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Frequency, Risk Factors, and Outcomes of Early Unplanned Readmissions to PICUs

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Abstract

Objectives—To determine the rate of unplanned PICU readmissions, examine the characteristics of index admissions associated with readmission, and compare outcomes of readmissions versus index admissions.

Design—Retrospective cohort analysis.

Setting—Ninety North American PICUs that participated in the Virtual Pediatric Intensive Care Unit Systems.

Patients—One hundred five thousand four hundred thirty-seven admissions between July 2009 and March 2011.

Interventions—None.

Measurements and Main Results—Unplanned PICU readmission within 48 hours of index discharge was the primary outcome. Summary statistics, bivariate analyses, and mixed-effects logistic regression model with random effects for each hospital were performed. There were 1,161 readmissions (1.2%). The readmission rate varied among PICUs (0–3.3%), and acute respiratory (56%), infectious (35%), neurological (28%), and cardiovascular (20%) diagnoses were often

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present on readmission. Readmission risk increased in patients with two or more complex chronic conditions (adjusted odds ratio, 1.72; $p < 0.001$), unscheduled index admission (adjusted odds ratio, 1.37; $p < 0.001$), and transfer to an intermediate unit (adjusted odds ratio, 1.29; $p = 0.004$, compared with ward). Trauma patients had a decreased risk of readmission (adjusted odds ratio, 0.67; $p = 0.003$). Gender, race, insurance, age more than 6 months, perioperative status, and nighttime transfer were not associated with readmission. Compared with index admissions, readmissions had longer median PICU length of stay (3.1 vs 1.7 d, $p < 0.001$) and higher mortality (4% vs 2.5%, $p = 0.002$).

Conclusions—Unplanned PICU readmissions were relatively uncommon, but were associated with worse outcomes. Several patient and admission characteristics were associated with readmission. These data help identify high-risk patient groups and inform risk-adjustment for standardized readmission rates.

Keywords

child; hospital readmission; intensive care units; pediatric

Unplanned readmissions have increasingly become a focus of healthcare quality measurement, given that they may be preventable and may reflect threats to patient safety or hospital efficiency (1–3). Similarly, readmissions to ICUs during the same hospitalization have been suggested as an indicator of quality of critical care (4–7). However, determining the appropriate timing for ICU discharge can be a challenge for patients at risk for complications of their resolving critical illness and/or new sequelae of their chronic conditions.

Among adults, multi-institutional studies have found ICU readmission rates of 2–6% (8, 9), depending on the timeframe considered, and that readmissions are associated with greater risk of in-hospital mortality (10, 11). In pediatrics, however, there have only been a few single-institutional studies (12–16). Thus, little generalizable information about the frequency, risk factors, or outcomes of unplanned readmissions is available.

We sought to estimate the rate of early unplanned readmissions to PICUs, using a multi-institutional cohort, and to examine the factors associated with readmission. We also sought to determine whether index admissions and readmissions have different outcomes.

MATERIALS AND METHODS

We performed a retrospective cohort study of consecutive patients admitted between July 2009 and March 2011 to 90 North American PICUs that participated in the Virtual Pediatric Intensive Care Unit Performance Systems (VPS) (VPS, LLC, Los Angeles, CA) (17). No endorsement or editorial restriction of the interpretation of these data or opinions of the authors have been implied or stated. Because all data were deidentified, this study qualified for exemption from review by the Columbia University Institutional Review Board.

Primary Outcome

Our primary outcome was unplanned PICU readmission within 48 hours of discharge from the PICU, during the same and different hospitalizations. This timeframe has been suggested by the Society of Critical Care Medicine (4). However, no consensus exists in the literature about what constitutes "early" ICU readmission; both 48 (9, 14, 16, 18) and 72 (15, 19–21) hours have been used. VPS unique patient identifiers permitted detection of readmission to the same PICU.

