coverage responsibilities, equipment, technology, quality metrics, relationships with other ICUs, and transport and transfer mechanisms.

A quaternary or specialized PICU provides regional care and serves large populations or has a large catchment area. The center would provide comprehensive care to all complex patients. Uniquely, a specialized PICU provides diagnosis-specific care for select patient populations. Examples of this might include a cardiac PICU. These ICUs have specialized equipment and supplies as well as medical, nursing, and other members of the patient care team with specific skills dedicated to a certain discipline. This highest level of PICU would have readily available resources to support an American College of Surgeons (ACS)-verified level I or level II Children's Surgical Center or level I or level II Pediatric Trauma Center (3, 4).

Tertiary PICUs provide advanced care for many medical and surgical illnesses in infants and children. In the previously published guidelines, these units were categorized as level I PICUs, as distinguished from level II PICUs. Tertiary PICUs should provide advanced ventilatory support such as high-frequency oscillatory ventilation (HFOV) and inotropic management but would not be expected to provide extracorporeal membrane oxygenation (ECMO) support. There would be ready access to most pediatric medical subspecialties, but there may not be in-house coverage for the highest level of surgical specialties such as burns, neurosurgery, craniofacial, or a dedicated pediatric trauma team. The tertiary PICU may be able to provide advanced technologies and services but will lack unique and/or comprehensive services offered in quaternary PICUs.

Community medical center (CMC) PICUs play an important role in healthcare systems that provide care to infants and children. In the previously published guidelines, these centers were categorized as level II PICUs. These units provide a broad range of services and resources that may differ based on institution, hospital size, and referral base. The majority of these will be located in general medical-surgical institutions with the capability of treating pediatric patients. The geographic setting will impact the populations/disease entities served, available providers and support services, relationships with other PICUs at various levels, and transport program capabilities.

Regardless of what type of facility in which the PICU is located, specific criteria regarding resources and personnel should be in place. **Table 2** outlines resources appropriate for each PICU level of care, and **Table 3** outlines personnel qualifications and roles and responsibilities by the level of care.

The Delphi Survey statements and consensus-based results corresponding to the specific level of care are presented in the quaternary or specialized, tertiary, and community level of care subsections. The complete Delphi Survey and responses are presented in Supplemental File 2 (Supplemental Digital Content 2, http://links.lww.com/PCC/A990). The task force recommendations and supporting rationale follow this section. The recommendations are organized similar to the ICU level of care content and include the following subheadings: 1) PICU level of care admission criteria; 2) ICU structure and provider staffing model based on PICU level of care; 3) ICU personnel and resources based on PICU level of care; 4) performance improvement and patient safety; 5) equipment and technology; and 6) PICU discharge and transfer criteria.

It is the expectation in all ACS-verified children's programs, either trauma or children's surgery, that the children's surgeons will be actively engaged in all phases of care for infants and

TABLE 1. Summary of Recommendations

Recommended PICU level of care admission criteria:

- Patients who are appropriately triaged according to level of illness and services provided in community/tertiary/quaternary PICU facilities will have comparable outcomes and quality of care. The specifics of each PICU level of care described above serve as a reference for minimum standards of quality care to guide appropriate PICU admissions and promote optimal patient outcomes.
- Individual hospitals and their PICU leadership team should develop admission criteria to assist in the placement of critically ill children that is aligned with their PICU level of care.
- Pediatric patients requiring specialized service interventions, such as cardiac, neurologic, or trauma-related surgery, have better/improved outcomes when cared for in a quaternary/tertiary ICU, and early interfacility transfer to the appropriate regional facility should be the standard of care.
- Congenital heart surgery should only be performed in a hospital that has a PICU with a dedicated pediatric cardiac intensive care team, including but not restricted to pediatric intensivists and nurses with expertise in cardiac intensive care, cardiovascular surgeon with pediatric expertise, pediatric perfusionists, pediatric cardiologists, and pediatric cardiac anesthesiologists.

Recommended ICU structure and provider staffing model:

- Expertise in the care of the critically ill child is required in all PICU levels of care.
- All critically ill children admitted to any PICU should be cared for by a pediatric intensivist who is board eligible, board certified, or undergoing maintenance of certification as primary provider while in the ICU setting.
- Trauma patients should be cared for by both the trauma service (including trainees) and the PICU service in a collaborative manner. The ACS requires that surgeons be the primary provider on all patients admitted with traumatic injuries. Programs where the attending surgeon has training and certification in surgical critical care may (institutional specific) allow for the primary attending to be a surgeon with such expertise working with the PICU attending.
- Burn patients should be comanaged by the burn surgeon of record (discipline may be pediatric surgery, general surgery, or plastic surgery) and the PICU service.
- In a PICU that supports an ACS-verified children's surgical center, an ICU team that demonstrates direct surgeon involvement in the day-to-day management of the surgical needs of the patient is essential. Both PICU and surgery services must be promptly available 24 hr a day.
- Any level of PICU that supports advanced ACGME training programs such as Pediatric Residency, General Surgery Residency, Pediatric Critical Care Medicine Fellowships, Pediatric Surgery Fellowships, and Pediatric Surgical Critical Care Fellowships, among others, will promote the participation of trainees in interprofessional care of patients providing appropriate communication and collaboration. Clear delineation of responsibilities will be sought on each patient. This requirement reflects the common program requirements outlined by the ACGME.
- A qualified medical provider (in quaternary facility PICUs, the "qualified medical provider" should be a pediatric intensivist), who is able to respond within 5 min to all emergent patient issues (e.g., airway management and cardiopulmonary resuscitation), is necessary for optimal patient outcomes in all levels of PICU. Specialized or quaternary facility PICUs have a minimum of an in-house critical care fellow.
- A qualified surgical provider able to respond readily to emergency surgical issues in critically ill patients should be available. The designation of "qualified" is defined by the surgical problem and availability should be commensurate with the level of care of the PICU and level of ACS Children's Surgical Verification of the institution.
- Night coverage response requirement for pediatric intensivists who are not in-house, primarily in community and tertiary PICUs, includes being readily available by telephone and present in the PICU within 30 min of request.

Recommended ICU personnel and resources:

- The ICU structure and care delivery model components that are essential in all PICU levels of care include nursing staff and respiratory therapists with PICU expertise as well as multidisciplinary rounds. In tertiary and quaternary facility PICUs, 24/7 in-house coverage, dedicated clinical pharmacist, social worker, child life specialist, and palliative care services are necessary.
- All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities.
- All providers including pediatric hospitalists, nurse practitioners, and physician assistants who provide first-line night coverage in PICUs must be skilled in advanced airway, IV and intraosseous line placement, and ventilator management.
- All PICUs must have access to a transfer and transport program that can ensure the safe and timely movement of a critically ill or injured child from a community hospital to an institution with a higher PICU level of care.
- Quaternary facilities or specialized PICUs have access to a critical care transport program with a dedicated trained pediatric team and specialized equipment.
- When PICUs require outsourcing of critical care transport activities, the transport service team members must all have training in pediatric emergency and critical care.

(*Continued*)

TABLE 1. (*Continued*). Summary of Recommendations

Recommended performance improvement and patient safety:

- Quaternary facilities and tertiary levels of PICU should participate in academic pursuits.
- All quaternary facilities and tertiary levels of PICU should be involved in providing peer community outreach education such as educational conferences, technical skill competencies, stabilization, and resuscitation (e.g., Pediatric Advanced Life Support education).
- Community and tertiary PICUs should be involved in providing community outreach through educational events that focus on technical skills needed for stabilization, resuscitation, and communication for the triage and transport of critically ill and injured children. These activities might include case conferences.
- All levels of PICU should provide feedback to referral centers following the transfer of a patient to a PICU, which is essential for both quality improvement and education.

Recommended equipment and technology:

- Some emergency resuscitative therapies, such as invasive and noninvasive respiratory support and central line access, can be safely performed in community PICUs.
- Renal replacement therapies (peritoneal dialysis, continuous hemofiltration and hemodialysis, and intermittent hemodialysis) may be offered in a community-based PICU when appropriately trained support personnel, which must include a nephrologist, are present.
- All PICU levels must have access to helium-oxygen. In selected PICUs, nitric oxide, epoprostenol sodium, and anesthetic agents may be used if appropriate personnel and equipment are available for the safe delivery and monitoring of these agents.
- The following are appropriate indications for PICU transfer from a community to a tertiary or quaternary level of care: intracranial pressure monitoring, acute hepatic failure leading to coma, congenital heart disease with unstable cardiorespiratory status, need for temporary cardiac pacing, head injury with initial Glasgow Coma Score ≤ 8, multiple traumatic injuries, or heart failure requiring an interventional cardiologist. For complicated burns > 10% total body surface area, access to a specialized burn unit or burn center is recommended.

Recommended PICU discharge and transfer criteria:

- Each PICU should have clearly defined criteria for escalation and de-escalation of resources and, therefore, the level of PICU required based on the physiologic status of the patient.
- All levels of PICU should have policies and protocols in place that specify when the patient's physiologic status requires escalation of care, with transfer to a more appropriate level of care as expeditiously as needed.
- When a patient's physiologic status improves, discharge from the PICU can occur in a number of ways:
  - transfer to an appropriate acute care bed within that facility;
  - return transfer to the referring facility;
  - transfer to a skilled nursing or rehabilitation facility; or
  - discharge directly to home.
- Upon discharge from the PICU, the following should take place:
  - appropriate communication with the accepting facility including oral handoff, a clear and concise written summary, and exchange of necessary health information;
  - discharge planning and communication with the family/caregivers if going home;
  - communication with the primary care physician who will assume care of the child once the patient is returned to the community;
  - communication with subspecialists caring for the child and appropriate follow-up arranged as necessary; and
  - as needed, careful care coordination with outpatient services such as but not limited to:
    - delivery and instruction in the use of durable medical equipment;
    - home pharmacy and nutrition support;
    - ongoing rehabilitation needs, such as occupational or physical therapy; and
    - ancillary support as required.

ACGME = Accreditation Council for Graduate Medical Education, ACS = American College of Surgeons.

TABLE 2. PICU Resources by Level of Care

Resources by Organ System	Quaternary Facility or Specialized	Tertiary	Community
Cardiovascular			
Hemodynamic monitoring			
Noninvasive	Essential	Essential	Essential
Invasive	Essential	Essential	Essential
Inotropic support	Essential	Essential	Essential
Echocardiogram (24-hr availability)	Essential	Essential	Essential
Extracorporeal membrane oxygenation/extracorporeal life support	Essential	Optional	NE
Ventricular assist devices	Essential	Optional	NE
Transplantation: heart	Desirable	Optional	NE
Gastrointestinal			
Upper and lower endoscopy	Essential	Essential	Desirable
Transplantation: liver	Desirable	Optional	NE
Hematologic			
Plasmapheresis/leukapheresis	Essential	Essential	Desirable
Transplantation: bone marrow	Essential	Optional	NE
Neurologic			
Intracranial pressure monitoring	Essential	Essential	Desirable
External ventricular drain	Essential	Essential	Desirable
Lumbar drain	Essential	Essential	Desirable
Continuous electroencephalogram	Essential	Essential	Optional
Video electroencephalogram	Essential	Essential	Optional
Respiratory			
Noninvasive ventilation (high-flow nasal cannula, continuous positive airway pressure, b-level or biphasic, negative pressure ventilation)	Essential	Essential	Essential
Conventional mechanical ventilation	Essential	Essential	Essential
Advanced mechanical ventilation (high inspiratory flow ventilation, high-frequency oscillatory ventilation)	Essential	Essential	Desirable
Conventional inhalation therapies (heliox, continuous albuterol)	Essential	Essential	Essential
Nitric oxide	Essential	Essential	Desirable
Advanced inhalation gases (epoprostenol sodium, anesthetic agents)	Essential	Desirable	Optional
Bronchoscopy	Essential	Essential	Desirable
Transplantation: lungs	Desirable	Optional	NE
Renal			
Continuous renal replacement therapy	Essential	Essential	Optional
Hemodialysis	Essential	Essential	Optional
Peritoneal dialysis	Essential	Essential	Optional
Charcoal hemofiltration	Essential	Essential	Desirable
Transplantation: kidney	Essential	Optional	NE

(*Continued*)

TABLE 2. (*Continued*). PICU Resources by Level of Care

Resources by Organ System	Quaternary Facility or Specialized	Tertiary	Community
Radiology			
Diagnostic imaging including CT (24-hr availability)	Essential	Essential	Essential
Advanced diagnostic imaging including MRI (with sedation)	Essential	Essential	Desirable
Interventional neuroradiology	Essential	Desirable	Optional
Interventional cardiology	Essential	Desirable	Optional
Cardiac MRI	Essential	Desirable	Optional

NE = not expected.

children with surgical problems. This expectation includes collaborative care in ICU environments (3, 4).

Quaternary Facility or Specialized PICU Level of Care

Purpose. A quaternary PICU facility is defined as one that is commonly found in university or children's hospitals that provide regional care and serve large populations or have a large catchment area. The center would provide comprehensive care to all complex patients, including but not limited to those with significant cardiovascular disease, end-stage pulmonary disease, complex neurologic/neurosurgical issues, transplantation services (both bone marrow transplant and solid organ), multisystem trauma, and burns greater than 10% total body surface area (TBSA). This highest level of PICU would have readily available resources to support an ACS-verified level I or level II Children's Surgical Center or level I or level II Pediatric Trauma Center (3, 4).

A specialized PICU provides diagnosis-specific care for select patient populations. Examples of this might include a cardiac ICU or a burn unit that provide pediatric critical care. These ICUs have specialized equipment and supplies as well as medical, nursing, and other members of the patient care team with specific skills dedicated to a certain discipline. These types of PICUs may be a subsection of a larger PICU, a separate surgical ICU, or a PICU in a specialty hospital.

Patient Population. Children who require complex medical and surgical interventions are cared for in a quaternary facility. The resources required to provide comprehensive services to these complex patients and their families can be highly specialized and require a skill set by staff who are colocated in only a few centers. The age range of patients may therefore extend from the care of premature neonates to certain adults (e.g., with complex congenital cardiac conditions) and others whose complex care has not yet transitioned to adult care providers (e.g., cystic fibrosis, unusual pediatric cancers occurring in young adults).

Delphi statement. Patients who are appropriately triaged according to the level of illness and services provided in community/tertiary/quaternary or specialized PICU facilities will have comparable outcomes and quality of care.

Results. Consensus met (97% agreement).

Subsequent to the 2004 PICU guidelines, the evidence to support whether specialized disease-specific resources promote best outcomes is primarily derived from data registries or other retrospective, observational designed studies. These cohort studies are large and include evaluation of pediatric outcomes in pediatric trauma centers (5–8), pediatric transplant units (9), and pediatric cardiac surgery units (10, 11). In addition, Gupta et al (12) evaluated the association of freestanding children's hospitals with outcomes in children <18 years of age with critical illness (2009–2014), using the national Virtual Pediatric Systems (VPS, Los Angeles, CA) database. Propensity score matching was performed to adjust for confounding variables, with results demonstrating improved outcomes in freestanding hospitals for mortality (freestanding vs nonfreestanding, 2.1% vs 2.8%; $n = 67{,}328$; $p < 0.001$), reintubation (3.4% vs 4.8%; $n = 67{,}328$; $p < 0.001$), and good neurologic outcome (97.7% vs 97.1%; $n = 12{,}300$; $p = 0.001$). All of these recent studies support the recommendation that triaging critically ill patients who require highly specialized services to a quaternary facility or specialized PICU leads to better outcomes including decreased mortality and improved neurologic outcomes.

Delphi Statement. Developing admission criteria assists in matching the placement of a critically ill child to an appropriate PICU level of care.

Results. Consensus met (100% agreement).

Admission criteria for specialized or quaternary facility PICUs identify the unique patient population (e.g., burns, trauma, cardiac surgery, neurologic) and match them to the resources available in the PICU and the hospital organizational characteristics (e.g., bed capacity, advanced technologies). Table 2 summarizes the consensus reached by the task force on the resource needs by PICU level. Quaternary facility PICUs are expected to be able to care for highly complex pediatric patients requiring the most sophisticated advanced technology and comprehensive interdisciplinary team management. Specialized PICUs would be expected to have resources and personnel unique to the care of a specific disease process or population of patients.

Delphi statement. Patient volume in the ICU setting has a positive impact on outcomes.

Results. Consensus not met (79.4% agreement).

