Physical Rehabilitation in Critically Ill Children: A Multicenter Point Prevalence Study in the United States

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Objectives: With decreasing mortality in PICUs, a growing number of survivors experience long-lasting physical impairments. Early physical rehabilitation and mobilization during critical illness are safe and feasible, but little is known about the prevalence in PICUs. We aimed to evaluate the prevalence of rehabilitation for critically ill children and associated barriers.

Design: National 2-day point prevalence study.

Setting: Eighty-two PICUs in 65 hospitals across the United States.

Patients: All patients admitted to a participating PICU for greater than or equal to 72 hours on each point prevalence day.

Interventions: None.

Measurements and Main Results: The primary outcome was prevalence of physical therapy– or occupational therapy–provided mobility on the study days. PICUs also prospectively collected timing of initial rehabilitation team consultation, clinical and patient mobility data, potential mobility–associated safety events, and barriers to mobility. The point prevalence of physical therapy– or occupational therapy–provided mobility during 1,769 patient-days was 35% and associated with older age (adjusted odds ratio for 13–17 vs < 3 yr, 2.1; 95% CI, 1.5–3.1) and male gender (adjusted odds ratio for females, 0.76; 95% CI, 0.61–0.95). Patients with higher baseline function (Pediatric Cerebral Performance Category, ≤ 2 vs > 2) less often had rehabilitation consultation within the first 72 hours (27% vs 38%; $p < 0.001$). Patients were completely immobile on 19% of patient-days. A potential safety event occurred in only 4% of 4,700 mobility sessions, most commonly a transient change in vital signs. Out-of-bed mobility was negatively associated with the presence of an endotracheal tube (adjusted odds ratio, 0.13; 95% CI, 0.1–0.2) and urinary catheter (adjusted odds ratio, 0.28; 95% CI, 0.1–0.6). Positive associations included family presence in children less than 3 years old (adjusted odds ratio, 4.55; 95% CI, 3.1–6.6).

Conclusions: Younger children, females, and patients with higher baseline function less commonly receive rehabilitation in U.S. PICUs, and early rehabilitation consultation is infrequent. These findings highlight the need for systematic design of rehabilitation interventions for all critically ill children at risk of functional impairments. (*Crit Care Med* 2020; 48:634–644)

Key Words: critical care; developmental pediatrics; intensive care units; occupational therapy; pediatrics; physical therapy; rehabilitation

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Resuscitation and reversal of organ failure are important aspects of patient management in the ICU. Deep sedation and bed rest are common because of clinician perceptions of improved patient safety, physiologic stability, and patient comfort. However, deep sedation and bed rest are associated with short-term harms, including pressure ulcers, muscle weakness, and venous thromboembolism (1–5). Survivors of critical illness also commonly experience long-term physical, cognitive, and psychological morbidities (6–8). These issues are compounded in the PICU given that critical illness is occurring during a period of intense physical and neurocognitive development in infancy and childhood (9–11). Growing numbers of children who survive acute critical illness face high technologic dependence (12), prolonged PICU stays (13, 14), and long-term morbidities (15, 16).

Early rehabilitation and mobility in adult ICUs are associated with improved muscle strength (1, 17) and physical functioning (17), along with decreased mechanical ventilation duration (1). Despite this evidence, point prevalence studies in adult ICUs have consistently demonstrated that physical rehabilitation is infrequent (18–21). In critically ill children, early rehabilitation and mobility are safe and feasible, with potential short- and long-term benefits (22). However, the current state of rehabilitation practices in PICUs is unknown.

Hence, we conducted a 2-day point prevalence study in 82 PICUs across the United States to determine the prevalence of physical rehabilitation and mobility for patients admitted for at least 3 days. Additionally, we evaluated perceived barriers and potential safety events for patient mobility.

MATERIALS AND METHODS

Prevalence of Acute Rehabilitation for Kids in the PICU (PARK-PICU) was a cross-sectional point prevalence study conducted in U.S. PICUs on 2 days (November 9, 2017, and February 12, 2018). PICUs in the United States were eligible to participate if they 1) cared for mechanically ventilated infants and children and 2) were located in a distinct physical space dedicated to pediatric patients. PICUs were recruited via the Pediatric Acute Lung Injury and Sepsis Investigators network, e-mail, social media, and a dedicated website (23). Institutional review board approval was obtained at all sites with waiver of informed consent for collection of de-identified data.

Patient Selection

All patients with PICU length of stay (LOS) greater than or equal to 72 hours as of 7 AM on each point prevalence day were included in the study. We chose greater than or equal to 72 hours because patients with longer stays are at greater risk for muscle atrophy and physical impairment (24), and ICU studies suggest up to 72 hours as the threshold for defining "early" rehabilitation and mobilization (22, 25, 26).