Admission Characteristics

We described characteristics of admissions, reporting them as proportions and 95% CIs, means and sds, or medians and interquartile ranges (IQRs). Clinical characteristics included gender, age, race, insurance, presence of complex chronic conditions (CCCs), and baseline and discharge Pediatric Overall Performance Category (POPC) and Pediatric Cerebral Performance Category (PCPC) (22). Because age had a nonlinear relationship with readmission, it was divided into ordinal categories of 2–6 months. A logistic regression was fitted with just this ordinal age variable to determine where the direction and magnitude of associations clustered together. These categories were then collapsed according to this clustering to create a less arduous ordinal age variable (0–2 mo, 2–6 mo, 6–12 mo, 1–18 yr, > 18 yr). CCCs were defined using Feudtner's definition (23) and identified among diagnoses using a list of VPS codes developed elsewhere (24). An ordinal variable for CCC was created (no CCC, 1 CCC, ≥ 2 CCC). POPC and PCPC scores range from 1 (normal function) to 6 (brain death). Scores of 2, 3, and 4 indicate mild, moderate, and severe disability, respectively. A score of 5 indicates coma or vegetative state. Race, insurance, POPC, and PCPC were optional data elements and were not available for all admissions.

Admission characteristics included planned (yes/no), perioperative (yes/no), trauma (yes/no), patient origin and disposition, total duration of positive pressure ventilation (PPV), discharge season and time, risk of mortality score, and PICU length of stay (LOS). PPV was an ordinal variable, grouped by the cohort's mean total time on PPV (no time on PPV, < 1.5 d, ≥ 1.5 d). PPV included conventional mechanical ventilation, high-frequency ventilation, and bi-level positive airway pressure via tracheal, mask, or nasal interface. Discharge season was included to control for seasonal illness variation (25–27) and was categorized as September–November, December–February, March–May, and June–August. Two binary discharge time variables were included to explore the relevance of evening (14, 28, 29) and weekend transfers (30). As a proxy for severity of illness at admission, a predicted probability of mortality was estimated using Paediatric Index of Mortality (PIM) 2 (31). Institutional variables included number of licensed PICU beds (≤ 17, 18–24, ≥ 25 beds), presence of a separate intermediate unit, and presence of a pediatric critical care fellowship program.

Statistical Analysis

To examine the characteristics that were associated with increased risk for readmission, index admissions were sorted by whether or not they resulted in a readmission. Bivariate comparisons of admission characteristics were performed using Pearson's chi-square test, two-tailed *t* test, or Kruskal-Wallis rank test. Each initial PICU admission during a new

hospitalization was treated as a new index admission. Index admissions were excluded if they resulted in death, as there was no possibility of readmission. Subsequent readmissions after the first and during the same hospitalization were excluded. Admissions missing diagnoses were excluded, because we considered chronic conditions particularly relevant to readmission risk.

To estimate the adjusted association between characteristics and unplanned readmission, mixed-effects logistic regression models were fitted. The models included random effects for each hospital to account for correlation of subjects within hospitals. Predictors for the final regression models were included if their *p* value was less than 0.2 in multivariate analysis. Because of nonlinearity, PIM2 and LOS were transformed into cubic splines. Because PIM2 is derived from categorical and physiologic data at admission to the PICU and is likely attenuated by LOS, an interaction term between PIM2 and LOS was included. C-statistics and Hosmer-Lemeshow goodness-of-fit tests were used to assess discrimination and calibration, respectively.

Three subanalyses were performed. In order to focus on functionality as a predictor, a regression model was fitted on index admissions that supplied discharge POPC and PCPC. Bivariate comparisons of index admissions that did and did not supply functionality scores were performed to examine differences between these subgroups. Also, we refitted the CCC model using 24 and 72 hours as the outcomes, because these times are endorsed by the National Quality Forum (6) and have been used in other studies (15, 18, 19, 21), respectively. To explore the reasons for readmissions, acute and chronic diagnoses that were present at admission were compared using chi-square tests. To compare the outcomes of all index admissions and readmissions, we performed bivariate analyses of admission outcomes (discharge functionality scores, disposition, LOS, duration of PPV, and PICU mortality). For this analysis only, the index admission group included those that resulted in death. We also performed a matched comparison of the readmissions and those index admissions that preceded them, using McNemar's chi-square test, paired *t* test, or Wilcoxon signed rank tests.