A volume-outcome relationship in adult ICU patients has been suggested (13–15); however, only a few studies have attempted to demonstrate whether a relationship between

TABLE 3. PICU Level of Care Matched to Personnel

Staff	Qualifications	Roles	Quaternary/ Specialized	Tertiary	Community
Leadership					
Medical Director	• Board certified for pediatric critical care medicine upon completion of an ACGME-accredited pediatric critical care medicine fellowship • Participates in training to meet ongoing education and certification requirements	• Primary attending physician • Provides consultation for PICU patients • Participates in development, review and implementation of policies • Supervises quality control and assessment activities • Supervises/coordinates all medical staff education/ competencies • Participates in program development, including budgetary preparation and policy implementation • Available to the PICU 24 hr a day, 7 d a week for both clinical and administrative issues (or similar qualified physician)	Essential	Essential	Essential
Nurse Manager or Director	• Training and expertise in pediatric critical care • Master's degree in pediatric nursing or nursing administration • Participates in education and training to meet ongoing education and certification requirements	• Assures appropriate nurse-to-patient ratios • Participates in development, review and implementation of unit and nursing policies and procedures • Assurance of nursing orientation and competency, performance reviews • Participates in program development, including budgetary preparation and policy implementation • Participates in the development of quality improvement projects • Available to PICU for clinical and administrative issues 24 hr/d (or qualified designee)	Essential Nurse-to-patient ratios: 1:1, 1:2, 2:1	Essential Nurse-to-patient ratios: 1:1, 1:2	Essential Nurse-to-patient ratios: 1:1, 1:2
Surgical Director/ Leader	• Board certified for pediatric surgery upon completion of an ACGME-accredited pediatric surgery fellowship. Additional certification in surgical critical care is desirable but not required.	• A children's surgeon who serves within the medical leadership structure of the PICU (who may be designated as the "surgical director") and is responsible for setting policies and defining administrative needs related to PICU patients with general or subspecialty pediatric surgical needs	Essential	Essential	Desirable (A general surgeon with pediatric interest would be an alternative)

(*Continued*)

TABLE 3. (*Continued*). PICU Level of Care Matched to Personnel

Staff	Qualifications	Roles	Quaternary/ Specialized	Tertiary	Community
Trauma Director	• Board certified for pediatric surgery upon completion of an ACGME-accredited pediatric surgery fellowship	• A children's surgeon who serves within the medical leadership structure of the PICU (who may be designated as the "trauma director") and is responsible for setting policies and defining administrative needs related to PICU patients with traumatic injuries (the Surgical Director/Leader may serve in this capacity for nontrauma centers)	Essential	Essential	Desirable (A general surgeon with pediatric interest would be an alternative)
Primary medical and surgical providers					
Pediatric Intensivist or equivalent	• Board eligible or board certified in pediatric critical care medicine after training in an ACGME-accredited program • Participates in training to meet ongoing education and certification requirements for pediatric critical care	• Physician in-house 24 hr/d • Available in ≤ 30 min (24 hr/d) • Provides medical care/ oversight for care provided by physicians in training, NPs, and PAs for all PICU patients • Participates in the development of quality improvement projects	Essential	Essential (Desirable*:* physician in-house 24 hr/d)	Essential (Optional*:* physician in-house 24 hr/d)
Pediatric Surgeon	• Board certified for pediatric surgery upon completion of an ACGME-accredited pediatric surgery fellowship. Additional certification in surgical critical care is desirable but not required • Participates in training to meet ongoing education and certification requirements for pediatric surgery	• Available in ≤ 1 hr to the PICU • Provides surgical care/ oversight for care provided by physicians in training, NPs, and PAs • Participates in the development of quality improvement projects	Essential	Essential	Desirable (A general surgeon with pediatric interest would be an alternative)
Other physicians: hospitalists, pediatric trainees, surgical trainees	• Postgraduate year 2 level or above assigned to PICU • ACGME-accredited pediatric or surgical critical care with focus on pediatric critical care residency program • Participate in training to meet ongoing education and certification requirements	• In-house PICU coverage 24 hr/d within ACGME restrictions • Participates in monitoring of quality improvement projects	Essential (may include combination of hospitalists and NPs)	Essential (may include combination of hospitalists and NPs)	Desirable (may include combination of hospitalists and NPs)

(*Continued*)

TABLE 3. (*Continued*). PICU Level of Care Matched to Personnel

Staff	Qualifications	Roles	Quaternary/ Specialized	Tertiary	Community
Advanced Practice Providers or NPs	• Training and expertise in pediatric critical care • Graduate of NP Program • Pediatric NP certification: acute care • Master of Science in Nursing or Doctorate in Nursing Practice • Participates in training to meet ongoing education and certification requirements	• Provide collaborative, comprehensive management of PICU patients • Performance of advanced therapeutic procedures • Participate in the development of quality improvement projects • May lead rapid response teams	Desirable (may include combination of hospitalists and NPs)	Desirable (may include combination of hospitalists and NPs)	Desirable (may include combination of hospitalists and NPs)
PAs	• Training and expertise in pediatric critical care • Graduate of PA program • Participates in training to meet ongoing education and certification requirements	• Direct patient management with physician supervision • Performance of advanced therapeutic procedures • Participates in monitoring of quality improvement • May lead rapid response teams	Desirable (may include combination of hospitalists and PAs)	Desirable (may include combination of hospitalists and PAs)	Desirable (may include combination of hospitalists and PAs)
Additional medical and surgical providers					
Pediatric Medical Subspecialists	• Cardiologist • Pulmonologist • Neonatologist	• Available 24 hr/d	Essential	Essential	Essential
	• Nephrologist • Hematologist/ oncologist • Endocrinologist • Gastroenterologist • Neurologist • Infectious Disease specialist	• Available 24 hr/d	Essential	Essential	Desirable
	• Interventional cardiologist • Allergist • Geneticist • Rheumatologist • Child Advocacy (Child Forensics or Abuse Specialists)	• Available 24 hr/d	Essential	Desirable	Optional
Pediatric Surgical Subspecialists	• Cardiovascular Surgeon • Neurosurgeon • Otolaryngologist • Orthopedic surgeon • Ophthalmologist • Plastic surgeon • Urologist	• Available in ≤ 1 hr to the PICU	Essential	Desirable (Essential: nonpediatric)	Optional (Desirable: nonpediatric)
Pediatric anesthesia	• Anesthesiologist	• Available in ≤ 1 hr to the PICU	Essential	Essential	Desirable (Essential: nonpediatric)

(*Continued*)

TABLE 3. (*Continued*). PICU Level of Care Matched to Personnel

Staff	Qualifications	Roles	Quaternary/ Specialized	Tertiary	Community
Pediatric radiologists	• Radiologist • Interventional radiologists • Neuroendovascular	• Available 24 hr/d • Available 24 hr/d • Available 24 hr/d	Essential Essential Essential	Essential Essential Desirable	Desirable (Essential: nonpediatric) Desirable (Essential: nonpediatric) Optional
Psychiatrist or psychologist or Mental Health NP		• Available for consultation	Essential	Essential	Essential
Nursing staff					
RNs	• Bachelor of Science in nursing degree preferred • Hospitals with Magnet designation require < 10% non–Bachelor of Science Nursing RNs • Completion of PICU orientation • Continuing education requirements for licensure renewal • BLS and PALS • Pediatric CCRN certification • Maintenance of designated PICU competencies	• Provision of continuous care based on needs and characteristics of the patient • Provision of physiologic assessments, implementation, and evaluation of responses to treatment plan • Skilled in advanced technology monitoring • Appropriate number of nurses trained in highly specialized therapies such as continuous renal replacement therapy and roles including: ◦ Charge nurse ◦ Arrest team nurse ◦ Transport team nurse ◦ Trauma team nurse ◦ Rapid response team • Preceptor for novice nurses • Participates in development and monitoring of quality improvement projects	Essential	Essential (Desirable: Pediatric CCRN Certification)	Essential (Desirable: Pediatric CCRN Certification)
Nurse educator or clinical nurse specialist	• Training and expertise in pediatric critical care • Master of Science in Nursing or Education or PhD or Doctor of Nursing Practice prepared • Pediatric nursing expertise • Pediatric CCRN certification • BLS and PALS	• Participates and coordinates nursing staff education • Clinical resource for nursing staff • Participates in the development of quality improvement projects • Participates in clinical research efforts	Essential	Essential	Desirable
Nursing assistants/ unlicensed personnel		• Assists RNs inpatient care tasks • Supervised by nursing staff	Desirable	Desirable	Optional

(*Continued*)

TABLE 3. (*Continued*). PICU Level of Care Matched to Personnel

Staff	Qualifications	Roles	Quaternary/ Specialized	Tertiary	Community
Respiratory therapy staff					
Supervisor	• Registered respiratory therapist with training and expertise in pediatric critical care	• Responsible for training therapists • Clinical resource for therapists	Essential	Essential	Essential
Respiratory therapists	• Registered respiratory therapist • BLS and PALS • Demonstrate competence with pediatric mechanical ventilation • Adjunctive respiratory therapies including gases	• Therapist assigned to PICU 24 hr/d • Skill in management of pediatric patients with respiratory disease • Maintenance of equipment and quality control/review • Participate in rapid response team	Essential	Essential	Essential
Other team members					
Pediatric Pharmacist	• Pediatric clinical pharmacist or PharmD (w/residency training)	• Available 24 hr/d	Essential	Essential	Desirable (Essential: nonpediatric)
Rehabilitation services	• Physical therapist, occupational therapist, speech therapist	• Available for consultation	Essential	Essential	Essential
Nutritionist or clinical dietitian		• Available for consultation	Essential	Essential	Essential
Social worker		• Available for consultation	Essential	Essential	Essential
Clergy		• Available for consultation	Essential	Essential	Essential
Child life specialist		• Available for consultation	Essential	Essential	Desirable
Pain team		• Available for consultation	Essential	Essential	Desirable
Palliative care		• Available for consultation	Essential	Desirable	Desirable
Rapid response team		• Available 24 hr/d	Essential	Essential	Essential
Transport team		• Available 24 hr/d	Essential	Essential	Desirable
Ethics committee		• Available for consultation	Essential	Essential	Essential
Quality and safety		• Available for consultation	Essential	Essential	Essential
Legal/risk management		• Available for consultation	Essential	Essential	Essential
Biomedical technician		• In-hospital or available within 1 hr, 24 hr/d	Essential	Essential	Essential
Radiology services		• Available in ≤ 1 hr	Essential	Essential	Essential
Laboratory services		• Available 24 hr/d • Provide basic hematologic, chemistry, blood gas, and toxicology analysis	Essential	Essential	Essential
Blood bank services		• Available 24 hr/d	Essential	Essential	Essential
Neuro-diagnostic services		• Electroencephalography available on-call for emergencies	Essential	Essential	Desirable
Unit clerk		• Staffed 24 hr/d	Essential	Essential	Desirable

ACGME = Accreditation Council for Graduate Medical Education, BLS = Basic Life-Support, CCRN = Critical Care Registered Nursing, NP = nurse practitioner, PA = physician assistant, PALS = Pediatric Advanced Life Support, RN = registered nurse.

PICU volume and outcomes exists. Tilford et al (16) conducted a prospective multicenter study with 16 PICUs that collectively admitted 11,106 consecutive patients over a 12-month period. With an average patient volume of 863 and SD of 341, the investigators found a significant inverse relationship between patient volume and risk-adjusted mortality and length of stay (LOS). A 100-patient increase in PICU volume decreased risk-adjusted mortality (adjusted odds ratio [OR] of 0.95 per 100 patients/yr; 95% CI, 0.91–99) and LOS (incident rate ratio, 0.98; 95% CI, 0.975–0.985). Marcin et al (17) conducted a retrospective analysis of 34,880 consecutive patient admissions from 15 PICUs in the PICU Evaluations database repository to evaluate the impact of PICU volume on mortality. Although the results revealed an association between lower severity-adjusted mortality and higher PICU volume, the best outcomes were seen in mid- to large-sized PICUs (annual admission volumes between 992 and 1,491).

Most recently, Markowitz et al (18) conducted the largest retrospective cohort national study of 186,643 patients from 92 PICUs in the VPS database to further determine the relationship between PICU volume and severity-adjusted mortality. The results did not support earlier findings, demonstrating that the relationship between volume and mortality was a function of patient severity of illness. Similar severity-adjusted mortality was seen in PICUs of different volumes when the severity of illness was low, but PICUs with higher volume had higher severity-adjusted mortality than low-volume PICUs. The investigators speculated that findings may be attributable to differences in quality of care, unmeasured confounding variables, or calibration limitation of the severity of illness scores for higher-risk patients. Although there may be a volume threshold that impacts patient outcomes, many factors are proposed to influence the quality of care (e.g., nursing ratios and radiology support services) and warrant further investigation.

Delphi statement. Pediatric patients requiring specialized service interventions, such as burn care, cardiac, neurologic, or trauma-related surgery, have better/improved outcomes when cared for in a quaternary/specialized or tertiary PICU.

Results. Consensus met (100% agreement).

Some data support improved outcomes in children requiring specialized surgical services when cared for in high-volume specialized centers. Small, single-center studies have seen a significant decrease in mortality and morbidity in patients care for in dedicated pediatric cardiac ICUs (19, 20); however, the same results have not been reproduced in larger, multi-institutional studies (21). Palmieri et al (22) conducted a retrospective review of 33,115 pediatric burn admissions in the National Burn Repository between 2000 and 2009. Results revealed high-volume centers, defined as greater than 200 pediatric patients admitted per year, had the lowest severity-adjusted mortality ($p < 0.05$). Recent studies examining pediatric transplant registry data demonstrate improved outcomes in centers with larger case volume and expertise, including liver transplantation, defined as more than five transplants per year (23); lung transplantation, defined as more than four transplants per year (9); heart transplantation, defined as more than three transplants per year (23); and kidney transplantation, defined as more than three transplants per year (24).

Centers supporting specialized surgical services should have the concomitant surgical personnel and resources to care for these patients. Specifically, complex and multisystem trauma patients should have resources outlined for level I and II trauma centers. Burn patients should have surgeons, physicians, physiatrists, psychologists, nurses, therapists, and other patient care team members capable of comprehensive burn care. Transplant patients with the primary transplant or transplant-related problems should be cared for in a hospital, preferably in good standing with United Network of Organ Sharing, that has readily available transplant surgeons, pediatric subspecialists, radiologists, nurses, and other members of the transplant care team. Neurosurgical patients should be cared for in a PICU and hospital with readily available neurosurgeons, neurologists, intensivists with neurologic interest, neuroradiologists, interventional radiologists, nurses, and other applicable members of the neurologic and neurosurgical teams.

Delphi statement. Surgical volume (cardiothoracic, neurosurgery, trauma, etc) has a positive impact on patient outcomes.

Results. Consensus met (82.4% agreement).

Data demonstrating decreased mortality related to surgical volume for different pediatric specialties are limited and inconsistent. Some data exist demonstrating decreased mortality in pediatric cardiac surgery centers with higher volumes. Welke et al (10) analyzed 32,413 patients from 48 programs in the Society of Thoracic Surgeons Congenital Heart Surgery Database (STS-CHSD) and found an inverse relationship between volume and mortality when case complexity increased (e.g., Norwood procedure). No difference in units was seen for less complex surgical cases. Size of centers was defined as small (< 150); medium (150–249); large (250–349); and very large (≥ 350 cases/yr). Oster et al (25) reviewed 49,792 pediatric congenital heart surgeries from the Pediatric Health Information Systems database and found that surgical volume was not significantly associated with mortality for lower-risk surgeries ($p = 0.4122$) but trended toward significant for higher-risk surgeries ($p = 0.0678$). Pasquali et al (11) examined the association of center volume with mortality and complications in 35,776 children undergoing cardiac surgery using the STS-CHSD. Although there was no association between center volume and rate of complications, lower center volume (< 150 cases/yr) was significantly associated with higher mortality in patients experiencing a postoperative complication. Gupta et al (26) examined outcomes after in-hospital cardiac arrest following pediatric cardiac surgery using STS-CHSD. Of 70,270 patients, 1,843 (2.6%) had postoperative cardiac arrest, and postcardiac arrest mortality was higher in low-volume centers (< 150 cases/yr) for both high- and low-complexity surgeries. Surgical volume may be associated with better patient outcomes, but currently, supporting data are limited.