Study Day Selection, Notification, and Data Collection

At the time of site enrollment, participating PICU study teams were informed of the designated months for the point prevalence study days. On the first day of the month, a clinician who was not involved with the study randomly chose a weekday for study conduct in all PICUs. Study teams were notified by text and/or e-mail at 3 PM Eastern Standard Time on the day before the selected day, with instructions to conduct screening for eligible patients and prepare for data collection on the following day. Prospective data collection began at 9 AM local time for all eligible patients and continued for 24 hours. All data were collected and managed using Research Electronic Data Capture (REDCap) tools hosted at Johns Hopkins University (27, 28). All data collection forms are publicly available on the study website (29).

Measures

ICU Characteristics. Before study initiation, each participating ICU (*n* = 82) completed an organizational survey (29) to provide data regarding clinical resources and protocols related to rehabilitation and mobility. Site principal investigators were instructed to complete this survey in collaboration with a rehabilitation team leader and the PICU nurse manager to ensure accuracy.

Patient Clinical Characteristics. Sites abstracted clinical data (29) for all eligible patients based on clinical status at 9 AM on each study day. Data included mechanical ventilation status, sedative infusions and sedation level, delirium status, and the use of specific medical devices. Mechanical ventilation was defined as positive-pressure ventilation delivered via an endotracheal tube, tracheostomy, or noninvasive ventilation. Preadmission functional status, categorized by the Pediatric Cerebral Performance Category (PCPC) Score, was collected based on the medical record or discussion with family and PICU team. Data were collected from the electronic health record or in real-time at the bedside based on site preference and data availability.

Mobility Data. Physical therapy (PT) and occupational therapy (OT) consultation and treatment documentation for the first 72 hours of PICU admission were abstracted retrospectively from the electronic health record. For mobility data, standardized forms (29) were distributed to the bedside of all eligible patients by 9 AM for real-time event recording. Nurses and multidisciplinary staff were instructed to document the following: 1) occurrence of any PT-, OT-, nurse-, family-, or other staff-provided mobility on the study day; 2) types and timing of mobility events (classified according to in-bed and out-of-bed activities); 3) perceived barriers to mobilization; and 4) potential safety events associated with mobilization (e.g., transient vital sign changes defined as ≥ 10% change in heart rate, oxygen saturation, or blood pressure; loss of invasive devices; and falls). Mobility events were defined as any activity involving physical movement of the patient, with the exception of routine care, including turning/repositioning for delivery of medical care or prevention of pressure ulcers. Both barriers and potential safety events were selected from a pre-specified list with a free-text option (29).

The primary outcome was "therapist-provided mobility," defined as greater than or equal to one mobility event performed by either a PT or OT on the study day. This primary outcome was chosen based on the following: 1) comparability to U.S. adult ICU point prevalence data (18) and 2) feedback from participating PICUs that PT and OTs are often consulted simultaneously and the rehabilitation team determines which services are most appropriate to provide. Out-of-bed mobility was defined as transfer from bed to chair, being held by family or staff, mat play, standing, or walking. Secondary outcomes were out-of-bed mobility, barriers to mobility, and potential safety events. We also analyzed PT- and OT-provided mobility separately.

Data Analysis/Statistical Methods

The prevalences of therapist-provided mobility and out-of-bed mobility were defined as the number of patient-days with at least one associated event divided by the total eligible patient-days across the 2 study days. Categorical data were

analyzed by chi-square test, and continuous data (expressed as medians [interquartile range (IQR)]) were analyzed by the Mann-Whitney U test. Patients discharged before 12 PM on the study days were excluded from the final analysis. Multivariable logistic regression models, with a random effect for ICU site, were used to calculate odds ratios (ORs), with 95% CIs, for therapist-provided mobility and out-of-bed mobility.

Covariates in the regression models were identified a priori based on clinical relevance and prior literature (30). The regression model for therapist-provided mobility included age category (0–2, 3–6, 7–12, 13–18, > 18 yr); sex; ethnicity; baseline PCPC before hospital admission; PICU LOS as of the study day; medical versus surgical admission; type of respiratory support; vasoactive, opioid, and benzodiazepine infusions; nurse-to-patient ratio; indwelling urinary catheter; central venous or arterial catheters; hemodialysis catheter; intracranial pressure monitor; unit mobility protocol; and family presence. The regression model for out-of-bed mobility included these variables in addition to a binary indicator of therapist-provided mobility on the study day. Additional details for data analysis and statistical methods are provided in **Supplemental Digital Content 1** (http://links.lww.com/CCM/F371). A two-tailed p value of less than 0.05 was considered statistically significant. Stata 14 (StataCorp LLC, College Station, TX) was used for all statistical analyses.

RESULTS

ICU and Patient Baseline Characteristics
Participating PICUs ($n = 82$; **Supplemental Digital Contents 2** and **3**, http://links.lww.com/CCM/F371) had a median of 24 beds (IQR, 16–30) and included medical-surgical-cardiac (44%), medical-surgical (40%), and cardiac only (16%) units. Most PICUs were in an academic teaching (92%) and freestanding children's hospital (55%). Early mobility protocols were reported in 27% of units. A physician consultation request was required for evaluation and treatment by a PT or OT in 93% of PICUs. A dedicated full-time equivalent (≥ 1) PT and OT staff were present in 18% and 16% of PICUs, respectively.