Statistical significance was determined using a *p* value of less than 0.05 and 95% CI. Stata 12 (StataCorp, College Station, TX) was used for statistical analyses.

RESULTS

There were 96,189 admissions from 87 PICUs included in this study (Supplemental Fig. 1, Supplemental Digital Content 1, http://links.lww.com/CCM/A714); of these, 1,161 (1.2%) were early unplanned readmissions. The prevalence rate was 12.3 readmissions per 1,000 PICU discharges (95% CI, 11.6–13). The prevalence of readmission varied among PICUs, ranging 0–3.3% (median, 1%; IQR, 0.6–1.5%). The patient, clinical, and institutional characteristics of the index admissions with and without readmissions are presented in Table 1. Index admissions that preceded a readmission involved younger patients (median age, 38 vs 56 mo; $p < 0.001$) and those with CCC (50% vs 42%, $p < 0.001$), compared with index admissions that did not precede a readmission. Patients who were readmitted were more

commonly discharged to a general ward (78% vs 65%, $p < 0.001$) or intermediate unit (19% vs 11%, $p < 0.001$).

The mixed-effects CCC model fitted on the entire cohort (Table 2) had reasonable discrimination and calibration—C-statistic 0.72 (95% CI, 0.71–0.74), Hosmer-Lemeshow *p* value 0.2. Significant predictors included age 2–6 months (compared with age 0–2 mo), having one or more CCC, and having an unscheduled index admission. Similarly, patients discharged to an intermediate unit were more likely to return, compared with those sent to general wards. In contrast, being admitted for trauma and being cared for in a moderate-sized PICU (18–24 beds) were associated with decreased odds of readmission. Patients discharged to chronic care or rehabilitation facilities and home also had significantly lower odds of returning than those discharged to general wards. Weekend discharge was negatively associated with readmission. Age more than 6 months was not associated with readmission. Gender, race, insurance, perioperative status, patient origin, nighttime transfer, and presence of a separate intermediate unit were left out of the final model ($p > 0.2$).

In the subgroup analysis of 31,434 admissions (33%) with discharge POPC and PCPC (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/CCM/A714; Table 2), progressively worse overall disability was associated with increasing odds of readmission, with the exception of coma/vegetative states (POPC 5). All levels of cerebral disability were not associated with readmission, after adjusting for overall disability scores and other covariates. Age 2–6 months and trauma were not significant predictors. Having an unscheduled index admission and being discharged to an intermediate care unit remained predictors. Being in a PICU with a fellowship became a negative predictor. This model also discriminated and calibrated well—C-statistic 0.77 (95% CI, 0.74–0.79); Hosmer-Lemeshow *p* value 0.53.

The 24- and 72-hour models (Supplemental Table 2, Supplemental Digital Content 1, http://links.lww.com/CCM/A714) were similar to the 48-hour model with a few exceptions. In the 24-hour model, having one CCC, trauma, and discharge to a chronic facility were not associated with readmissions. Weekend discharge was not associated with 24- or 72-hour readmission. Being on PPV for less than 1.5 days was negatively associated with 48- and 72-hour readmission, but being on PPV for greater than or equal to 1.5 days was positively associated with 24-hour readmission.

The PICU outcomes of unplanned readmissions and the matched and unmatched index admissions are presented in Table 3. Readmissions had longer median LOS (3.1 d) compared with both all index admissions (1.7 d) and their preceding admission (2 d) ($p < 0.001$). Readmissions had lower mean PIM2 risk of mortality compared with their matched preceding index admissions (2.2% vs 2.7%, $p = 0.04$). However, readmissions had a higher mortality rate (4%) compared with index admissions (2.5%, $p = 0.002$).

Acute diagnoses that were present at admission are presented in Table 4. Respiratory and neurological diagnoses were 10% and 7%, respectively, more common in readmissions compared with matched index admissions ($p < 0.001$). Adverse events or complications were present in 6% of both index admissions and readmissions. Chronic diagnoses of our

cohort sorted by readmission status are found in Supplemental Table 3 (Supplemental Digital Content 1, http://links.lww.com/CCM/A714). Several chronic diagnoses were found in greater proportions of readmitted patients, although diabetes and asthma were found less frequently in readmitted patients.