A level I Children's Surgical Center has a requirement of at least 1,000 surgical procedures each year. A level I Pediatric Trauma Center must annually admit 200 or more injured

children younger than 15 years old and level II Pediatric Trauma Center must admit 100 or more injured children younger than 15 years old. A PICU in a level I Children's Surgical Center or level I or II Pediatric Trauma Center should be able to support the critical care needs of these patients. The impact of hospital and PICU resources and volume on patient outcomes must be considered, including the availability of resources, expertise, and personnel to match the volume and patient complexity.

Delphi statement. Congenital heart surgery should only be performed in a hospital that has a PICU with a dedicated pediatric cardiac ICU, including but not restricted to pediatric intensivists and nurses with expertise in cardiac intensive care, cardiovascular surgeon with pediatric expertise, pediatric perfusionist, pediatric cardiologist with catheterization and imaging experience, pediatric anesthesiologist, and advanced practice providers (APPs) (NPs and PAs).

Results. Consensus met (88.2% agreement).

Gupta et al (12) in a large observational study examined the relationship between freestanding children's hospitals and outcomes in children with critical illness in comparison to nonfreestanding hospitals in matched and unmatched groups. After matching, more pediatric cardiac surgery patients were cared for in a dedicated cardiac ICU than a nonspecialized PICU (6.2% vs 5.2%), and the majority of patient outcomes were better including mortality, reintubation, and good neurologic outcome. However, Burstein et al (21) conducted a large multi-institutional study including 20,992 children undergoing congenital heart surgery in 47 centers (25 pediatric cardiac ICUs) and were unable to detect a difference in postoperative morbidity and mortality associated with a dedicated cardiac ICU. The investigators suggested that further investigation is warranted to evaluate the impact of confounding ICU factors on outcomes including the availability of personnel, surgeon technical skill, and standardized management protocols. Oster et al (25) found that low-complexity congenital heart surgeries performed in PICUs with and without a dedicated pediatric cardiac ICU have similar outcomes.

Providers. Groups of providers needed to care for complex cardiac patients in a quaternary facility or specialized PICUs include intensivists, as well as medical and surgical subspecialists skilled in the care of patients who require organ-specific attention. Some intensivists will have had additional training in another pediatric subspecialty, such as cardiology, neurology, pulmonology, or anesthesiology, with enhanced ability to care for these complex patients. In addition to intensivists, advanced pediatric practice providers (NP and PA), hospitalists, bedside nurses, and respiratory therapists (RTs) must have special training to care for this specific patient population. Many patients may require specialized forms of circulatory and respiratory assistance (e.g., ECMO, ventricular assist devices [VADs], continuous renal replacement therapy [CRRT]), requiring advanced technical knowledge and training. In addition to the providers of direct patient care, specialized expertise in anesthesiology may be required to assist with procedural sedation in patients with difficult airways or needing intrafacility patient transfer to other diagnostic and therapeutic areas within the hospital.

Delphi statement. Expertise in the care of the critically ill child is required in a community/tertiary/quaternary or specialized PICU.

Results. Consensus met (100% agreement).

Physicians who care for children in PICUs should have expertise in pediatric critical care and be appropriately credentialed and privileged by the hospital governance structure. Physicians in tertiary and quaternary facilities should be Board Eligible or Certified in critical care with pediatric expertise or equivalent if available in the specialty. Designated medical directors for the PICU as well as specialized programs including trauma are necessary to provide administrative oversight and management of the PICU. Trauma programs require formal surgical coleadership. A PICU associated with an ACS-verified Children's Surgical Center requires demonstrable surgical leadership participating in operational management, quality and safety initiatives, and educational programs (4).

Advanced pediatric practice providers (NPs and PAs), hospitalists, bedside nurses, RTs, pharmacists, dieticians, social workers, and child life specialists should also have special training in caring for these specific patient populations. Other specialized providers able to manage advanced technologies for advanced physiologic support as dictated by the level of PICU are needed. A patient- and family-centered multidisciplinary approach is optimal in the management of critically ill children.

Although clinical expertise is deemed fundamental for PICU staff in all levels of care to promote optimal patient care, the impact of ICU structure alone has not consistently demonstrated improved outcomes in specialized ICUs. Although highly specialized knowledge and clinical skill are expected, other ICU-related factors, including the availability of personnel, surgeon technical skill, standardized management protocols, and other processes and systems, have a bigger impact on outcomes than ICU structure in specialized ICUs.

Delphi statement. All critically ill children admitted to any PICU should be cared for by a pediatric intensivist either board eligible, board certified, or undergoing maintenance of certification as the primary provider or in consultation while in the ICU setting.

Results. Consensus met (87.9% agreement).

The majority of the Voting Panel agreed that a pediatric intensivist should serve as the primary provider for all PICU patients rather than function in a consultant role in all levels of PICU. Currently there are limited, low-quality data in pediatrics to support this statement. However, a systematic review and meta-analysis of "adult" ICU physicians staffing models conducted by Wilcox et al (27) compared high-intensity staffing models (comprehensive intensivist-led care for all ICU patients) versus low-intensity staffing (partial or nonintensivist care) and found that the high-intensity staffing model was associated with lower hospital and ICU mortality (pooled respiratory rate [RR], 0.83; 95% CI, 0.70–0.99; and pooled RR, 0.81; 96% CI, 0.68–0.96, respectively).

In some institutions, PICUs are defined as "open," where the admitting physicians may not be on the PICU staff. In such cases, a pediatric surgeon who is board eligible or board certified and undergoing maintenance of certification in surgical critical care may be the admitting physician. In other institutions, PICUs are "closed" units and the patients must be admitted to the PICU staff. When the admitting physician is not eligible in critical care, the admitting physician should be the pediatric intensivist. If the pediatric intensivist is not the admitting physician, a pediatric intensivist who is board eligible or board certified and meeting current requirements for maintenance of certification in pediatric critical care medicine should consult and provide guidance on all critically ill children admitted to a PICU.

Trauma patients should be cared for by both the surgical/trauma service (including trainees) and the PICU service in a collaborative manner. The ACS requires that surgeons be the primary provider on all patients admitted with traumatic injuries (4). To deliver multispecialty care required for the trauma patient, surgical/trauma consultation or comanagement with the pediatric intensivists is advised. Trauma care should be collegial and a team effort by the PICU and trauma providers.

In accordance with the requirements of the ACS Children's Surgical Verification program, the surgical service that assumes initial responsibility for the care of the critically ill patient with surgical needs must maintain that responsibility and involvement either throughout the acute care phase of hospitalization or until formal transfer to another service upon adequate resolution of acute surgical issues. The surgeon must remain actively involved with the surgical needs of the patient while in the ICU and be involved in the therapeutic decisions.

Support Services. In addition to the direct patient care providers, additional support service personnel should have expertise in providing care to the patient and family. These services may include social workers, pharmacists, case managers, chaplains, palliative care, integrative care, occupational therapy (OT), physical therapy (PT), speech language pathology (SLP), child life specialists, and other parental and family support staff. Social workers and case managers should work closely with families and care providers to address housing, financial, and other issues. Many children will require long-term management at the acute care facility, and significant support is required to meet the needs of the families. Some children will require significant OT, PT, and/or SLP prior to discharge either to home or to a repatriated inpatient facility closer to home or to rehabilitation and this requires optimal discharge planning and care coordination. Some patients will require palliative care, which should begin at the acute care facility. This is usually provided by a comprehensive team of professionals who help both the family and the healthcare team in decision making regarding further interventions, pain and symptom management, and overall assistance in long-term care planning. A proactive comprehensive approach assists with decision making (e.g., code status).

Delphi statement. The ICU structure/care delivery model components having the greatest impact on patient outcomes include the following: in-house intensivist, nursing staff with PICU expertise, dedicated clinical pharmacist, registered dietitians, multidisciplinary rounds (providers and specialized staff), social worker, child life specialist, chaplain/clergy, palliative care, and RTs with PICU expertise.

Results. Consensus met for nursing staff with PICU expertise, multidisciplinary rounds, pharmacists, and RTs with PICU expertise (> 80% agreement) (Table 3).

The PICU structure and care delivery model components continue to evolve. There is an expectation that the team leader will be an intensivist who is complemented by a dedicated, skilled multidisciplinary team (28, 29). Ideal care of children with multisystem illness and dysfunction also requires the involvement of medical and surgical specialists. The consensus was met for nursing and respiratory staff with PICU expertise having the greatest impact on patient outcomes, the importance of care that is immediately available and also comprehensive, with team members including dedicated clinical pharmacists, registered dietitians, rehabilitation therapists, and others, has become increasingly important in specialized PICUs.

Delphi statement. All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities.

Results. Consensus met (93.9% agreement).

A clinical pharmacist involved in direct ICU patient management has been shown to improve patient safety and clinical outcomes in quaternary, tertiary, and community adult and PICUs (30–40).

Coverage Responsibilities. Because quaternary facilities provide the most inclusive and innovative care to the most complex medical and surgical patients, coverage responsibilities should be carefully spelled out and patient care responsibilities assigned to those with the most skill, training, and knowledge in caring for these patients. In-house attending coverage on a 24/7 basis is the benchmark to which most, if not all, quaternary facility PICUs aspire because of the types and acuity of patients seen. Others may participate in the minute-to-minute care of the patient (ICU and other subspecialty fellows, APPs with special expertise). In addition, specific surgical and medical specialists need to be able to respond expeditiously to dynamic changes in physiologic status. For example, anesthesiologists or those skilled in critical airway management, surgeons who can "perform an emergency thoracotomy" if indicated, and other interventionalists must be able to respond within a very narrow window of time (< 30 min). Others who are necessary but not as time sensitive may respond within 60 minutes or longer, depending on the issue that needs to be addressed.

Delphi statement. A qualified medical provider who is able to respond within 5 minutes to all emergency patient issues (such as airway management and cardiopulmonary resuscitation) is necessary for optimal outcomes in all levels of PICU.

Results. Consensus met (100% agreement).

A qualified medical provider able to readily respond to emergency patient issues may include a pediatric intensivist,

critical care fellow, subspecialty fellow, hospitalist, or APP and will depend on PICU level of care. In the quaternary facility or specialized PICUs, the opinion of the task force is that the "qualified medical provider" should be a pediatric intensivist. With the expectation that the most critically ill children are being cared for in these centers, the highest level of critical care and specialized service expertise should be readily available. For a verified Children's Surgical Center, a qualified general pediatric or pediatric subspecialty surgeon able to respond readily to emergency surgical issues in critically ill patients should be available (this includes a trauma patient). The designation of "qualified" is defined by the surgical problem and availability should be commensurate with the level of care of the PICU and level of Children's Surgical Verification of the institution.

Delphi statement. Specialized or quaternary facility ICUs must have an in-house pediatric postgraduate year (PGY) 3 or higher physician with training and experience in the designated specialty.

Results. Consensus not met (69.7% agreement).

The critical care physician shortage and ACGME restriction on resident duty hours have led to the use of alternative providers, including APPs and hospitalists, for in-house night coverage in all levels of PICUs. Data demonstrating improved outcomes in specialized ICUs attributable to the presence of in-house night coverage of attending physicians are limited. A recent study by Gupta et al (12) found that the presence of 24-hour ICU attending physician coverage in children following cardiac surgery was associated with decreased mortality at ICU discharge (24/7 vs no 24/7 coverage was 2.8% vs 4.0%, respectively; $p = 0.002$), and the use of ECMO, frequency of cardiac arrest, extubation within 48 hours postsurgery, rate of reintubation, and duration of arterial catheters and central venous catheter were significantly improved in the 24/7 group. Although further research is needed to determine whether other factors impact patient outcomes, the Voting Panel agreed that quaternary facility or specialized ICUs should have a minimum of an in-house critical care fellow (PGY4).

Delphi statement. Night coverage response requirement for pediatric intensivists, who are not in-house, includes being readily available by telephone and present in the PICU within 30 minutes of request.

Results. Consensus met (84.8% agreement).

Although Gupta et al (12) found the presence of 24/7 attending coverage was associated with decreased ICU mortality in children following cardiac surgery, other recent ICU data have not shown an association (27, 41). However, other studies have demonstrated improvements in ICU processes of care, staff and family satisfaction, and reductions in adverse events and hospital LOS (42–49). The opinion of the majority of the Voting Panel is that 24/7 intensivist coverage should be the standard of practice in a quaternary facility or specialized ICUs to promptly care for highly complex children requiring sophisticated advanced technology.

Delphi statement. Pediatric hospitalists, NPs, and PAs who provide first-line night coverage in PICUs must be skilled in advanced airway, line placement, and ventilator management.

Results. Consensus met (84.8% agreement).

The specific clinical expertise and procedural competencies for hospitalists and APPs have predominately been determined by individual PICUs and institutions. These expectations are typically mitigated by the availability of other skilled providers such as an intensivist in-house or critical care fellow. In the quaternary facility or specialized ICU, providers skilled in advanced airway and other emergency procedures are expected to always be available.

Delphi statement. The use of medical providers in the PICU, including hospitalists, NPs, or PAs, may improve patient outcomes.

Results. Consensus not met (78.8% agreement).

The utility of the APP role has been well established, and when compared with physicians in training, the results demonstrate similar patient outcomes. Some recent adult studies comparing care provided by NPs and PAs to residents in specialized ICUs have also demonstrated similar or improved outcomes (50–52). However, the intent of this question was not clear to the Voting Panel and results were not interpretable.

Equipment and Technology. Quaternary facility PICUs must have the necessary equipment and technology that enable them to monitor and care for the physiologic needs of patients. Hemodynamic monitoring must include the ability to monitor and capture heart rate and rhythm, blood pressure, oxygen saturation, central venous pressure (CVP), left atrial pressure, and pulmonary artery pressure if indicated. Other forms of monitoring may be needed for neurologic monitoring (e.g., near-infrared spectroscopy [NIRS], continuous electroencephalography). Point-of-care testing needs to be optimized for various blood tests and imaging modalities, including echocardiography. Organ support devices should have regular evaluations to provide safe, quality care. Real-time monitoring and telemedicine capabilities may be considered in tertiary or community PICUs so that providers who are not physically at the bedside may be able to provide both diagnostic and therapeutic input away from the patient.

Performance Improvement and Patient Safety (Quality and Safety Initiatives). A quality and safety program is imperative for PICUs of all levels. A quality improvement (QI) program regularly evaluates patient outcomes and, when possible, allows benchmark comparisons to a similar group of patients in other centers, which guides project design to improve patient care. All PICUs should have a focused group that studies and implements safety initiatives and documents achievement of safety metrics on a regular basis. A regular morbidity and mortality review should be held with sentinel events undergoing a more in-depth root cause analysis with all involved subspecialties.

Delphi statement. All levels of PICUs should participate in academic pursuits: clinical trials, basic research, and/or scholarly pursuits.

Results. Consensus not met (20.59% clinical trials, 8.82% basic research, 52.94% scholarly pursuits).

The consensus was not achieved for research to be a requirement for all levels of PICU. However, the Voting Panel

agreed that academic pursuits should be an expectation for quaternary facility or specialized PICUs.

Delphi question. Which levels of PICUs should be affiliated with a training program that has at least medical students and residents?

Results. Consensus met for quaternary facility or specialized PICUs (81.8% agreement).

The Voting Panel agreed that affiliation with a training program that can support medical student learning and Pediatric Residency experience should be an expectation for quaternary facility or specialized PICUs. The consensus was not met on whether tertiary or community PICUs should be able to support student learning or a Pediatric Residency program.

When a Pediatric Critical Care Medicine Fellowship is supported by the quaternary facility or specialized PICU, there will be direct supervision of the fellows as directed in the Program Requirements of the ACGME. When Pediatric Critical Care and/or Pediatric Surgical Critical Care Fellowships are also present in the medical institution, the pediatric intensivists, their team, and trainees will participate in interprofessional care of patients providing appropriate communication and collaboration. Clear delineation of responsibilities will be sought on each patient. This requirement reflects the common program requirements outlined by the ACGME.

Delphi statement. All levels of PICUs should be involved in providing peer community outreach education, such as educational conferences, technical skills competencies, stabilization, and resuscitation (e.g., Pediatric Advanced Life Support [PALS] education).

Results. Consensus not met (75.8% agreement).

The consensus was not achieved for all levels of PICUs providing peer community outreach education. However, the panel considered community outreach to be an expectation of quaternary facility or specialized PICUs.

Relationships with other PICUs or adult ICUs.