Among 3,098 patients screened over 2 study days, 1,769 (57%) met inclusion criteria (**Supplemental Digital Content 4**, http://links.lww.com/CCM/F371); 74 patients (4%) contributed data on both study days. Most were medical patients (73%), less than 3 years old (62%), with a median (IQR) PICU stay of 12 days (6–30 d), and 48% had a baseline PCPC score of greater than 2 (**Table 1**).

Patient Clinical Characteristics on Study Day
About half of all eligible patients were receiving greater than or equal to one continuous infusion of a sedative or analgesic, and 59% of all patients were mechanically ventilated (**Table 2**); 87% ($n = 529$) of all intubated patients received a continuous analgesic and/or sedative infusion. Most patients had a central venous catheter (67%; $n = 1,189$), and 371 (21%) received a vasoactive infusion.

Timing of PT/OT Consultation
By PICU day 3, PT and/or OT had been consulted for 538 patients (32%), with 411 (24%) having received treatment. Across the 2 study days, 671 patients (38%), with a median PICU LOS of 7 days (IQR, 5–12 d), did not have an active PT or OT consultation. Children with higher baseline function (PCPC, ≤ 2 vs > 2) were less likely to have had PT or OT consultation by day 3 than were those with lower baseline function (27% vs 38%; $p < 0.001$; **Supplemental Digital Content 5**, http://links.lww.com/CCM/F371).

Therapist-Provided Mobility
The prevalence of PICU patients who received PT- and/or OT-provided mobility on the study day was 35% (95% CI, 33–38%). Patients received only PT, only OT, or both on 13%, 10%, and 13% of study days, respectively; 42% of study days with both PT- and OT-provided mobility ($n = 103$) were cotreatment during the same session. Tables 1 and 2 display univariate analysis for demographic and clinical factors and the primary outcome of PT- or OT-provided mobility, whereas **Supplemental Digital Contents 6–8** (http://links.lww.com/CCM/F371) provide PT- and OT-specific data. Therapist-provided mobility (Supplemental Digital Content 8, http://links.lww.com/CCM/F371) was associated with older age (adjusted OR [aOR] compared with age < 3: 7–12 yr, 1.91 [95% CI, 1.34–2.73] and 13–17 yr, 2.1 [95% CI, 1.45–3.06]), moderate baseline disability (PCPC 3 vs PCPC 1: 1.38; 95% CI, 1.04–2.06), and longer PICU LOS (2.49 per 10-fold higher PICU day before day 100; 95% CI, 1.85–3.45). The presence of intracranial pressure monitoring also was associated with therapist-provided mobility (aOR, 2.25; 95% CI, 1.15–4.39). Therapist-provided mobility increased with family presence on the study day (aOR, 1.43; 95% CI, 1.08–1.89) and with the presence of a PICU mobility protocol (aOR, 1.58; 95% CI, 0.99–2.51). In contrast, female sex (aOR, 0.76; CI, 0.61–0.95) was inversely associated with therapist-provided mobility. In discipline-specific regression analysis (Supplemental Digital Content 8, http://links.lww.com/CCM/F371), PT-provided mobility was associated with surgical (vs medical) admission and older age groups, whereas OT-provided mobility was negatively associated with moderate and severe disability (PCPC 4 or 5 vs PCPC 1).

All Mobilization Events
Of 1,769 patient-days, 335 (19%) had no reported mobilization event. Most patients with no mobilization were mechanically ventilated (243 of 335 patient-days, 72%). On the 1,434 patient-days with mobility, 4,700 mobilization events occurred, for a median (IQR) of 2 (1–4) events per day. **Figure 1** shows the highest level of mobility achieved on the study day. Among mechanically ventilated children, passive range of motion was the most common mobility event (age < 3: 33%; age ≥ 3: 41%). Among those not mechanically ventilated, being held by family/nurse was most common for children less than 3 years old (51%), and ambulation was most common for patients greater than or equal to 3 years old (29%). Nurses

TABLE 1. Patient Baseline Characteristics, by Physical Therapy–/Occupational Therapy–Provided Mobility on Study Day