DISCUSSION

To our knowledge, this is the first study to estimate the frequency of early unplanned readmissions to PICUs, explore the factors associated with higher odds of readmission, and compare outcomes using a multi-institutional cohort. We demonstrated that readmissions were relatively uncommon but had significantly longer PICU LOS and higher mortality compared with index admissions. Furthermore, we identified several characteristics that were independently associated with readmission.

Earlier studies of PICU readmission reported data from single institutions. Two such studies reported that 7–8% of patients had planned or unplanned readmissions within any timeframe during the hospitalization (12, 13). Bernard and Czaja (16) found that 1.8% of their patients had unplanned readmissions within 48 hours; Bastero-Miñón et al (15) found that 2.4% of pediatric cardiac ICU patients had unplanned readmissions within 72 hours.

Our regression analyses went beyond those earlier studies by adding institutional covariates, incorporating more clinical variables (e.g., CCC, functionality scores, disposition location, and PICU characteristics), using splines to better model risk of mortality scores and LOS, and including interactions. Several of these variables were found to be significant predictors of readmission. Patients with greater than or equal to two CCC were especially likely to return. Those discharged to intermediate units were also at increased risk; intermediate units likely cared for patients whose critical illness had not fully resolved and were at risk for deterioration. In contrast, patients discharged directly home were very unlikely to return in 48 hours. Although we could not assess if these patients required care again at an emergency department or were readmitted to a general ward or to another PICU, this may suggest that ICU teams were good at determining when patients' clinical condition did not warrant further inpatient care. Waiting for this level of clinical stability may have resulted in longer PICU LOS for these patients. Patients who were on PPV for shorter periods were less likely to be readmitted than those who did not receive PPV, and being on PPV for longer periods was not associated with readmission. This is possibly because patients previously on PPV were observed for longer periods after weaning and before discharge. In all models, patients cared for in PICUs with 18–24 beds were significantly less likely to be readmitted compared with smaller units. However, being in a larger PICU (≥25 beds) did not confer any decreased risk. Having a fellowship program was a positive predictor of readmission in all models incorporating CCC.

In our model incorporating functionality at PICU discharge, increasing overall disability was associated with increasing odds of readmission, with the exception of coma or vegetative state. This may reflect the impact of disabilities on patients' need for highly specialized care and vulnerability even after discharge, which has been noted in studies of readmissions to children's hospitals (32–34). Patients with CCC or substantial disability are likely at risk for

new complications of their underlying states and take longer to fully recover from critical illness. After adjusting for functionality, there were notable changes in magnitude and direction of association of some of our predictors compared with the CCC model. For instance, having a fellowship program was a negative predictor. These variations in the associations are possibly related to POPC and PCPC being a more granular assessment of chronic condition status, PICU management idiosyncrasies, and/or case-mix differences that are not fully explained in the model but manifest when analyzing the POPC/PCPC subgroup (Supplemental Table 3, Supplemental Digital Content 1, http://links.lww.com/CCM/A714). Differences in some predictors' direction of association with 24-, 48-, and 72-hour readmission may reflect variation in the types of patients who are readmitted in those timeframes and/or variation in discharge criteria for different patients.

Examining acute diagnoses present on readmission, respiratory, infectious, and neurological conditions were especially common (all > 25%), suggesting that these conditions were the reasons for most readmissions. VPS coders may designate a diagnosis as the primary diagnosis for admission. However, we chose not to focus on this designation because some patients had more than one primary diagnosis, and we believe it is often difficult to discern a single reason for ICU admission (e.g., should one code the respiratory distress or the pneumonia as primary?). This is especially true in PICU patients who commonly have multiple, interrelated reasons for admission. Interestingly, no acute adverse event or complication was listed as the primary diagnosis present on readmission, and the proportion of index and readmissions with these diagnoses was similar. Unless these diagnoses were undercoded, this may suggest that adverse events were not large drivers of readmission. Likely some readmissions could be anticipated, but prospective research on the reasons for unplanned readmissions is needed to assess their preventability. Higher mortality rates and longer LOS among unplanned PICU readmissions also give impetus to better understand why they occur.