Quaternary facility PICUs should maintain strong relationships with referring facilities for many reasons. These include transfer agreements, transfer protocols based on the need for a higher level of care, and/or formal regionalization of care networks. The alignment of medical and surgical needs often requires transfer to a higher level of PICU care, but repatriation to the home PICU or hospital is also appropriate when acute issues have resolved, and care can be rendered closer to home where it is more convenient for the family. A close working relationship among different centers can be cultivated with ongoing communication and, when possible, the use of telemedicine.

Quaternary facility PICUs are central to regionalization of pediatric care, which aims to rationally build capacity and appropriately match patient needs with appropriate resources through a deliberate, systems-driven approach to provide optimal care and enhance outcomes of critically ill children. Regional transfer networks will vary based on factors such as center designation, capabilities or specialty resources of local hospitals, bed capacity/availability of referring and receiving hospital, and ease of transfer. The development of collaborative partnerships, defined transfer criteria, coordinated, efficient transfer processes, and optimal communication including handoff and exchange of necessary health information will be crucial to the development of a robust regional network. Resources for interfacility transfer should be defined between centers and include transport team, equipment, and different modes of transfer (e.g., ambulance, helicopter, fixed-wing aircraft). Quaternary facility PICUs are expected to have access to the appropriate transport structure and resources to assist tertiary and community PICUs with interfacility transfers.

Transport and Transfers. PICUs must have access to safe intrafacility and interfacility transfer of critically ill patients. Intrafacility transfers are necessary when moving critically ill patients from the PICU to other locations in the hospital. Interfacility transfer of patients requires skilled personal and specialized equipment that allows for the provision of PICU level care during transport using the safest mode of transport under the conditions of patient acuity, distance to travel, geography, and weather conditions.

Delphi statement. PICUs should have their own freestanding critical care transport program with their own team, own equipment, and dedicated rig.

Results. Consensus not met (< 33% agreement).

The consensus was not met on whether a transport team is necessary for all PICUs. The majority of the Voting Panel agreed that quaternary facility or specialized PICUs should have access to a dedicated transport program. Tertiary and community hospitals may choose to outsource patient transport to a service with pediatric emergency and critical care expertise.

Delphi statement. PICUs may outsource some, if not all, of their critical care transport activities; however, the transport service used must have training in pediatric critical/emergency care.

Results. Consensus met (100% agreement).

The consensus was achieved for all levels of PICU, including quaternary facility or specialized, as long as the transport team has expertise in the emergency and critical care services required by the patient during transport.

Tertiary PICU Level of Care

Purpose In the previously published guidelines, these units were categorized as level I PICUs, as distinguished from level II PICUs. Tertiary PICUs provide advanced care for many medical and surgical illnesses in infants and children. Tertiary PICUs should provide advanced ventilatory support such as HFOV and inotropic management but would not be expected to provide ECMO support. There would be ready access to most pediatric medical subspecialties, but there may not be in-house coverage for the highest level of surgical specialties such as burns, neurosurgery, craniofacial, or a dedicated pediatric trauma team. Tertiary PICUs often reside in institutions located in or adjacent to metropolitan areas. Tertiary PICUs are found in university or children's hospitals, but some may be in large general medical-surgical centers that include pediatric services. These tertiary PICUs may have a formal affiliation with a medical school or residency training program, but

this academic association is not a requirement. Either basic science or clinical research may be pursued in a tertiary PICU but is not a requirement. Regardless of location, a tertiary PICU should be able to provide advanced care for complex patients. The tertiary PICU may be able to provide advanced technologies and services but will lack unique and/or comprehensive services offered in quaternary facility PICUs.

Patient Populations. Tertiary PICUs serve children who require advanced medical or surgical care for the treatment of actual or potential life-threatening illnesses, injuries, or complications. Tertiary PICUs often serve as referral centers for community PICUs, especially when quaternary facility PICUs are not available in the region. A tertiary PICU should have the ability to support vital functions and provide multisystem life support for an indefinite period (Table 2). Tertiary PICUs require extensive backup laboratory, clinical service facilities, and an expanded level and depth of pediatric resources to provide these services. Tertiary PICUs tend to be concentrated in centers where the expertise required to care for these patients and their families can be provided by pediatric-focused professionals. The age range of the population for some of these tertiary PICUs may extend beyond pediatrics to the care of neonates and adults. Tertiary PICUs may also play an important role in certain situations by providing additional resources via telemedicine for community PICUs.

The tertiary PICU should have readily available resources to support an ACS-verified Children's Surgical Center or Pediatric Trauma Center (3, 4).

Delphi statement. Patients who are appropriately triaged according to the level of illness and services provided in community/tertiary/quaternary or specialized PICU facilities will have comparable outcomes.

Results. Consensus met (97% agreement).

Patients who are appropriately triaged according to the level of illness and services provided in tertiary PICUs will have comparable outcomes and quality of care compared with similar patients cared for in quaternary facility or specialized ICUs, assuming that all systems are in place for optimizing the quality of care.

Delphi statement. Developing admission criteria assists in the placement of a critically ill child in an appropriate PICU level of care.

Results. Consensus met (100% agreement).

All facilities that contain PICUs should have admission criteria established so that patients may receive a level of critical care commensurate with their needs.

Delphi statement. Patient volume in the ICU setting has a positive impact on outcomes

Results. Consensus not met (78.8% agreement).

Patient volume in the PICU may have a positive impact on outcomes although there is no current evidence that definitively confirms this. Patient volume is only one factor affecting patient outcome. PICUs with lower volumes may have equivalent outcomes although lower patient volumes require more frequent staff education (18).

Delphi statement. The minimum number of patients requiring respiratory support in all PICU levels of care: 50–75 cases/yr, 76–100 cases/yr, 101–150 cases/yr, greater than 151 cases/yr.

Results. Consensus not met (< 37% agreement).

There is currently no agreement regarding the minimum volumes for specific disease entities and therapies in tertiary PICUs to promote optimal patient outcomes. Low-volume, high-risk disease entities and therapies should prompt ongoing education and competency training for the multidisciplinary PICU staff.

The disease entities that can be cared for in tertiary PICUs are conditions that are seen frequently in the critically ill pediatric population. These include, but are not limited to:

- Acute and chronic respiratory insufficiency (e.g., asthma, infection, acute lung injury, congenital airway, and pulmonary conditions)
- Circulatory failure (e.g., congenital cardiac disease, sepsis, heart failure)
- Infectious diseases leading to major organ system dysfunction
- Metabolic disorders (e.g., recognition and stabilization and treatment of diabetic ketoacidosis and inborn errors of metabolism)
- Neurologic diseases (e.g., status epilepticus, encephalopathy, traumatic brain injury [TBI])
- Toxic ingestions/exposures
- Trauma (management and treatment)
- Hematologic and oncologic disease

Providers. Tertiary PICUs require board-certified pediatric critical care specialists to provide direct care and coordinate care for patients who require multisystem or complex support. Some of the intensivists may have had additional training in another pediatric subspecialty, such as cardiology, neurology, pulmonology, or anesthesiology, enhancing their skills to care for these complex patients. Other medical and surgical subspecialists skilled in the care of such patients are also needed in a tertiary PICU. Pediatric medical subspecialists are required and include, but are not limited to, pediatric anesthesiology, cardiology, neurology, nephrology, pulmonology, endocrinology, hematology/oncology, gastroenterology, infectious diseases, and radiology. Pediatric surgical specialists needed include pediatric general and thoracic surgery, otorhinolaryngology, neurosurgery, urology, craniofacial and plastic surgery, and orthopedics.

A tertiary PICU also requires a designated medical director who is a board-certified pediatric critical care specialist to provide administrative oversight and management of the PICU. In tertiary PICUs that care for trauma patients, a designated pediatric trauma medical director who is board certified in pediatric surgery should also be a part of the leadership team. In PICUs that support an ACS Children's Surgical Center, there must be a children's surgeon who serves within the medical leadership structure of the PICU. The surgical representation will help in setting policies and defining administrative needs of trauma and surgical patients.

In addition to physician coverage, APPs, hospitalists, bedside nurses, and RTs should have special training to care for these critically ill patients. Many patients will require circulatory and

respiratory assistance (e.g., mechanical ventilation, CRRT, and possibly ECMO), requiring additional skill sets at the bedside. In addition to the providers of direct patient care, specialized expertise in anesthesiology may be required to assist with bedside procedures or intrafacility transfer for the patient to other diagnostic and therapeutic areas within the hospital. If a tertiary PICU does not have an appropriate medical or surgical provider, transfer arrangements should be in place to ensure that the critically ill or injured pediatric patient receives these services. Critical care nurses with training and experience caring for children are required for tertiary PICUs. A dedicated nurse manager/director with pediatric critical care training and clinical experience is required to provide administrative oversight/management of the tertiary PICU.

Delphi statement. All critically ill children admitted to any PICU should be cared for by a pediatric intensivist either board eligible, board certified, or undergoing maintenance of certification as a primary provider or in consultation while in the ICU setting.

Results. Consensus met (87.9% agreement).

The majority of the Voting Panel agreed that the pediatric intensivist should serve as a primary provider for all PICU patients rather than function in a consultant role in all levels of PICU. However, the ACS requires that surgeons be the primary provider on all patients admitted with traumatic injuries and should be cared for by both the trauma service and the PICU service in a collaborative manner (3).

For hospitals participating in the ACS Children's Surgical Verification program, the surgical service that assumes initial responsibility for the care of the critically ill patient with surgical needs should maintain that responsibility and involvement either throughout the acute care phase of hospitalization or until formal transfer to another service upon adequate resolution of acute surgical issues. The surgeon must remain actively involved with the surgical needs of the patient while in the ICU and be involved in the therapeutic decisions.

When the surgeon is not the admitting physician, a pediatric intensivist who is board eligible or board certified and meeting current requirements for maintenance of certification should consult on all critically ill children admitted to a PICU.

Support Services. *Delphi statement.* The ICU structure/care delivery model components having the greatest impact on patient outcomes include the following: in-house intensivists, nursing staff with PICU expertise, dedicated clinical pharmacists, registered dietitians, multidisciplinary rounds (providers and specialized staff), social workers, child life specialists, chaplain/clergy, palliative care specialists, or RTs with PICU expertise.

Results. Consensus agreement met for nursing staff with PICU expertise, multidisciplinary rounds, pharmacists, and RTs with PICU expertise (Table 3).

The PICU structure and care delivery model components continue to evolve. There is an expectation that the team leader will be an experienced intensivist who is complemented by a dedicated, skilled multidisciplinary team (28, 29). Ideal care of children with multisystem illness and dysfunction also requires the involvement of medical and surgical specialists. Although consensus was only met for nursing and respiratory staff with PICU expertise having the greatest impact on patient outcomes, the importance of care that is immediately available and comprehensive, with ancillary staff including dedicated clinical pharmacists, registered dietitians, rehabilitation therapists, and others, is just as important in tertiary PICUs as it is in quaternary facility PICUs. As some PICUs do not have access to dedicated pharmacists, the value for patient safety and quality of care of these daily team member consultants may well be underestimated.

Delphi statement. All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities.

Results. Consensus not met (73.5% agreement).

Clinical pharmacists have become integral members of the multidisciplinary team in all PICUs and demonstrate increasing contributions to improving patient safety and clinical outcomes in adult and PICUs (30–40).

Coverage Responsibilities. Because tertiary facilities provide advanced care to complex medical and surgical patients, coverage responsibilities should be carefully spelled out and patient care responsibilities assigned to those with the most skill, training, and knowledge in caring for these patients. In-house attending coverage on a 24/7 basis may be the benchmark to which most, if not all, tertiary PICUs should aim based on the types and acuity of patients seen. Others may participate in the minute-to-minute care of the patient (ICU and other subspecialty fellows, APPs with special expertise). In addition, specific surgical and medical specialists need to be able to respond expeditiously to dynamic changes in physiologic status. Typically, anesthesiology or those skilled in critical airway management, surgeons who can perform an emergency thoracotomy if indicated, and other interventionalists needed in the catheterization laboratory or at the bedside, should be able to respond within 30 minutes. Others who are necessary but not as time sensitive may respond within 60 minutes or longer depending on the issue that needs to be addressed.

Delphi statement. A qualified medical provider, who is able to respond within 5 minutes to all emergency patient issues (such as airway management, cardiopulmonary resuscitation), is necessary for optimal outcomes in all levels of PICU.

Results. Consensus met (100% agreement).

A qualified medical provider who is able to respond within 5 minutes to all emergency patient care issues is necessary for optimal patient outcomes in all PICU levels of care. In a tertiary care PICU, the qualified medical provider may be a pediatric intensivist, critical care fellow, senior resident, APP, or hospitalist.

A qualified surgical provider who is able to respond readily to emergency surgical issues in critically ill or trauma patients should be available. The designation of "qualified" is defined by the surgical problem and availability should be commensurate with the level of care of the PICU and level of ACS Children's Surgical and/or Pediatric Trauma Center Verification of the institution.

Delphi statement. Night coverage response requirement for pediatric intensivists, who are not in-house, includes being readily available by telephone and present in the PICU within 30 minutes of request.

Results. Consensus met (84.8% agreement).

Evidence of improved patient outcomes with 24/7 intensivist coverage exists (42–49), although reduced mortality has not been demonstrated (27, 41).

Delphi statement. Pediatric hospitalists, NPs, and PAs who provide first-line night coverage in PICUs must be skilled in advanced airway, line placement, and ventilator management.

Results. Consensus met (84.8% agreement).

Procedural skill expertise for hospitalists and APPs has been determined by individual PICU expectations and availability of other skilled providers, such as the presence of an in-house intensivist or critical care fellow. APPs are employed in many tertiary PICUs, often providing direct patient care management 24/7 and must be skilled in advanced airway and other emergency procedures.

Performance Improvement and Patient Safety (Quality and Safety Initiatives). A tertiary PICU should have a quality program that evaluates its practice and compares risk-adjusted patient outcomes against similar institutions and national benchmarks. These data should continue to inform the PICU leadership regarding QI projects that would most impact individual subsets of patients. Minimum requirements include regulatory program requirements (e.g., internal organizational requirements and The Joint Commission). Appropriate use of resources and provision of care should be addressed by ongoing utilization review and case management. A regular morbidity and mortality review should be held with sentinel events undergoing a more in-depth root cause analysis with all involved subspecialties.

Specific educational requirements should be clearly delineated for all staff who work in the PICU. These requirements should be relevant and directly apply to the practice of pediatric critical care. For some personnel, this may include formal certification by recognized professional organizations. It is the responsibility of the tertiary PICU to provide education to other healthcare providers who do not work in the critical care environment, both within the institution and at outlying referral facilities (outreach). These educational initiatives and programs will ensure timely and appropriate referral of critically ill children to improve outcomes.

Delphi statement. All levels of PICUs should participate in academic pursuits: clinical trials, basic research, and/or scholarly pursuits.

Results. Consensus only met for basic science and clinical research in tertiary PICUs (91.18% agreement).

Although all levels of PICUs will not have the same resources available to promote extensive academic pursuits, some participation should be expected in advancing pediatric critical care science.

Delphi question. Which levels of PICUs should be affiliated with a training program that has at least medical students and residents?

Results. Consensus not met (< 54% agreement).

The consensus was not met on whether tertiary or community PICUs should be able to support student learning or a Pediatric Residency program. Educational opportunities for medical students, pediatric residents, and surgical residents should be made available if there is a sponsoring institution that has these programs. Other opportunities for education might include trainees in nursing (regular and NP), PA, pharmacy, and respiratory therapy among others.

When a Pediatric Critical Care Medicine Fellowship is supported by the tertiary PICU, there will be direct supervision of the fellows as directed in the Program Requirements of the ACGME. When Pediatric Critical Care and/or Pediatric Surgical Critical Care Fellowships are also present in the medical institution, the pediatric intensivists, their team, and trainees will participate in interprofessional care of patients providing appropriate communication and collaboration. Clear delineation of responsibilities will be sought on each patient. This requirement reflects the common program requirements outlined by the ACGME.

Delphi statement. All levels of PICUs should be involved in providing peer community outreach education, such as educational conferences, technical skills competencies, stabilization, and resuscitation (e.g., PALS education).

Results. Consensus not met for tertiary PICUs (75.8% agreement).

Although consensus was not met, tertiary PICUs should at least be involved in providing community outreach through educational events that focus on technical skills needed for stabilization, resuscitation, and communication for the triage and transport of critically ill and injured children.