Demographics	All Patient-Days $n = 1,769$	PT/OT-Provided Mobility $n = 625$	No PT/OT-Provided Mobility $n = 1,144$	p^a
Age (yr), n (%)				0.006
0–2	1,100 (62)	355 (57)	745 (65)	
3–6	196 (11)	71 (11)	125 (11)	
7–12	220 (12)	90 (14)	130 (11)	
13–17	195 (11)	83 (13)	112 (10)	
> 18	58 (3)	26 (4)	32 (3)	
Female, n (%)	767 (43)	247 (40)	520 (46)	0.02
Ethnicity, n (%)[b]				0.10
White	864 (49)	324 (52)	540 (48)	
Black	397 (23)	141 (23)	256 (23)	
Hispanic	76 (4)	30 (5)	46 (4)	
Asian	295 (17)	94 (15)	201 (18)	
Other	130 (7)	35 (6)	95 (8)	
Body mass index, median (IQR)[b]	17 (15–20)	17 (15–21)	17 (15–20)	0.07
PICU length of stay, median (IQR)	12 (6–30)	16 (7–41)	10 (6–25)	0.007
Preadmission function, n (%)[c]				< 0.001
1: good	455 (26)	140 (22)	315 (28)	
2: mild disability	472 (27)	177 (28)	295 (26)	
3: moderate disability	380 (22)	167 (27)	213 (19)	
4: severe disability	442 (25)	137 (22)	305 (27)	
5: coma/vegetative state	20 (1)	4 (1)	16 (1)	
Ambulatory before admission, if age ≥ 3, n (%)[a]	424 (63)	209 (77)	215 (54)	< 0.001
Primary admission reason, n (%)[b]				0.10
Surgical				
Cardiac	274 (16)	96 (15)	178 (16)	
Neurologic	85 (5)	42 (7)	43 (4)	
Orthopedic	8 (1)	4 (0)	4 (0)	
Other	101 (6)	33 (5)	68 (6)	
Medical				
Respiratory	671 (38)	207 (33)	464 (41)	
Cardiac	282 (16)	109 (17)	173 (15)	
Hematology-oncology	40 (2)	19 (3)	21 (2)	
Infectious/inflammatory	104 (6)	36 (6)	68 (6)	
Neurologic	103 (6)	42 (7)	61 (5)	
Other	97 (5)	37 (6)	60 (5)	
Early mobility protocol[d]	468 (26)	191 (31)	277 (24)	0.004

IQR = interquartile range, OT = occupational therapy, PT = physical therapy.

[a]Calculated using χ^2 test for categorical variables and Mann-Whitney U test for continuous variables.

[b]Missing data: ethnicity (n = 7); body mass index (n = 84); admission reason (n = 6).

[c]Pediatric Cerebral Performance Category.

[d]Defined as unit-based guideline or policy for early mobility.

TABLE 2. Patient Clinical Characteristics on Study Day, by Physical Therapy–/Occupational Therapy–Provided Mobility Status

Clinical Characteristic on Study Day	All *n* = 1,769	PT/OT-Provided Mobility *n* = 625	No PT/OT-Provided Mobility *n* = 1,144	*p*[a]
Respiratory support, *n* (%)[b]				< 0.001
No support	312 (18)	127 (20)	185 (16)	
Nasal cannula or face mask	166 (9)	75 (12)	91 (8)	
High-flow nasal cannula or RAM cannula	209 (12)	71 (11)	138 (12)	
Tracheostomy collar	38 (2)	17 (3)	21 (2)	
Mechanical ventilation—noninvasive	167 (9)	62 (10)	105 (9)	
Mechanical ventilation—tracheostomy	260 (15)	109 (17)	151 (13)	
Mechanical ventilation—endotracheal	611 (35)	162 (26)	449 (39)	
F_{IO_2}, median (IQR)[b],[c]	35 (28–50)	30 (25–45)	35 (30–50)	0.02
Glasgow Coma Scale , median (IQR)[b]	12 (9–15)	14 (9–15)	11 (9–15)	0.001
≥ 1 sedative/analgesic infusion, *n* (%)	809 (46)	251 (40)	558 (49)	0.001
Delirium present, *n* (%)				0.11
No	453 (26)	172 (28)	281 (25)	
Yes	182 (10)	72 (12)	110 (10)	
Not available	1,133 (64)	380 (61)	753 (66)	
Any vasoactive infusion, *n* (%)[d]	371 (21)	109 (17)	262 (23)	0.007
Any physical restraint, *n* (%)	249 (14)	74 (12)	175 (15)	0.05
Any central venous catheter, *n* (%)	1,189 (67)	430 (69)	759 (66)	0.29
Arterial catheter, *n* (%)	483 (27)	146 (23)	337 (30)	0.006
Hemodialysis catheter, *n* (%)	84 (5)	39 (6)	45 (4)	0.03
Extracorporeal membrane oxygenation cannula, *n* (%)	39 (2)	13 (2)	26 (2)	0.79
Indwelling urinary catheter, *n* (%)	249 (14)	73 (12)	176 (15)	0.03
Surgical drain, *n* (%)	135 (8)	56 (9)	79 (7)	0.12
Chest tube, *n* (%)	194 (11)	65 (10)	129 (11)	0.57
Ventricular assist device, *n* (%)	16 (1)	7 (1)	9 (1)	0.48
Intracranial pressure monitor, *n* (%)	50 (3)	26 (4)	24 (2)	0.01
Presence of pressure ulcer(s)	125 (7)	41 (7)	84 (7)	0.54
Nurse-to-patient ratio, *n* (%)[b]				0.002
2:1 or 1:1	733 (42)	228 (37)	505 (45)	
1:2 or 1:3	1,023 (58)	392 (63)	631 (56)	
Family present at bedside	1,315 (74)	497 (80)	818 (72)	< 0.001

IQR = interquartile range, OT = occupational therapy, PT = physical therapy.
[a]Calculated using χ^2 test and Mann-Whitney *U* test, as appropriate.
[b]Missing data: respiratory support (*n* = 6), F_{IO_2} (*n* = 2), Glasgow Coma Scale (*n* = 3), nurse-to-patient ratio (*n* = 13).
[c]Among patient-days with all types of respiratory support above nasal cannula or face mask (*n* = 1,291).
[d]Excluding milrinone.