Relationships With Other PICUs or Adult ICUs. Tertiary PICUs should maintain strong relationships with referring facilities for many reasons. These include transfer agreements, transfer protocols based on the need for a higher level of care, and/or formal regionalization of care networks. The alignment of medical and surgical needs often requires transfer to a higher level of PICU care, but repatriation to the home PICU or hospital is also appropriate when acute issues have resolved, and care can be rendered closer to home where it is more convenient for the family. A close working relationship among different centers can be cultivated with ongoing communication and, when possible, the use of telemedicine.

The most efficient and appropriate use of resources require established relationships with other PICUs, including community, quaternary facility, and other tertiary units. Services or providers that may not be available at the tertiary PICU may be provided by another PICU. Transfer or support from another PICU may be necessary in cases of temporary limitation of resources, such as bed availability, activation of a disaster plan, or other limitations. In such instances, it is important to have other PICUs that can receive patients when the tertiary PICU has reached capacity. Formal relationships with other PICUs in the form of transfer agreements are desirable.

Delphi statement. PICUs should have a transfer plan with PICUs that can provide a higher level of specialized care (e.g., burn center, transplant center) when needed.

Results. Consensus met (97% agreement).

Tertiary PICUs may provide some specialized services but must have a transfer plan in place with PICUs that provide specialized services that are not provided in their center. Regional transfer networks will vary based on factors such as center designation, capabilities or specialty resources of local hospitals, bed capacity/availability of referring and receiving hospital, and ease of transfer. The development of collaborative partnerships, defined transfer criteria, coordinated, efficient transfer processes, and optimal communication including handoff and exchange of necessary health information will be crucial to the development of a robust regional network.

Transport and Transfers. Each ICU center must have procedures in place that permits the safe intrafacility and interfacility transfer of very fragile patients.

Delphi statement. PICUs should have their own freestanding critical care transport program with their own team, equipment, and dedicated rig.

Results. No consensus met (< 33% agreement).

The Voting Panel reached 100% consensus that all tertiary PICUs may outsource some, if not all, of their critical care transport activities; however, the transport service must have training in pediatric emergency and critical care. Resources for interfacility transfer should be defined between centers and include transport team, equipment, and different modes of transfer (e.g., ambulance, helicopter, fixed-wing aircraft).

Community PICU Level of Care

Purpose. PICUs located in CMCs play an important role in healthcare systems that provide care to infants and children. In the previously published guidelines, these centers were categorized as level II PICUs, as distinguished from level I PICUs (1, 2). In the intervening years, these designations no longer accurately describe the current state of care delivered to critically ill infants and children. Therefore, this section will describe the various iterations of PICUs in CMCs. The geographic setting will impact the populations/disease entities served, available providers and support services, relationships with other PICUs at various levels, and transport program capabilities. These units provide a broad range of services and resources that may differ based on institution, hospital size, and referral base. The majority of these will be located in general medical-surgical institutions with the capability of treating pediatric patients. By definition, PICUs represent at least tertiary care or the ability to provide medical care to children with complex medical and surgical illnesses. Units may be classified by one or more of the following designations:

- Rural
- Suburban
- Urban
- Academic
- Nonacademic

Regardless of what type of facility in which the PICU is located, specific criteria in the following areas should be in place.

Delphi statement. Patients who are appropriately triaged according to the level of illness and services provided in community/tertiary/quaternary PICU facilities will have comparable outcomes.

Results. Consensus met (97% agreement).

Patients who are appropriately triaged according to the level of illness and services provided in CMC PICU facilities will have comparable outcomes and quality of care compared with similar patients cared for in tertiary and quaternary facility PICUs, assuming that all systems are in place for optimizing the quality of care.

Delphi statement. Developing admission criteria assists in the placement of a critically ill child in an appropriate PICU level of care.

Results. Consensus met (100% agreement).

All facilities that contain PICUs should have admission criteria established so that patients may receive a level of critical care commensurate with their needs.

Patient Populations. The disease entities that can be cared for in PICUs located in CMCs are those conditions that are seen most frequently in the critically ill pediatric population. These include but are not limited to:

- Acute and chronic respiratory insufficiency (e.g., asthma, infection, acute lung injury)
- Circulatory failure (e.g., sepsis, shock, heart failure not requiring ECMO, or surgical correction of congenital heart disease)
- Infectious diseases leading to major organ system dysfunction
- Endocrine and metabolic disorders (e.g., diabetic ketoacidosis, recognition and stabilization of inborn errors of metabolism and mitochondrial disorders, hypothyroidism, and adrenal crisis)
- Neurologic diseases (e.g., status epilepticus, encephalopathy)
- Toxic ingestions/exposures
- Trauma (initial stabilization and ongoing care are resource dependent)
- Hematologic and oncologic disease (resource dependent)
- Uncomplicated burns < 10% TBSA

In addition to the components detailed in the following sections, minimum specific pediatric subspecialty availability is required.

Rural CMCs. A PICU located in a rural CMC may be the only unit capable of providing intensive care to infants and children in a large, sparsely populated geographic region. These units are the sole access to care for critically ill infants and children and will represent a broad range of conditions and acuity.

Certain conditions may be stabilized in the PICU in rural CMCs but will require specialists or services that are only found in a tertiary or quaternary facility or specialized medical centers. In these cases, the rural CMC will stabilize the patient and arrange for a transfer. Ideally, there will be an established relationship with a higher level of care. Examples of patient

conditions that may require transfer include major trauma, newly diagnosed congenital heart disease, need for extracorporeal life support (ECLS), organ transplantation, and oncologic disease. Criteria for transfer to a burn center include partial thickness burns greater than 10% TBSA; burns on the face, hands, feet, genitalia, perineum, and major joints; third-degree burns; electrical burns; chemical burns; inhalation injury; and concomitant traumatic injury. Depending on the nature and severity of injuries, PICU resources and specialty physicians and staff may be necessary for these patients.

Transfer of patients may place a burden on families from a financial and emotional standpoint. If appropriate resources are available to the rural CMC PICU, requisite care can be provided to select patients. In this regard, telemedicine may play an important role as an additional resource for PICUs in CMCs.

Suburban/Urban/Academic/Nonacademic CMCs. PICUs may be located in CMCs located in suburban or urban regions. Among these programs, formal affiliations with medical schools or residency training programs are variable. PICUs in suburban and urban CMCs frequently have greater access to medical subspecialty and surgical specialty services than can be found in a rural CMC. These services may be community based rather than dedicated consultant services to the hospital. These PICUs play an important role in managing critically ill children whose medical and surgical needs are met within the institution. Appropriate triage of patients to community PICUs optimizes the use of resources within a region. Traditional academic activities, such as research, are usually limited to clinical investigation, frequently as part of multicenter studies.

Delphi statement. Patient volume in the ICU setting has a positive impact on outcomes.

Results. Consensus not met (78.8% agreement).

Patient volume in the ICU setting may have a positive impact on outcomes, although there is no current evidence that definitively confirms this. Patient volume is only one factor affecting patient outcome. PICUs with lower volumes may have equivalent outcomes, although lower patient volumes require more frequent staff education (18).

Delphi statement. The number of patients requiring respiratory support (invasive and noninvasive) in PICU has an impact on patient outcomes. The minimum number of patients requiring respiratory support in all PICU levels of care: 50–75 cases/yr, 76–100 cases/yr, 101–150 cases/yr, greater than 151 cases/yr.

Results. Consensus not met: 50–75 cases/yr 17%, 76–100 cases/yr 24%, 101–150 cases/yr 24%, greater than 151 cases/yr 35%.

There was no consensus regarding minimum volumes for specific disease entities and therapies, particularly in CMC PICU facilities (as well as specialty units). Future data regarding minimum numbers that would be associated with optimal outcomes for each disease process as well as the impact of resource limitations both in small and large PICUs would be desirable. Current concerns include the negative impact on outcomes in very large PICUs because of staffing issues and exceeding the limitations of other resources (17).

Providers. *Delphi statement.* Expertise in the care of the critically ill child is required in a community/tertiary/quaternary or specialty-based PICU.

Results. Consensus met (100% agreement).

Expertise in the care of the critically ill child is required in all PICUs, including CMCs. In CMCs, expertise in acute phase stabilization for patients who require tertiary or quaternary services is imperative. Expertise in pediatric critical care is paramount to the recognition of limitations in appropriate providers and services within the CMC and therefore, the need for referral to a tertiary or quaternary center.

If the center is a verified ACS Children's Surgical Center, there must be a children's surgeon who serves within the medical leadership structure of the ICU and is responsible for setting policies and defining administrative needs related to PICU patients with surgical needs. If the center is an ACS-verified Pediatric Trauma Center or an Adult Trauma Center that takes care of some children, a designated pediatric trauma director who is board certified in pediatric surgery or an adult trauma surgeon with pediatric expertise who is credentialed by the trauma director is required if the CMC PICU cares for trauma patients.

Delphi statement. All critically ill children admitted to any PICU should be cared for by a pediatric intensivist, either board eligible, board certified, or undergoing maintenance of certification as a primary provider or in consultation while in the ICU setting.

Results. Consensus met (88% agreement).

Board-prepared critical care physicians are required to provide care for all children admitted to PICUs, regardless of designation, either as the primary provider or as a consultant. In a CMC, this physician may not necessarily be a pediatrician. A designated medical director as well as a designated pediatric trauma medical director who is board certified in surgical critical care and has been credentialed by the trauma medical director for the specific care of children are required to provide administrative oversight and management of the PICU and to be available to provide direct patient care when necessary. Pediatric medical subspecialists are desirable as are pediatric general and thoracic surgeons and surgical specialists. However, in certain settings, such as PICUs in rural CMCs, these subspecialty and specialty resources may not be available, although these PICUs serve a vital and indispensable role. In these instances, an anesthesiologist, general surgeon, neurosurgeon, and radiologist are a minimum requirement. In addition, some pediatric medical subspecialty needs may be addressed with the use of telemedicine technology.

Trauma patients should be cared for by both the trauma service and the PICU service in a collaborative manner. The ACS requires that surgeons be the primary provider on all patients admitted with traumatic injuries, and therefore, programs where the attending surgeon has training and certification in surgical critical care may (institutional specific) allow for the primary attending with such expertise to be a surgeon working with the PICU attending. If a CMC PICU is supporting

an ACS-verified Children's Surgical Center, a surgeon must remain responsible for surgical issues in his or her patients while they are in the ICU. Documentation of day-to-day involvement is mandatory (4).

The resources and personnel available to both rural and urban/suburban PICUs are expected to vary. In suburban and urban medical center PICUs, the accessibility of medical and surgical pediatric providers will be greater than in a rural medical center. When a patient requires resources that are not readily available in a CMC PICU, transfer arrangements must be in place to ensure that the critically ill pediatric patient receives appropriate care.

Critical care nurses with training and experience caring for children are required for all PICUs, especially those located in CMCs. A nurse manager/director with pediatric critical care training and clinical experience is required to provide administrative oversight and management of the PICU.

Support Services. Other essential members of the healthcare team include but are not limited to RTs, pharmacists, social workers, dietitians/nutrition specialists, and child life specialists. Chaplains and physical and occupational therapists are also essential. Training and experience in caring for critically ill pediatric patients are highly desirable.

Delphi statement. The ICU structure/care delivery model components having the greatest impact on patient outcomes include the following: in-house intensivist, nursing staff with PICU expertise, dedicated clinical pharmacist, multidisciplinary rounds (providers and specialized staff), social worker, child life specialist, chaplain/clergy, palliative care professionals, or RTs with PICU expertise.

Results. Consensus agreement met for nursing staff with PICU expertise, multidisciplinary rounds, pharmacist, and RTs with PICU expertise (Table 3).

Agreement depends on individual and PICU team member results:

Team Member	Responses (%)
In-hospital intensivist	64.7
Registered nurse staff with PICU training	100.0
Clinical pharmacist	94.0
Multidisciplinary rounds	88.2
Social worker	64.7
Child life	55.8
Chaplain/Clergy	47.0

As shown above, unanimous agreement was reached regarding the presence of pediatric-trained critical care nurses. There was a greater agreement with this than multidisciplinary rounds being conducted although this remained a higher priority (88.2%), access to a clinical pharmacist was also recommended (94%), having an in-house intensivist (64.7%) was ranked lower. This question addressed all levels of PICU, from rural CMC to quaternary.

Delphi statement. All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities.

Results. Consensus met (94% agreement).

All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities. Although most respondents felt that the presence of an on-site pediatric pharmacist is important who participates in rounds and as stipulated provides education, this may not be feasible in many CMC PICUs (30, 35). Kopp et al (35) documented the impact that a pediatric pharmacist can have on decreasing medication errors.

Coverage Responsibilities. PICU coverage in CMCs begins with required services and extends to more comprehensive coverage when appropriate resources are available. The minimum coverage for the PICU in a CMC includes the following:

- There must be a physician in-house in the facility 24 hr/d, 7 d/wk, capable of responding to pediatric emergencies. Pediatric expertise can come from multiple specialties including, for example, anesthesia, emergency medicine, and surgery.
- The physician should be at the PGY2 level or above and available to the PICU and ideally assigned to the PICU.
- A pediatric intensivist must be available within 30 minutes or less. Anesthesia, general surgery, and neurosurgery must be available within 1 hour or less.
- Nurse-to-patient ratios should be based on patient need and acuity.
- RTs must be in-house 24 hours per day, have experience and training in caring for critically ill and injured pediatric patients and ideally assigned primarily to the PICU.

Delphi statement. A qualified medical provider able to respond within 5 minutes to all emergency patient issues (such as airway management, cardiopulmonary resuscitation) is necessary for optimal outcomes in all levels of PICUs.

Results. Consensus met (100% agreement).

A qualified medical provider able to respond within 5 minutes to all emergency patient care issues (such as airway management, cardiopulmonary resuscitation) is necessary for optimal patient outcomes in all PICUs, regardless of designation. A qualified medical provider in a CMC may include a pediatric intensivist or other providers capable of caring for pediatric emergencies. Pediatric expertise can come from multiple specialties including, for example, anesthesia, emergency medicine, and surgery.

Delphi statement. Night coverage response requirement for pediatric intensivists, who are not in-house, includes being readily available by telephone and present in the PICU within 30 minutes of request.

Results. Consensus met (85% agreement).

Evidence of improved patient outcomes with 24/7 intensivist coverage exists (42–49), although reduced mortality has not been demonstrated (27, 41). Night coverage response requirements for pediatric intensivists, who are not in-house 24/7,

include readily available by telephone and being physically present in the PICU within at least 30 minutes.

Delphi statement. Pediatric hospitalists, NPs, and PAs who provide first-line night coverage in PICUs must be skilled in advanced airway procedures, line placement, and ventilator management.

Results. Consensus not met (79.4% agreement).

The use of APPs and hospitalists in the PICU may improve patient outcomes. The use of these alternative providers has increased due to many factors, including physician availability, finances, and the development of specialized PICU training programs for NPs.

When PICU CMCs do not provide 24-hour in-house pediatric intensivist coverage, any pediatric hospitalists or APPs who provide first-line night coverage must be skilled in the advanced airway and ventilator management as well as IV/intraosseous access unless there is immediate and prearranged availability of anesthesia support with pediatric expertise.

Equipment and Technology. The variety of equipment and technologies as well as their cost is continually evolving and may not be available in a CMC PICU. Pulse oximetry is the most notable example of this evolving technology in the past 3 decades. The minimum required equipment and technology for PICUs in CMCs must address the ability to monitor cardiorespiratory status and identify and record pathophysiologic events as well as neuromonitoring devices, including electroencephalographic monitoring. Invasive intravascular monitoring is required to provide at a minimum systemic arterial and CVP monitoring. Ventilatory support devices, both invasive (conventional and nonconventional mechanical ventilation) and noninvasive (including bilevel continuous positive airway pressure [CPAP], CPAP, and high-flow nasal cannula [HFNC]) are required, although some nonconventional therapies may not be readily available in some PICUs.

Delphi statement. All levels of PICUs should have access to the following inhalation gases: helium-oxygen, nitric oxide, and anesthetics.

Results. Consensus met for helium-oxygen (93.9% agreement), consensus not met for nitric oxide or anesthetic gases (< 63% agreement).

The ability to deliver helium-oxygen must be present in the CMC PICU, but the ability to deliver nitric oxide and anesthetic agents is not required.

Delphi statement. Renal replacement therapies (RRTs) (peritoneal dialysis, continuous hemofiltration and hemodialysis, intermittent dialysis) may be safely performed in a community-based hospital.

Results. Consensus not met (63.6% agreement).

Community PICUs may have the ability to provide CRRT with appropriately trained personnel, but this must include a nephrologist. Consideration for the overall complexity involved to successfully manage these children should be considered. Pediatric surgeons, pediatric pharmacists, and pediatric intensivists who are experienced in providing RRTs and managing their inherent complications are also needed for the safe delivery of this therapy.

Delphi statement. The following technologic or monitoring capabilities are required for a community-level PICU: noninvasive and invasive ventilation support, continuous electroencephalographic monitoring, central line access or monitoring, initiation of chemotherapy with anticipated tumor lysis syndrome, RRT, and exchange transfusion.

Results. Consensus met for noninvasive and invasive ventilation support and central line access or monitoring.

Technologic or monitoring capabilities required for a community-level PICU results:

Intervention	Agree (%)	Disagree (%)
Noninvasive and invasive ventilation support	100.0	0.0
Continuous electroencephalographic monitoring	35.3	64.7
Central line access or monitoring	91.2	8.8
Initiation of chemotherapy	29.4	70.6
RRT	11.8	88.2
Exchange transfusion	35.3	61.8

There was consensus for two technologic or monitoring capabilities that many respondents believed were important for CMC PICUs. These were the ability to provide noninvasive and invasive ventilatory support and central line access and monitoring. Patients requiring continuous electroencephalographic monitoring, RRT, and exchange transfusions should be cared for in tertiary or quaternary care facilities that perform these procedures more frequently and where the necessary subspecialty support is available. Under certain circumstances, older pediatric patients may have access to adult specialists who are comfortable with managing these processes.

Equipment and support services must be appropriate for infants and children, including but not limited to correctly sized airway equipment, ventilatory support devices, infusion pumps, laboratory testing (e.g., small volume blood testing, point-of-care testing), and imaging.

Delphi statement. The following monitoring or specific management needs are appropriate indications for PICU transfer from community level of care to a tertiary or quaternary facility or specialized level of care: intracranial pressure (ICP) monitoring, acute hepatic failure leading to coma, congenital heart disease with unstable cardiorespiratory status, need for temporary cardiac pacing, burns greater than 10% of body surface, head injury with initial Glasgow Coma Score (GCS) less than or equal to 8, multiple traumatic injuries, or heart failure requiring an interventional cardiologist.

Results. The consensus was reached for PICU transfer from community level of care to a tertiary or quaternary facility or specialized level of care for all the monitoring and specific management needs (ranging from 88% to 100%; see Supplemental File 2, Supplemental Digital Content 2, http://links.lww.com/PCC/A990).

Data exist to support improved outcomes in children requiring specialized services when cared for in tertiary or quaternary facility or specialized level of care (5–12, 19, 20, 22–25). Pediatric critically ill patients should be cared for in tertiary or quaternary care facilities that provide these advanced monitoring or specialized therapies and specialty support resources. For partial thickness burns greater than 10% of TBSA, access to a specialized burn unit or burn center is recommended.

Performance Improvement and Patient Safety (Quality and Safety Initiatives). All CMC PICUs should have a unit-specific standardized program for QI and safety metrics. Minimum requirements include programs for the prevention of central line–associated bloodstream infections, catheter-associated urinary tract infections, ventilator-associated pneumonia, medication errors, and processes for ongoing review of mortality and sentinel events. Specific QI and patient safety programs should be in place to address unique patient populations if present (e.g., trauma, hematologic, and oncologic disease). Appropriate use of resources and provision of care should be addressed by ongoing utilization review and case management. Direct links to patients' medical homes should be available to ensure a safe transition from the ICU to their primary and subspecialty care providers.

Specific educational requirements should be clearly delineated for all staff who work in the PICU. These requirements should be relevant and directly apply to the practice of pediatric critical care. For some personnel, this may include formal certification by recognized professional organizations. In addition, it is the responsibility of the CMC PICU staff to provide education to other providers who do not work in the critical care environment, within the institution and at outlying referral facilities. These programs will ensure timely and appropriate referral of critically ill patients to the CMC PICU.

Delphi Statement. All levels of PICUs should participate in academic pursuits: clinical trials, basic research, and/or scholarly pursuits.

Results. The consensus was not met: agree: clinical trials 21%, basic research 9%, scholarly pursuits 18%. One abstention from voting on scholarly pursuits. Traditional academic activities, such as clinical trials and basic science research, are not considered part of the core competencies of a community PICU. However, physicians who practice in these settings should strive to participate in scholarly activity to improve the care delivered in the PICU.

Delphi question. Which levels of PICUs should be affiliated with a training program that has at least medical students and residents?

Results. Consensus not met for community-level PICUs (0.9% agreement).

Because CMC PICUs focus on direct patient care, they may not have the resources available to participate in resident and medical student education.

Delphi statement. All levels of PICUs should be involved in providing peer community outreach education, such as educational conferences, technical skills competencies, stabilization, and resuscitation (e.g., PALS education).

Results. Consensus not met (75.8% agreement).

Although consensus was not met, community PICUs should at least be involved in providing community outreach through educational events that focus on the technical skills needed for stabilization, resuscitation, and communication for the triage and transport of critically ill and injured children. This might include PALS.

Relationships With Other PICUs or Adult ICUs. *Delphi Statement.* PICUs should have a transfer plan with PICUs that can provide a higher level of specialized care when needed.

Results. Consensus met (97% agreement).

CMC PICUs may provide some specialized services but must have a transfer plan in place with PICUs that provide specialized services that are not provided in their center. Regional transfer networks will vary based on factors such as center designation, capabilities or specialty resources of local hospitals, bed capacity/availability of referring and receiving hospital, and ease of transfer. The development of collaborative partnerships, defined transfer criteria, coordinated, efficient transfer processes, and optimal communication including handoff and exchange of necessary health information will be crucial to the development of a robust regional network.

Delphi statement. PICUs should have a transfer plan in place that assists in the referral to a specialized facility (e.g., burn center, transplant center, rehabilitation facility).

Results. Consensus met (97% agreement).

Community PICUs should establish transfer plans for critically ill children who require a higher level of specialized care or referral to a specialized facility including burn, transplant, and rehabilitation centers. Community PICUs should seek immediate consultation with a tertiary or quaternary facility PICU regarding transfer to a higher level of care for any patient with the need for ICP monitoring or cardiac pacing, heart failure requiring an interventional cardiology procedure or circulatory assist device, or acute respiratory failure that requires ECMO. Patients suffering from acute hepatic failure, unstable congenital heart disease, multiple traumatic injuries, and a head injury with a GCS less than or equal to 8 should be discussed with a tertiary or quaternary facility PICU for immediate transfer. For patients with partial thickness burns covering greater than 10% TBSA or when inhalation injury is suspected, access to a center with specialized burn resources is recommended.

Transport and Transfers. The ability to transport critically ill patients is essential. Policies must be in place to address all transport scenarios, including intrafacility and interfacility transport. Intrafacility transport requirements should address the necessary components of moving critically ill patients within the facility, such as to and from the operating room, or for imaging procedures. Delineation of essential personnel and equipment needed for intrafacility transport must be determined in advance of need. If the transport service is not part of the CMC, contracted services should meet all the same criteria that are set forth in policy by the PICU.

Interfacility transport includes both transports from referring facilities and to another PICU from the CMC PICU. Incoming transports are usually from other CMCs without pediatric critical care capabilities and may originate from the emergency department after stabilization or from an acute care inpatient unit following a deterioration in clinical status. Incoming transports may also be from another PICU lacking a specific service or provider that is available at the receiving CMC PICU, whereas outgoing interfacility transports are usually attributable to need for a provider or service that is not available at the CMC PICU (see relationships with other PICUs above).

The mode of transport and personnel required will be dependent on individual patient needs. The team members may include critical care nurses, paramedics, RTs, APPs, and physicians. Team composition is determined on a case-by-case basis, but all members must have experience and training in the care of critically ill pediatric patients. The transport may be via ground vehicle, fixed wing, or rotor. The mode of transport is most often dictated by anticipated travel time, with fixed wing or rotor air transport reserved by longer distances (e.g., rural) or need for immediate medical intervention (e.g., trauma/burn).

Delphi statement. PICUs should have access to a transfer and transport program that can ensure the safe and timely movement of a critically ill child from a community hospital to the institution with a higher level of care PICU.

Results. Consensus met (100% agreement).

Community PICUs should have access to a transfer and transport program that can ensure the safe and timely movement of a critically ill child from a CMC to the institution with a PICU.

Delphi statement. PICUs may outsource some, if not all, of their critical care transport activities; however, the transport service used must have training in pediatric critical and emergency care.

Results. Consensus met (100% agreement).

Community PICUs often do not have resources to have a dedicated transport program and often outsource all their transport activities to services with pediatric critical and emergency care training. The Voting Panel reached 100% consensus that all CMC PICUs may outsource some, if not all, of their critical care transport activities; however, the transport service must have training in pediatric emergency and critical care. Resources for interfacility transfer should be defined between centers and include transport team, equipment, and different modes of transfer (e.g., ambulance, helicopter, fixed-wing aircraft).

PICU LEVEL OF CARE ADMISSION CRITERIA

The evidence demonstrating improved patient outcomes based on quaternary facility or specialized, tertiary, and community PICU level of care since the 2004 guidelines remains insufficient and the quality of data moderate. Based on the results of the Delphi Survey and expert panel consensus, the following admission recommendations are suggested for PICU levels of care.

Recommendations

- Patients who are appropriately triaged according to the level of illness and services provided in community/tertiary/quaternary PICU facilities will have comparable outcomes and quality of care. The specifics of each PICU level of care described above serve as a reference for minimum standards of quality care to guide appropriate PICU admissions and promote optimal patient outcomes.
- Individual hospitals and their PICU leadership team should develop admission criteria to assist in the placement of critically ill children that is aligned with their PICU level of care.
- Pediatric patients requiring specialized service interventions, such as cardiac, neurologic, or trauma-related surgery, have better/improved outcomes when cared for in a quaternary/tertiary ICU, and early interfacility transfer to the appropriate regional facility should be the standard of care.
- Congenital heart surgery should only be performed in a hospital that has a PICU with a dedicated pediatric cardiac intensive care team, including but not restricted to pediatric intensivists and nurses with expertise in cardiac intensive care, cardiovascular surgeon with pediatric expertise, pediatric perfusionists, pediatric cardiologists, and pediatric cardiac anesthesiologists.

ICU STRUCTURE AND PROVIDER STAFFING MODEL

The evidence supporting specific ICU structure or provider staffing models based on PICU level of care since the 2004 guidelines remains insufficient and of low quality. Based on the results of the Delphi Survey and expert panel consensus, the following recommendations are suggested for ICU structure/provider staffing models based on PICU level of care.

Recommendations

- Expertise in the care of the critically ill child is required in all PICU levels of care.
- All critically ill children admitted to any PICU should be cared for by a pediatric intensivist who is board eligible, board certified, or undergoing maintenance of certification as a primary provider while in the ICU setting.
- Trauma patients should be cared for by both the trauma service (including trainees) and the PICU service in a collaborative manner. The ACS requires that surgeons be the primary provider on all patients admitted with traumatic injuries. Programs where the attending surgeon has training and certification in surgical critical care may (institutional specific) allow for the primary attending to be a surgeon with such expertise working with the PICU attending.
- Burn patients should be comanaged by the burn surgeon of record (discipline may be pediatric surgery, general surgery, or plastic surgery) and the PICU service.

- In a PICU that supports an ACS-verified children's surgical center, an ICU team that demonstrates direct surgeon involvement in the day-to-day management of the surgical needs of the patient is essential. Both PICU and surgery services must be promptly available 24 hours a day.
- Any level of PICU that supports advanced ACGME training programs such as Pediatric Residency, General Surgery Residency, Pediatric Critical Care Medicine Fellowships, Pediatric Surgery Fellowships, and Pediatric Surgical Critical Care Fellowships, among others, will promote the participation of trainees in interprofessional care of patients providing appropriate communication and collaboration. Clear delineation of responsibilities will be sought on each patient. This requirement reflects the common program requirements outlined by the ACGME.
- A qualified medical provider (in quaternary facility PICUs, the "qualified medical provider" should be a pediatric intensivist), who is able to respond within 5 minutes to all emergent patient issues (e.g., airway management, cardiopulmonary resuscitation) is necessary for optimal patient outcomes in all levels of PICU. Specialized or quaternary facility PICUs have a minimum of an in-house critical care fellow.
- A qualified surgical provider able to respond readily to emergency surgical issues in critically ill patients should be available. The designation of "qualified" is defined by the surgical problem, and availability should be commensurate with the level of care of the PICU and level of ACS Children's Surgical Verification of the institution.
- Night coverage response requirement for pediatric intensivists who are not in-house, primarily in community and tertiary PICUs, includes being readily available by telephone and present in the PICU within 30 minutes of request.

Rationale

Although limited pediatric evidence exists, there is considerable research evaluating adult intensive care models and the level of intensivist participation on patient outcomes (27, 40, 53–62). However, variations in staffing models and what is considered an "open" or "closed" ICU, the number of hours of intensivist coverage, and the level of supervision versus consultation of the intensivist make the interpretation of these findings challenging. Historically, intensive care models include a high-intensity staffing model characterized by an intensivist-led team responsible for patient management in a closed ICU setting in which the intensivist serves as the primary physician for all ICU patients or through mandatory consultation, in comparison to a low-intensity staffing model in which intensivist participation is through an elective consultation, either in an open ICU setting where patient care is managed by another physician or because there is no intensivist available. Despite differences in the staffing models, data continue to be generated demonstrating the superiority of the closed ICU model with high-intensity staffing to the open, low-intensity staffing model in improving patient outcomes. A systematic review and meta-analysis of ICU physicians staffing models conducted by Wilcox et al (27) provide additional support for the use of high-intensity staffing models. The findings of this study revealed that compared with low-intensity staffing (partial or nonintensivist care), the high-intensity staffing model (comprehensive intensivist-led care) was associated with lower hospital and ICU mortality (pooled RR, 0.83; 95% CI, 0.70–0.99; and pooled RR, 0.81; 96% CI, 0.68–0.96, respectively).

Critical care provider staffing models have evolved over the past 2 decades, primarily because of the ACGME resident work hour restrictions, intensivist shortages, increasing severity of illness, complexities of ICU care, and economic constraints. These factors led to the emergence of APPs and hospitalists to provide direct care management of critically ill patients in all ICU settings (63–74) as well as the use of telemedicine technologies to provide access to a critical care physician in remote locations (71–74). These changes in healthcare delivery and the established benefit of a high-intensity staffing model also prompted research evaluating the need and impact of 24-hour intensivist coverage. Both pediatric and adult data demonstrate that an intensivist 24/7 coverage model is beneficial to improving ICU processes of care and staff and family satisfaction and decreasing adverse events and hospital LOS (42–49). However, data evaluating the impact of 24/7 intensivist coverage on ICU mortality are mixed with recent adult studies revealing no impact (27, 42, 75). Kerlin et al (76) conducted the only randomized clinical trial (RCT) to date and found no difference in ICU and hospital LOS, in-hospital mortality, and readmission when comparing nighttime staffing with in-hospital intensivists to the use of daytime intensivists available for consultation but not in-hospital.

Although evidence exists demonstrating improved outcomes based on ICU models led by critical care intensivists and supported by teams with specialized expertise and an ICU environment that includes the necessary resources (e.g., bed availability, equipment, and technology) to achieve optimal outcomes, the current evidence is primarily limited to adult ICUs and of moderate to low quality. Therefore, the updated ICU recommendations are primarily based on the Delphi consensus-based results.

ICU PERSONNEL AND RESOURCES

The evidence supporting ICU personnel and resources based on PICU level of care since the 2004 guidelines remains limited and of moderate to low quality. Based on the results of the Delphi Survey and expert panel consensus, the following recommendations are suggested for ICU personnel and resources.

Recommendations

- The ICU structure and care delivery model components that are essential in all PICU levels of care include nursing staff and RTs with PICU expertise as well as multidisciplinary rounds. In tertiary and quaternary facility PICUs, 24/7 in-house coverage, dedicated clinical pharmacist,

social worker, child life specialist, and palliative care services are necessary.
- All PICUs should have access to an on-site pediatric pharmacist who is available for daily rounds, pharmacy support, and ongoing educational activities.
- All providers including pediatric hospitalists, NPs, and PAs who provide first-line night coverage in PICUs must be skilled in advanced airway, IV and intraosseous line placement, and ventilator management.
- All PICUs must have access to a transfer and transport program that can ensure the safe and timely movement of a critically ill or injured child from a community hospital to an institution with a higher PICU level of care.
- Quaternary facilities or specialized PICUs have access to a critical care transport program with a dedicated trained pediatric team and specialized equipment.
- When PICUs require outsourcing of critical care transport activities, the transport service team members must all have training in pediatric emergency and critical care.