Highest Level of Mobility, Age<3

Highest Level of Mobility, Age≥3

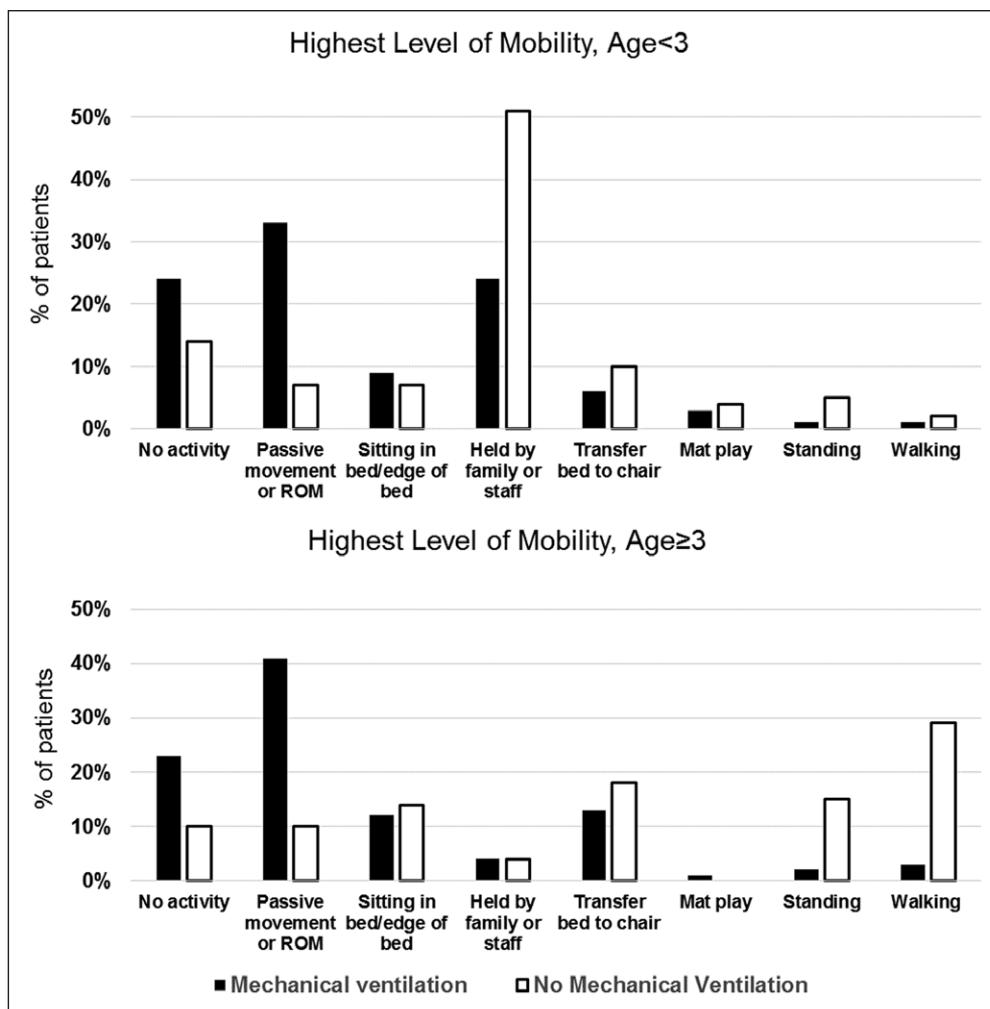■ Mechanical ventilation   □ No Mechanical Ventilation

Figure 1. Highest level of mobility by mechanical ventilation status, stratified by age. ROM = range of motion.

most commonly facilitated mobilization (n = 3,134, 67%), either alone or in combination with family or other PICU staff, whereas 12% of events were facilitated by family alone (n = 546) (**Fig. 2**).