Rationale

Multidisciplinary ICU Team. The delivery of critical care is most effective when intensivist staffing is complemented by a dedicated, skilled multidisciplinary ICU team and endorsed by the SCCM and the AACN (28, 29). Important to the multidisciplinary approach to care are the team members and the effectiveness of the teamwork. Vital components include the presence of nurses, clinical pharmacists, RTs, nutritionists, and others participating in day-to-day patient management. The effectiveness of the multidisciplinary team is dependent on multiple organizational factors and team attributes, with some evidence demonstrating a relationship between patient outcomes and multidisciplinary rounds, presence of a clinical pharmacist, nurse staffing and education, and a culture of teamwork and communication (77).

The SCCM and the AACN have endorsed the concept that critical care is best delivered by a multidisciplinary ICU team (28, 29). This team includes specialists, nurses, clinical pharmacists, RTs, nutritionists, and others participating in day-to-day patient management. Although each of these team members brings their knowledge, skills, and abilities to the care of the patient, the impact of the ICU multidisciplinary processes of care on patient outcomes cannot be understated (77). Kim et al (78) conducted a retrospective cohort study of medical ICU patients in 169 hospitals (n = 107,324) linked to a statewide hospital survey to evaluate the effect of multidisciplinary care teams on ICU mortality. In a stratified model that included intensivist staffing, multidisciplinary care was associated with reductions in the odds of death (OR, 0.84; 95% CI, 0.76–0.93; p = 0.001) with lowest odds of death in ICUs with high-intensity staffing and multidisciplinary team (OR, 0.78; 95% CI, 0.68–0.89; $p < 0.001$) followed by low-intensity staffing and multidisciplinary team (OR, 0.8; 95% CI, 0.79–0.97; p = 0.014) compared with hospitals with low-intensity staffing and no multidisciplinary team. Although daily multidisciplinary rounds were associated with lower mortality in ICU patients, characteristics of the team members and details of rounding process were not obtained.

Nursing. A number of studies have evaluated the association between nursing staffing in PICUs and patient outcomes. Marcin et al (17) conducted a matched case-control cohort study involving 1,004 patients in a single PICU and found that higher nurse-to patient ratio was associated with decreased unplanned extubation. A systematic review and meta-analysis by Kane et al (79) included a subanalysis of adult and PICU patients and found that reduced nurse staffing was associated with adverse patient outcomes. Increased registered nurse (RN) staffing was associated with lower odds of ICU-related mortality (OR, 0.91; 95% CI, 0.86–0.97) and adverse patient outcomes. An increase by one RN per patient day was associated with decreased odds of hospital-acquired pneumonia (OR, 0.70; 95% CI, 0.56–0.88), unplanned extubation (OR, 0.49; 95% CI, 0.31–0.67), respiratory failure (OR, 0.70; 95% CI, 0.27–0.59), and cardiac arrest (OR, 0.72; 95% CI, 0.62–0.84). LOS was shorter by 24% (OR, 0.76; 95% CI, 0.62–0.94). Cimiotti et al (80), in a large prospective neonatal ICU cohort study, found that higher RN hours per patient day were associated with decreased hospital-acquired bloodstream infection in neonates. There has been much debate regarding appropriate nurse-to-patient ratio to optimize patient safety and quality of care and ensure manageable nursing workload. In the United States, state and federal agencies have established nurse-to-patient ratio standards (e.g., one nurse to two patients in critical care settings) linked to reimbursement and mandatory staffing ratios exist in some states. Determining the appropriate nurse-to-patient ratio for critically ill patients is complex and based on several factors, including patient characteristics, nursing experience, specialized technology needed, and work environment. However, striving to ensure appropriate staffing is critical to the delivery of quality patient care and has been shown to directly influence the rate of preventable adverse events (79–82).

Critically ill children require nurses who have specialized knowledge, skills, and experience. The AACN endorses a critical care educational orientation and training program to ensure minimum competencies needed to care for critically ill patients are met (83–85). The AACN's pediatric critical care nurse certification signifies mastery of comprehensive pediatric critical care knowledge and is viewed as a best nursing practice measure to promote optimal patient management (83). A growing body of nursing evidence exists supporting specialty certification, clinical experience, and higher education because these are all associated with improved patient outcomes (86–88). In a recent pediatric study, clinical nursing experience was found to be independently associated with in-hospital mortality in pediatric cardiac surgery patients in children's hospitals across the United States (88). Much of the research to date has been primarily focused on examining the influence of higher education on patient outcomes. Aiken et al (86) found that every 10% increase in the proportion of nurses who received a Bachelor of Science Nursing (BSN) on a hospital staff was associated with a 4% reduction in risk of

mortality and confirmed this finding in a follow-up study (89). Several other studies support the strong link between higher levels of nursing education and patient outcomes (90–95) as recommended in the Institute of Medicine report "The Future of Nursing" (96). More recently, Hickey et al (88) assessed the impact of nursing education and experience with in-hospital postoperative cardiac surgery mortality among 15,463 patients using the STS-CHSD. PICUs with a higher proportion of nurses with a BSN degree or higher had significantly lower odds of complications (OR for 10% increase, 0.85; 95% CI, 0.76–0.96; $p = 0.009$), and higher proportion of nurses with greater than 2 years of clinical experience was associated with lower risk of mortality (OR for 10% increase, 0.92; 95% CI, 0.85–0.99; $p = 0.025$).

Clinical Pharmacists. Pharmacy services in the ICU have evolved substantially and were recognized by the SCCM as essential for optimal multidisciplinary care of critically ill patients more than a decade ago (28, 58). A clinical pharmacist, particularly those who have engaged in specialty residency training and who is involved in direct patient management in the ICU, has been shown to improve patient safety and clinical outcomes; examples include optimizing antibiotic stewardship, decreasing medication errors, and supporting timely and safe medication administration during emergencies (30–40). Although the existing evidence is primarily retrospective and pre-/postintervention design, the contributions of pharmacists to improving clinical efficiency and safety as members of the multidisciplinary ICU team are significant.

RTs. RTs have played a primary role in the direct respiratory care needs of the majority of PICU patients in the United States, although outcomes related to practice primarily evaluate the use of RT-driven protocols. In single-center observational studies conducted primarily in non-ICU adult settings, RT-driven protocols have been shown to contribute to standardizing care and decreasing costs and hospital LOS (97–102). However, with significant advances in mechanical ventilation, adjuncts to mechanical ventilation (e.g., aerosolized pulmonary vasodilators, nonconventional forms of ventilatory support), and ECLS techniques, the role and competencies of the RT in the ICU have changed considerably. In response to these changes, the American Association for Respiratory Care established a task force in 2007 charged with redesigning roles and responsibilities of RTs in the United States and identifying specific competencies required for practice in 2015 and beyond (103, 104). The expanded education and roles of RTs will be necessary for the care of critically ill children in all PICUs.

Support Specialists. Multiple support personnel is needed to provide comprehensive, family-centered care in the PICU. In 2007, the SCCM developed guidelines for the support of patients and families in all ICU settings (105). These guidelines address family psychosocial, cultural, and spiritual support needs. These guidelines also recognize the need for interprofessional collaboration between the ICU team and support services and the importance of the role the social worker, palliative care, pastoral care, and other services play in supporting families, patients, and the multidisciplinary team in the ICU. Much qualitative research shows the impact of these individual support services on patient, family, and staff satisfaction and the emotional burden of ICU care. Although some evidence exists demonstrating the benefit of specific ICU personnel (e.g., intensivists, nurses), the current evidence is limited and of moderate to low quality. Therefore, the updated ICU recommendations are primarily based on the Delphi consensus-based results.

PERFORMANCE IMPROVEMENT AND PATIENT SAFETY (QUALITY AND SAFETY INITIATIVES)

No data have been published defining quality metrics and academic pursuit expectations by PICU level of care since the 2004 guidelines. Based on the results of the Delphi Survey and expert panel consensus, we endorse the following general education recommendations.

Recommendations

- Quaternary facilities and tertiary levels of PICU should participate in academic pursuits.
- All quaternary facilities and tertiary levels of PICU should be involved in providing peer community outreach education such as educational conferences, technical skills competencies, stabilization, and resuscitation (e.g., PALS education).
- Community and tertiary PICUs should be involved in providing community outreach through educational events that focus on technical skills needed for stabilization, resuscitation, and communication for the triage and transport of critically ill and injured children. These activities might include case conferences.
- All levels of PICU should provide feedback to referral centers following the transfer of a patient to a PICU, which is essential for both QI and education.

Rationale

Regional and local referral centers should be involved in the education of referring facilities, including for the recognition, stabilization, and triage of patients.

EQUIPMENT AND TECHNOLOGY

Evidence demonstrating the impact of specialized technology provided by PICU level of care since the 2004 guidelines is sparse. Based on the results of the Delphi Survey and expert panel consensus, the expert panel made the following recommendations for equipment and technology by PICU level of care.

Recommendations

- Some emergency resuscitative therapies, such as invasive and noninvasive respiratory support and central line access, can be safely performed in community PICUs.

- RRTs (peritoneal dialysis, continuous hemofiltration and hemodialysis, intermittent hemodialysis) may be offered in a community-based PICU when appropriately trained support personnel, which must include a nephrologist, are present.
- All PICU levels must have access to helium-oxygen. In selected PICUs, nitric oxide, epoprostenol sodium, and anesthetic agents may be used if appropriate personnel and equipment are available for the safe delivery and monitoring of these agents.
- The following are appropriate indications for PICU transfer from a community to a tertiary or quaternary level of care: ICP monitoring, acute hepatic failure leading to coma, congenital heart disease with unstable cardiorespiratory status, need for temporary cardiac pacing, head injury with initial GCS less than or equal to 8, multiple traumatic injuries, or heart failure requiring an interventional cardiologist. For complicated burns greater than 10% TBSA, access to a specialized burn unit or burn center is recommended.

Rationale

Significant advances in ICU technology have occurred since the earlier admission guidelines publications (1, 2, 106). However, few data exist regarding the impact of specialized technological modalities provided by the PICU level of care on patient outcomes. Outcome data published within the past 15 years evaluating resources deemed necessary (Table 2) and factors impacting the level of care were reviewed.

Nonconventional Advanced Ventilatory Support. Ventilator modes and strategies to support children with acute hypoxemic respiratory failure have primarily included HFOV and ECMO. A recent retrospective review compared the outcomes of HFOV with those of conventional ventilation in children with acute respiratory failure from 98 PICUs in the United States between 2009 and 2011 (26). In comparison to conventional mechanical ventilation, the use of HFOV and early HFOV was associated with increased standardized mortality (1.62; 95% CI, 1.31–2.01 vs 0.76; 95% CI, 0.62–1.16, respectively), increased length of mechanical ventilation (20.3 vs 14.6; $p < 0.001$), and increased ICU LOS (24.9 vs 19.1; $p < 0.001$). However, early use of HFOV was associated with improved outcomes, including decreased length of mechanical ventilation and decreased ICU LOS when compared with late HFOV. Further investigation is needed to determine the timing of HFOV and impact on patient outcomes (106).

Airway pressure release ventilation (APRV) is an alternative mode of ventilation for children with acute respiratory failure, but its current impact on outcomes is not well described (107). Some studies show that APRV in children with mild to moderate lung disease has comparable levels of ventilation and oxygenation at significantly lower inspiratory peak and plateau pressures than conventional ventilation (108–110). Although there are no current data to support the need to provide this mode of ventilation in any PICU level, its availability may be useful in the armamentarium of higher level PICUs that would care for many different types of respiratory failure.

Noninvasive Ventilation. Some data demonstrate that early initiation of HFNC therapy may be effective in preventing intubation in infants with bronchiolitis (111, 112). Kelly et al (111) found that respiratory rates greater than 90th percentile for age, initial venous pH less than 7.3, and P_{CO_2} greater than 50 mm Hg were associated with failure of HFNC therapy in children younger than 2 years old. Abboud et al (113) also found that infants with bronchiolitis who did not respond to HFNC therapy were more hypercarbic before and after starting HFNC ($p < 0.001$) and had no change in respiratory rate after HFNC initiation. Lazner et al (114), in a large retrospective review, found that HFNC responders improved within 2 hours of initiation and had sustained improvement at 4 hours versus those who did not respond. Despite these findings, only one small RCT evaluating the effectiveness of HFNC therapy treating infants with bronchiolitis exists (115). In addition, there is a paucity of data demonstrating the effectiveness of HFNC therapy over other types of noninvasive respiratory support. A recent Cochrane review revealed only one small RCT examining the use of HFNC in comparison to other forms of noninvasive therapy in infants with bronchiolitis and found no studies in children (116). Currently, there is no evidence that HFNC is superior to other forms of noninvasive respiratory support in infants and children.

Inhalation Gases. Inhaled nitric oxide (iNO) is an effective agent to treat acute pulmonary hypertension in children. There are some data supporting its use in acute hypoxemic respiratory failure are limited. Some studies show that iNO use may improve oxygenation in children with acute respiratory distress; Bronicki et al (117). randomly assigned 55 children with acute respiratory distress syndrome to receive either iNO or placebo in nine centers. A trend toward an improved oxygen index in the iNO group when compared with the placebo group was seen at 4 hours and became significant at 12 hours. Ventilator-free status at 28 days (14.2 + 8.1 d and 9.1 + 9.5 d in nitric oxide vs placebo group, respectively) and the rate of ECMO-free survival were significantly greater in the iNO group (92%, 22/24) versus (52%, 15/29) the placebo group. An older review of five trials ($n = 623$) had evaluated the use of iNO in patients with acute hypoxemic respiratory failure on oxygenation, mortality, ventilator-free days, and hospital LOS (118). Only one of the studies showed improvement in oxygenation in the first 4 days of treatment and was not clinically significant.

Isoflurane and sevoflurane have been described as potentially effective to improve gas exchange in children with life-threatening bronchospasm (119–121). The current evidence is limited to small retrospective reviews. If these agents are used, an anesthesiologist should be involved in the administration of these anesthetic gases.

Helium-oxygen (heliox) during noninvasive ventilation has been showed to improve gas exchange in some patients, thus preventing intubation (122). A recent Cochrane review of 447 infants with acute bronchiolitis (123) showed that helium-oxygen therapy decreased respiratory distress in the first hour

after starting treatment, but no reduction in intubation rate was found.

Mechanical Circulatory Support Devices. The use of VADs to augment cardiac function prior to transplantation has increased dramatically over the past 15 years (124). Prior to the availability of VAD, ECMO was the most widely used option for children requiring hemodynamic support. Recent data show that ECMO is less advantageous than VAD in patients who require prolonged wait times prior to transplantation (125). Fraser et al (126) prospectively compared VAD (Excor; Berlin Heart GmbH, Berlin, Germany) to ECMO in 48 children and showed that survival rates were significantly higher with a VAD than ECMO. VAD utilization has shown improvement in mortality from 42% between 2000 and 2002 to 25% between 2007 and 2010 ($p = 0.004$) (124).

Two large pediatric U.S. single centers describe their use of VADs as a bridge to heart transplantation. Stein et al (127) retrospectively identified 25 patients younger than 18 years old requiring mechanical circulatory support using a VAD as a bridge to heart transplantation between 1998 and 2007. Survival to transplant was 74%. Chen et al (128) identified 37 patients with a VAD between 2000 and 2010. Survival to transplant was 86.5%. An earlier study conducted by Blume et al (129) used a multi-institutional, prospectively maintained database of outcomes in children listed for heart transplantation to analyze outcomes of 99 VAD patients between 1993 and 2003. Survival to transplant was 77%.

Using the Kids' Inpatient Database, Morales et al (130) characterized the utilization of VAD in children nationwide. In 2006, 187 children had a VAD implant. Sixty-seven hospitals placed VADs, 66% of VADs were implanted at large teaching hospitals (> 500 beds), and 46% (84) were at high-volume hospitals (> 5 VADs per year). High-volume, large teaching hospitals (12) had better survival (89% vs 61%; $p < 0.001$) compared with all other hospitals. Mansfield et al (124) also found lower mortality at larger volume VAD centers. Preliminary data suggest that outcomes in children requiring VAD are better in high-volume centers.

ECLS. ECLS or ECMO has been used as rescue therapy for children with respiratory and cardiovascular failure for more than 40 years. Patient selection and prompt consultation with a pediatric center providing ECLS are important to optimize patient outcomes. Zabrocki et al (131) conducted a large multicenter analysis to evaluate survival and predictors of mortality in 3,213 children with acute respiratory failure requiring ECLS. Survival was found to be unchanged over time (57%), but ECLS was increasingly offered to medically complex children. Similar survival outcomes have been observed in tertiary PICUs (132, 133).

VAD and ECMO, along with the cardiothoracic surgeons, cardiologists, and perfusionists, should be available in a quaternary facility PICU. These technologies are desired in a tertiary PICU and are not expected in a community PICU.

Invasive/Noninvasive Hemodynamic Monitoring. Several advanced hemodynamic monitoring devices are available for clinical use in critically ill children. Although direct evidence for monitoring devices reducing morbidity and mortality is sparse, goal-directed therapies would be impossible to reach without these devices. All types of shock including sepsis (134), cardiogenic, and hypovolemic shock rely on hemodynamic indices for continued therapy. Goals for therapy are guided by mixed venous oxygen saturation and other markers of oxygen delivery, such as lactate levels.

NIRS technology is increasingly used to provide additional assessment of renal and cerebral oxygenation in critically ill children. Several studies have been conducted to compare this noninvasive monitoring to invasive cerebral jugular venous bulb catheter and circulatory venous oxygen saturation, but results are inconsistent. Ortmann et al (135) found a strong correlation between renal NIRS and venous oxygen saturation in children weighing less than 10 kg undergoing cardiac catheterization ($r = 0.821$; $p = 0.002$) but not in children weighing greater than 10 kg. In a prospective observational study of 40 infants following biventricular cardiac repair, Owens et al (136) found that low renal NIRS correlated with other markers of renal dysfunction. Suemori et al (137) conducted a retrospective study in 399 children to examine whether cerebral NIRS predicts outcomes after cardiac surgery. In multivariate regression analysis, postoperative cerebral NIRS was independently associated with major morbidity and mortality. However, Knirsch et al (137) compared cerebral NIRS with central venous and internal jugular oxygen saturation during interventional catheterization in 60 children. Cerebral NIRS was found to be an unreliable estimate of central venous or jugular oxygen saturation. Bhalala et al (138) in a small prospective observational study found that the sensitivity and specificity of renal NIRS as an indicator of low cardiac output in children following cardiac surgery were low (48% and 67%, respectively). The use of NIRS noninvasive monitoring to assess cerebral and renal perfusion provides additional information to guide therapy in critically ill children, but evidence examining the accuracy of NIRS in comparison to invasive monitoring is inconsistent.

The entire armamentarium of invasive and noninvasive hemodynamic monitoring is necessary in quaternary facilities and tertiary PICUs. All noninvasive and some invasive monitoring are required in community PICUs.

ICP Monitoring. The Brain Trauma Foundation guidelines recommend ICP monitoring to detect and treat intracranial hypertension in children with severe TBI (139). Alkhoury and Kyriakides (139) conducted a retrospective review of the National Trauma Data Bank to determine the effect of ICP monitoring on survival in pediatric patients with severe TBI. ICP monitoring was performed in only 77% of children meeting criteria. ICP monitoring was associated with a reduction in mortality only in children with a GCS of 3 (OR, 0.64; 95% CI, 0.43–1.00). Davidson et al (140) conducted a retrospective cohort study of 99,513 pediatric trauma patients including TBI patients using the National Trauma Data Bank to determine the impact of timing of craniotomy, ICP monitoring, and abdominal surgery. No difference was found in mortality for patients who had an ICP monitor placed within 4 hours of admission

when compared with those in whom monitor placement was delayed; however, the early operative intervention was associated with a shorter ICU and hospital LOS.

Bennett et al (141) found significant between hospital variations in ICP monitoring. Using the Pediatric Health Information System database, 4,667 patients with TBI were identified between 2001 and 2011 from 43 children's hospitals in the United States. Better patient outcomes were observed in hospitals that had larger TBI patient volumes and monitored ICP more often. Sathya et al (142) evaluated the association between type of trauma center—pediatric, mixed, or adult center—and in-hospital mortality among young children (≤ 5 yr), older children (6–11 yr), and adolescents (12–18 yr). In this retrospective review, 175,585 injured children were identified in 252 trauma centers in the United States. Results revealed that children treated at adult (OR, 4.31; 95% CI, 3.3–5.62) and mixed (OR, 3.29; 95% CI, 2.47–4.37) trauma centers had higher in-hospital mortality compared with those treated at pediatric trauma centers, and this was most evident in young children. There are accumulating data demonstrating that children with severe TBI have improved outcomes when cared for in a pediatric level I trauma center.

The use of ICP monitoring for nontraumatic causes of intracranial hypertension is limited primarily to case reports and case series. ICP monitoring has been described as helpful in the successful management of intracranial hypertension in bacterial meningitis (141, 142), hydrocephalus, brain tumors, ventriculoperitoneal shunt failure, and craniosynostosis (141–145) and as a complication of diabetic ketoacidosis-associated cerebral edema (145). Sæhle and Eide (146) describe the role of ICP monitoring in pediatric and adult patients with hydrocephalus and suspected shunt failure. In this cohort, ICP monitoring was helpful in preventing unnecessary shunt revision in 49% of patients. Although ICP monitoring has been shown to be beneficial in nontraumatic causes of intracranial hypertension, the role of ICP monitoring for these causes remains unclear.

ICP monitoring, neurosurgical, and neurologic availability are mandatory in quaternary facility ICUs and recommended in tertiary ICUs.

RRTs. CRRT has emerged as a common modality in the treatment of critically ill children with acute kidney injury and fluid overload. Sutherland et al (147) conducted a prospective observational study in 297 children from 13 centers across the United States who participate in the Prospective Pediatric CRRT Registry to determine the association between fluid overload and mortality (148). Patients who developed 20% or greater fluid overload before initiation of CRRT experienced higher mortality (61/93; 65.6%) than those who had 10%–20% fluid overload (22/51; 43.1%) and those with less than 10% fluid overload (45/153; 29.4%). The association between the degree of fluid overload and mortality remained after adjusting for intergroup differences and severity of illness. This finding is consistent with earlier studies results demonstrating that increased fluid overload is associated with increased mortality (149–154). A recent single-center retrospective study in 113 children added further evidence as increased fluid overload was associated with increased mortality, independent of illness severity (155). Currently, evidence supporting early initiation of CRRT in fluid overloaded critically ill children to improve clinical outcomes is primarily observational and of low quality.

Symons et al (155), using the Prospective Pediatric CRRT Registry, examined the indications for CRRT between 2001 and 2005. Excluding patients who received CRRT via ECMO, 344 patients were identified and had an overall survival rate of 58%. Mortality was increased when CRRT was initiated for fluid overload and electrolyte abnormalities and lowest with drug intoxication, tumor lysis syndrome, and inborn error of metabolism. Although CRRT may be initiated in all levels of PICUs, no studies were found comparing the initiation of CRRT in a community versus a tertiary or quaternary hospital.

All modalities of RRT are required in a quaternary facility PICU. Hemodialysis and peritoneal dialysis are required in tertiary PICU.

Telehealth. The use of telehealth has increased considerably over the past 2 decades as the affordability, quality, and reliability of communication equipment have improved. Several reports describe the feasibility of urgent subspecialty critical care consultation with the use of telemedicine to underserved rural or community hospitals (156–161). However, limited data exist describing improved clinical outcomes related to telemedicine consultation. Dharmar et al (161) compared processes of care delivered to 320 critically ill children receiving telehealth, telephone, or no consultation in five rural emergency departments. Quality was measured using a validated quality of care instrument to assess aspects of care during the telehealth consultation including diagnostic evaluation, treatment interventions, and disposition. Telehealth consultations were associated with more frequent changes in diagnostic and therapeutic interventions and higher parent satisfaction than telephone consultations.

Telehealth has also been proposed as a means of providing intensivist coverage to multiple ICUs without 24/7 coverage and has been endorsed by the Leapfrog Group (56) as an acceptable form of nighttime intensivist coverage. Yager et al (162) conducted a small retrospective review of nighttime telecommunication between remote staff intensivists and PICU staff. Telecommunication was found to be technologically feasible, enhanced team communication, and led to changes in patient management, but the study did not evaluate the impact on clinical outcomes. Although there are increasing reports of the use of telehealth to assist in the remote care of critically ill children, the quality of evidence is low, and outcomes of care have not been studied (165, 166).

Although significant advances in ICU technology have occurred since the 2004 guidelines, limited pediatric data exist regarding the impact of specialized technological modalities by PICU level of care on patient outcomes. Table 2 outlines the resources appropriate for each PICU level of care based on the Delphi results and task force consensus.

PICU DISCHARGE AND TRANSFER CRITERIA

The evidence supporting specific discharge criteria for PICU levels of care since the 2004 guidelines remains insufficient and of low quality. Based on the results of the Delphi Survey and

expert panel consensus, the following general recommendations are suggested for PICU discharge criteria.

Recommendations

- Each PICU should have clearly defined criteria for escalation and de-escalation of resources and, therefore, level of PICU required based on the physiologic status of the patient.
- All levels of PICU should have policies and protocols in place that specify when the patient's physiologic status requires escalation of care, with transfer to a more appropriate level of care to be undertaken as expeditiously as needed.
- When a patient's physiologic status improves, discharge from the PICU can occur in these ways:
  - transfer to an appropriate acute care bed within that facility;
  - return transfer to the referring facility;
  - transfer to a skilled nursing or rehabilitation facility; or
  - discharge directly to home.
- Upon discharge from the PICU, the following should take place:
  - appropriate communication with the accepting facility including oral handoff, a clear and concise written summary, and exchange of necessary health information;
  - discharge planning and communication with the family/caregivers if going home;
  - communication with the primary care physician who will assume care of the child once the patient is returned to the community;
  - communication with subspecialists caring for the child and appropriate follow-up arranged as necessary; and as needed, careful care coordination with outpatient services such as but not limited to:
  - delivery and instruction in the use of durable medical equipment;
  - home pharmacy and nutrition support;
  - ongoing rehabilitation needs, such as occupational or PT; and
  - ancillary support as required.

Rationale

Although little evidence exists to guide practitioners regarding appropriate timing for PICU discharge, an unplanned readmission has become an important quality metric as it is a potentially preventable event and a threat to patient safety. Three recent large retrospective VPS analyses were conducted to identify factors associated with unplanned readmissions. Czaja et al (163) reviewed 117,923 admissions from 73 PICUs between 2005 and 2008 and found unplanned readmission was low (3.7%), but late readmissions (> 48 hr after discharge) were associated with higher mortality (6.6% vs 3.3%; $p < 0.001$) and longer PICU LOS (11 vs 6 d; $p < 0.0001$) when compared with early readmissions (< 48 hr). Several patient characteristics were strongly associated with increased risk of early readmission and included age less than 5 months, acute respiratory and renal disease, underlying chronic conditions such as liver disease, bone marrow transplant, airway stenosis, and abnormal antidiuretic hormone balances. Edwards et al (164) reviewed 96,189 admissions from 87 PICUs between 2009 and 2011 and also found that early unplanned readmissions were uncommon (1.2%; range, 0%–3.3%) but associated with worse outcomes, including longer median PICU LOS (3.1 vs 1.7 d; $p < 0.001$) and higher mortality (4% vs 2.5%; $p = 0.002$). Patients with two or more complex chronic conditions were more likely to be readmitted (adjusted OR, 1.72; $p<0.001$) and discharged to intermediate units (adjusted OR, 1.29; $p < 0.001$), whereas trauma patients had a decreased risk of readmission (adjusted OR, 0.67; $p = 0.003$). A recent follow-up study by Edward et al (165) examined readmissions within 1 year to the PICU and found 11% of patients were readmitted and 3.4% had two or more readmissions. Mortality and PICU LOS were significantly higher in readmitted patients. A primary risk factor for readmission was complex chronic conditions. Unplanned readmissions have also been found to be associated with higher mortality in single-center PICU studies (166–168) and pediatric cardiac ICU studies (169, 170). Interventions to reduce unplanned PICU readmissions from other patient care areas include rapid response teams and use of bedside severity of illness scores to quantify risk of clinical deterioration (e.g., Pediatric Early Warning Score), although the impact of these interventions on readmissions is not clear (171–176). Reducing unplanned readmissions in medically complex children poses a greater challenge. Some proposed interventions include longer observation of stability in the PICU, designation of a primary care team for medically complex patients, and comprehensive care coordination between the PICU and medical home (165).

Efforts to improve the quality of care for children with complex chronic conditions or medical complexity led to the development of the medical home by the AAP (177). Since its inception 50 years ago, the concept of the medical home has evolved significantly to address the increasing complexities of the healthcare system (178). The medical home has expanded beyond a place and comprehensive, family-centered care coordinated by primary care physicians to an integrated system designed to meet all the comprehensive elements required to care for the medically complex child, including subspecialty and hospital needs coordinated by a dedicated team of professionals. Evidence to support the enhanced medical home for medically complex children is seen in an RCT demonstrating that comprehensive coordinated care including treatment from primary care clinicians and specialists in the same clinic as compared with usual care (e.g., uncoordinated, private office) reduced serious illnesses, emergency department visits, PICU admissions, hospitalizations, days in the hospital, and costs of care (179).

Discharge guidelines should be developed by PICUs that consider the unique hospital characteristics (e.g., type of facility, systems, resources, PICU size, case mix, advanced technologic capabilities), geographic location, and available

healthcare services. In general, a patient is considered ready for de-escalation of care when the PICU scope of services is no longer required and patient care needs can be managed by a lower level of care, such as an intermediate care unit, general pediatric service, rehabilitation facility, or long-term care facility. A patient is considered ready for discharge to home with reversal of the disease process or resolution of the unstable physiologic condition that prompted PICU admission. Several of the discharge criteria outlined in the previous 2004 guideline remain appropriate: stable hemodynamic parameters, stable respiratory status and airway, neurologic stability, arrhythmias controlled, and IV inotropic support, vasopressors, vasodilators, and antiarrhythmics are no longer needed (2). However, currently there is no evidence regarding the appropriate length of time for monitoring to ensure stability, but length of time for monitoring may be guided by the anticipated discharge location (e.g., home vs general pediatric floor) and may range from 6 to 48 hours or even longer, depending on the medical complexities of the child (e.g., acute on chronic mechanical ventilation–dependent child) allowing time for appropriate transfer of care from the acute to the postacute setting. In addition, as the medical home becomes more sophisticated, children are discharged to home with equipment once deemed specific to the ICU setting. Therefore, preparing medically complex children for discharge can be extremely challenging and requires comprehensive care coordination by the interdisciplinary healthcare team with some key factors identified: 1) the child's medical stability; 2) preparedness of family and home caregivers; 3) necessary medical equipment; and 4) the safety of the home and community environment (165).

Ethical challenges regarding what constitutes futile care and the impact of extraordinary treatment measures on pediatric critical care resource consumption and healthcare costs are beyond the scope of the practice statement and guidance. A multiorganizational policy statement led by the SCCM Ethics Committee (2016) provides guidance to ICU clinicians regarding difficult treatment decisions and recommends reserving the term "futile" to rare circumstances that an intervention simply cannot accomplish the intended physiologic goal and determined using process-based approach (180). Further investigations and ongoing national dialogue are necessary.

CONCLUSIONS

The practice statement and guidance address important specifications for each PICU level of care, including the team structure and resources, technology and equipment, education and training, quality metrics, admission and discharge criteria, and indications for transfer to a higher level of care. The sparse high-quality evidence led the panel to use a modified Delphi process to seek expert opinion to develop consensus-based recommendations where gaps in the evidence exist. Despite this limitation, the members of the task force believe that these recommendations provide guidance to practitioners in making informed decisions regarding pediatric admission or transfer to the appropriate level of care to achieve the best outcomes. Further well-designed clinical investigations are needed to determine and address the confounding factors that impact admission, discharge, and transfer of children in all levels of PICUs.

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The American College of Critical Care Medicine (ACCM), which honors individuals for their achievements and contributions to multidisciplinary critical care medicine, is the consultative body of the Society of Critical Care Medicine (SCCM) that possesses recognized expertise in the practice of critical care. The College has developed administrative guidelines and clinical practice parameters for the critical care practitioner. New guidelines and practice parameters are continually developed, and current ones are systematically reviewed and revised.

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