Out-of-Bed Mobility

Out-of-bed mobility was achieved on 824 of 1,769 study days, a prevalence of 47% (95% CI, 44–49%), most commonly being
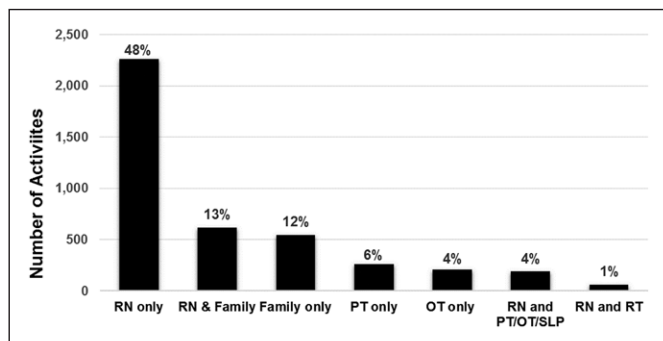
Figure 2. Number of activities by clinician type. OT = occupational therapist; PT = physical therapist, RN = registered nurse, RT = respiratory therapist, SLP = speech-language pathology.

held by a family member or nurse (n = 403, 23%). Out-of-bed mobility was achieved on 70% of patient-days by those not mechanically ventilated (n = 504), but only 30% of patient-days by mechanically ventilated children (n = 320). Three of 136 patients (2%) who were ambulatory before PICU admission achieved ambulation with an endotracheal tube.

Variables that had the strongest negative association with out-of-bed mobility included presence of an endotracheal tube (aOR, 0.13; 95% CI, 0.08–0.2), urinary catheter (aOR, 0.28; 95% CI, 0.14–0.57), and other medical devices (**Fig. 3**; and **Supplemental Digital Content 9**, http://links. lww.com/CCM/F371). Opioid infusion (0.42; 95% CI, 0.24–0.73) and severe baseline disability (PCPC 4 vs 1: aOR, 0.59; 95% CI, 0.4–0.87) were also negatively associated with out-of-bed mobility.

Out-of-bed mobility was positively associated with longer PICU LOS (1.99 per 10-fold higher PICU day after day 10; 95% CI, 1.3–3.0) and lower nurse-to-patient ratio, a marker of lower patient acuity (1.82; 95% CI, 1.2–2.8). Among children less than 3 years old, family presence had a strong positive association with out-of-bed mobility (aOR, 4.55; 95% CI, 3.1–6.6), whereas PT or OT involvement was strongly associated with children of 3 years old or older (aOR, 3.1; 95% CI, 2.01–4.79).

Barriers to Mobility and Potential Safety Events

At least one barrier to mobilization was reported during 892 patient-days (51%) and 232 patient-days (72%) with no mobilization (**Supplemental Digital Content 10**, http://links.lww.com/CCM/F371). Most common barriers were medical contraindications (n = 154, 9%), cardiovascular instability (n = 154, 9%), and oversedation (n = 148, 8%).

Staff reported a potential safety event in 195 (4%) of 4,700 mobility events, most commonly transient vital sign changes (n = 136, 3%). Chest tubes and arterial catheters were displaced in three of 194 (0.7%) and two of 982 (0.2%) mobility events, respectively. Three of these five events occurred with a nurse and family member, one with a family member alone, and another with a nurse alone. Dislodgment of endotracheal
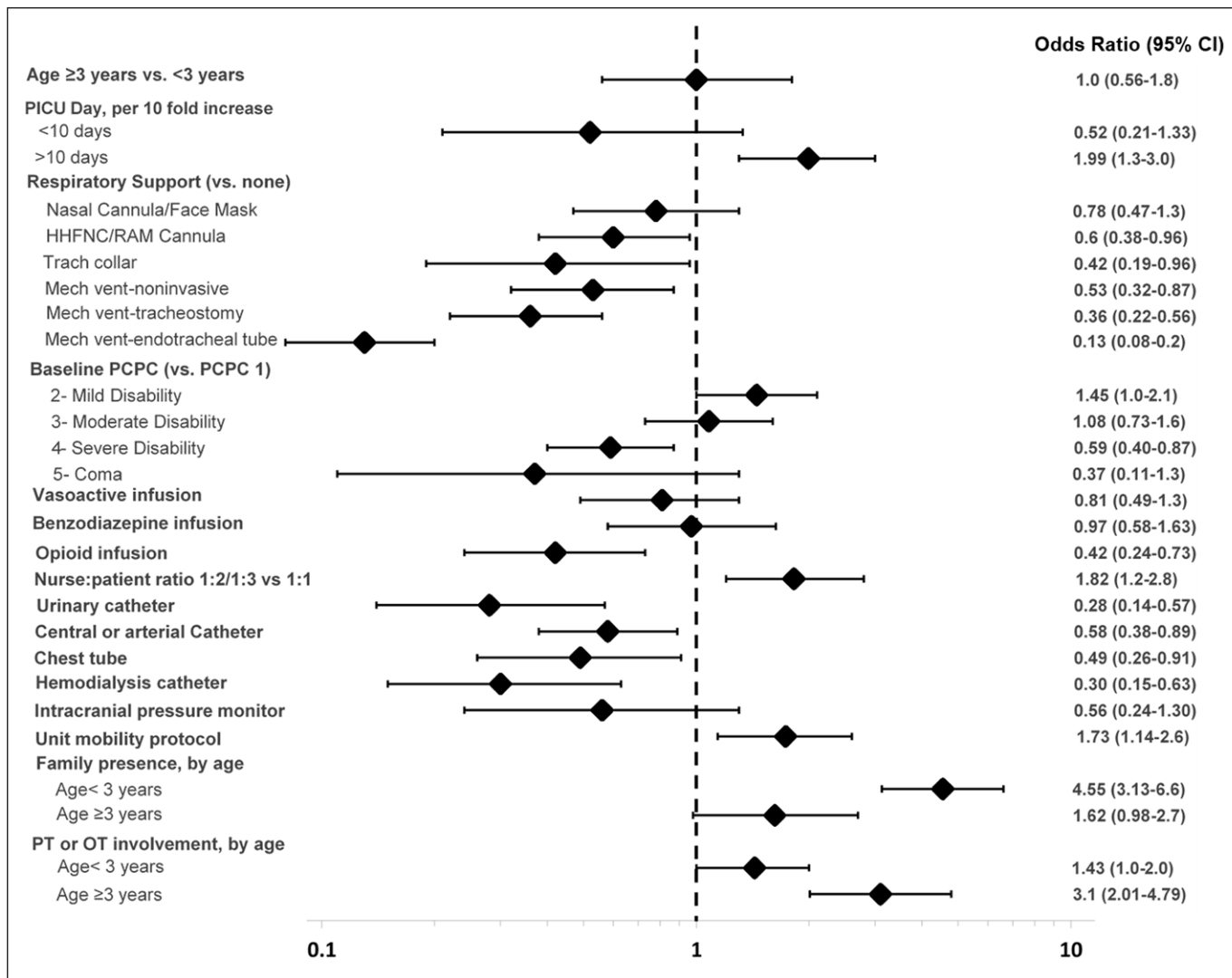
Figure 3. Adjusted odds ratios for out-of-bed mobility on study day. The multivariable model included random effect for site, adjusted for admission reason, gender, and ethnicity in addition to all characteristics listed. Vasoactive infusion excluded milrinone. The interaction term for family presence by age strata was *p* value equals to 0.005 in the univariate model and *p* value equals to 0.001 in the multivariable model. The interaction term for physical therapy (PT) or occupational therapy (OT) involvement by age strata was *p* value equals to 0.16 in the univariate model and *p* value equals to 0.005 in the multivariable model. HHFNC = heated high-flow nasal cannula, mech vent = mechanical ventilation, PCPC = Pediatric Cerebral Performance Category.

tube was reported in two of 1,299 mobilization events (0.15%) during passive range of motion and proning with a nurse. One tracheostomy (0.1% of 888 events) was dislodged during an attempt to stand with an OT.

DISCUSSION

In this point prevalence study representing one third of all PICU beds in the United States (13), the youngest children and patients with higher baseline function less often received PT- or OT-provided mobility. Despite evidence supporting the safety and feasibility of early mobility in critically ill children (22), early rehabilitation consultation was infrequent, and one fifth of patients were completely immobile. The family presence was strongly associated with out-of-bed mobility for children less than 3 years old. The rate of potential safety events was low across the large number of mobility events, especially when compared with the harms of bed rest in critically ill children. These findings provide important insights to inform systematic design of rehabilitation interventions in the PICU to optimize outcomes for critically ill children.

Our finding that 62% of all PICU patients with a stay greater than or equal to 72 hours are less than 3 years old and less likely to receive therapist-provided mobility highlights an important issue given the rapid neurocognitive and physical development of these youngest patients. PTs and OTs provide key interventions to advance infants' and toddlers' gross and fine motor skills, sensory processing, and cognition during critical illness (31, 32). It is reassuring that family engagement increased mobility for children less than 3 years old. However, it is ideal for families to partner with rehabilitation specialists and help facilitate prescribed interventions (i.e., passive range of motion, sensory stimulation). Interestingly, family presence was associated with increased therapist-provided mobility. Families of

chronically critically ill children and those with previous PICU admission experiences may advocate more often for rehabilitation consultation (33, 34).

Similar to previous retrospective and quality improvement studies in the PICU (34, 35), early rehabilitation consultation and therapist-provided mobility were less frequent in patients with higher baseline function. Rehabilitation consultation may be delayed because of the perception that these patients are at lower risk for functional impairment. However, PICU studies demonstrate that these children are, in fact, at high risk for functional deterioration and slow functional recovery (9). It is unclear why female sex was negatively associated with therapist-provided mobility. This finding requires further investigation given that girls have similar rates of morbidity to boys (9, 15).

The presence of a unit mobility protocol was associated with both therapist-provided mobility and out-of-bed mobility in our study. Standardized, unit-based protocols can increase mobility and improve clinical outcomes for all patients regardless of age, diagnosis, or functional baseline, decreasing potential for implicit bias in clinician decision-making (36–40). However, we found that a minority of PICUs have dedicated PT or OT staff. Although many PICU patients may benefit from early consultation and collaborative treatment by both PT and OT, it is critical for interdisciplinary teams to determine the best timing, frequency, and approach to rehabilitation team involvement, given finite rehabilitation resources. Pediatric PTs focus on increasing physical function and rehabilitation of the musculoskeletal system (41, 42), whereas OTs have a central role in enabling infants and children to progress toward, or return to, key daily activities including play, feeding, and eating (43). Therefore, educating PICU staff about these unique and complementary skillsets and indications for PT and OT consultation can optimize resource utilization and clinical care in the context of each hospital's rehabilitation team staffing model.

Our results share several key similarities and differences with adult point prevalence data. The low prevalence of out-of-bed mobility in mechanically ventilated patients (30%) was similar to that in adult studies (0–33%) (18–21), but a higher proportion of PICU patients (16%) achieved out-of-bed mobility with an endotracheal tube (0–10% in adults) (18–21). This difference is likely because 67% of intubated PICU patients were less than 3 years old and more likely to be held out-of-bed. Among intubated children 3 years old or older, only 9% were mobilized out-of-bed. Our study also highlights the central role of PICU nurses in mobilization, nearly identical to the U.S. ARDS Network mobilization point prevalence study where nurses facilitated most mobility events (67% vs 65%) (18). As a constant presence at the bedside, nurses are integral members of the interdisciplinary mobility team (44–47).

Invasive devices are barriers to early rehabilitation across all ICU populations (48, 49). Our findings of decreased out-of-bed mobility with most types of respiratory support and invasive medical devices are consistent with adult studies. A unique finding, however, was indwelling urinary catheters as a PICU risk factor for decreased out-of-bed mobility. Daily review for potential medical device removal can both reduce infection risk and avoid tethering patients to bed. If these devices are required, out-of-bed mobility can be safe, especially if there is multiprofessional education regarding device securement and premobility planning (50).

As such, we found a low frequency (4%) of potential safety events associated with mobilization, similar to that in adult literature (2.6%) (51). Most PICU safety events (81%) were transient vital sign changes without clinical consequence. Only 0.3% of all mobility events were associated with dislodgement of a device, similar to the 0.6% rate in adults (51). Therefore, our data, in parallel with evidence from single-center PICU studies (22, 36, 38), suggest that mobilization of PICU patients is safe. However, education on methods for safe mobilization is critical for the interdisciplinary team.

Finally, we identified perceived barriers to mobility including medical status, lack of physician order, isolation precautions, and oversedation. Opioid infusion, the first-line approach to analgosedation for PICU patients (52), was negatively associated with out-of-bed mobility, which may also be a reflection of acute pain that can impact mobility. Goal-directed and minimal sedation using multicomponent approaches facilitates participation in ICU rehabilitation for all patients and improves outcomes (37, 53–56). Similar PICU bundles have increased mobility and rehabilitation team involvement, and multicenter trials are underway to evaluate the impact on outcomes (22, 36, 38, 39, 57–59).

There are several strengths and limitations to our study. First, although we included a large proportion of U.S. PICUs which provide robust prevalence data, the point prevalence design cannot establish a causal relationship among the data. Second, knowledge of the study by clinical staff may have increased mobility events. However, this knowledge would not affect data on early rehabilitation consultation. Additionally, any bias would result in our overestimating mobility, which would further reinforce the message of low levels of rehabilitation and mobilization. Third, prospective data collection is limited by the quality of bedside documentation. Study teams worked closely with clinical staff during both day and night shifts to optimize data collection. Fourth, we included only weekdays, which may not reflect weekend rehabilitation characteristics. Fifth, both point prevalence days were during winter months, with potential limited generalizability to other times of the year. Sixth, citing nurse-to-patient ratio as a measure of patient acuity has limitations; however, in some PICUs, validated illness severity and nursing workload tools are used when deciding on nursing ratios (60, 61). Seventh, our study focused solely on mobility-based interventions and did not capture nonmobility interventions that are important for PICU rehabilitation (i.e., activities of daily living, cognition, speech, swallow) that may primarily be performed by OT or speech-language pathology. In addition, combining PT and OT-provided mobility as the primary outcome may not recognize their unique contributions. Finally, the study results may not be generalizable to all U.S. PICUs or internationally,

particularly in smaller units and low-resource settings. Yet, it is important to note that all 82 ICUs participated in this study without any financial support, reflecting the high level of interest in understanding physical rehabilitation and mobility in critically ill children in the United States.

CONCLUSIONS

In U.S. PICUs, younger children, females, and patients with higher baseline function less often receive physical rehabilitation, and the presence of invasive devices is associated with decreased out-of-bed mobility. Early consultation and treatment by rehabilitation clinicians are infrequent despite a low rate of potential safety events. As a growing number of children survive critical illness with long-lasting physical impairments, there is a need to systematically design and evaluate PICU rehabilitation interventions for a vulnerable patient population.

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APPENDIX 1. PREVALENCE OF ACUTE REHABILITATION FOR KIDS IN THE PICU (PARK-PICU) INVESTIGATORS

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