This study has several limitations. First, because it is retrospective and VPS lacks non-PICU data, we were unable to evaluate the extent to which readmissions were preventable. Second, some potential confounders could not be analyzed (e.g., discharge severity of illness and unit census at the time of discharge). Additionally, we were unable to study differences among PICUs in their tendencies to transfer or reaccept patients and how these differences impact readmissions. This confounding is somewhat mitigated using a mixed-effects model that incorporates within-unit correlations. Third, adverse event diagnoses could have been coded for care other than that immediately preceding readmission. So besides describing how common adverse events are, we do not know how they contributed to readmissions. Fourth, patients may have been readmitted to a different PICU or have unexpectedly died outside the PICU (though this number would presumably be small). Lastly, while our models' accuracy was not exceptional, the C-statistics were higher than those reported for most adult multi-institutional ICU readmission studies (9, 17, 21).

CONCLUSIONS

The decision of when to discharge patients from the PICU can be a challenging balance of benefits (e.g., longer ICU observation) and burdens (e.g., unnecessary costs and greater risk

of ICU-related infections) for patients who may still have complex needs. Intensivists at each PICU are charged with striking the proper balance for their patients, but pressure to avoid unplanned readmissions is rising. Knowing the frequency of early unplanned readmissions permits physicians to better understand how their unit compares to a larger group of PICUs. Furthermore, identifying high-risk patient groups (e.g., those with CCC or functional limitations at discharge) and admission characteristics (e.g., unscheduled admission and intermediate unit disposition) can guide risk-adjustment and future predictive scoring systems of PICU readmission (21, 35, 36). Finally, this knowledge could direct interventions to decrease unplanned readmissions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of PICU patients and their index admissions by readmission status

Characteristic, % (95% CI)	Not readmitted n=93,867 (98.8%)	Readmitted <48 hrs n=1,161 (1.2%)
Male sex	55.8 (55.5–56.2)	56 (53.1–58.8)
Age		
0–2 months†	8.3 (8.1–8.5)	10.2 (8.5–11.9)
2–6 months*	8.7 (8.5–8.8)	14.7 (12.7–16.8)
6–12 months	7.6 (7.4–7.8)	8.7 (7.1–10.4)
1–18 years*	71.1 (70.8–71.4)	60.8 (58–63.6)
>18 years	4.3 (4.2–4.5)	5.5 (4.2–6.8)
Race[a]		
Caucasian	52.1 (51.8–52.5)	53.7 (50.6–56.9)
African American	18.3 (18–18.6)	18.6 (16.1–21)
Hispanic	18.1 (17.8–18.4)	17.4 (15–19.7)
Asian/Indian/Pacific Islander	2.6 (2.5–2.7)	2.5 (1.5–3.4)
American Indian	0.7 (0.7–0.8)	0.8 (0.3–1.4)
Other/mixed/unspecified	8.1 (7.8–8.3)	7.1 (4.8–9.4)
Insurance[b]		
Medicaid/Medicare	49.7 (49.2–50.2)	53.5 (49.2–57.8)
Commercial	23.1 (22.7–23.5)	22.8 (19.1–26.4)
Managed Care	17.6 (17.2–18)	15.4 (12.2–18.5)
Government	3.7 (3.6–3.9)	2.9 (1.5–4.4)
Self-Pay/other	5.8 (5.5–6.1)	5.4 (2.6–8.2)
Complex chronic condition*		
No CCC*	58 (57.7–58.4)	50 (47.1–52.8)
1 CCC	24.5 (24.2–24.7)	25.5 (23–28)
≥2 CCC*	17.5 (17.3–17.7)	24.5 (22–27)
Baseline POPC Score[c]		
No disability*	48.6 (48–49.1)	37.1 (32–42.2)
Mild disability	24.5 (24–24.9)	27 (22.3–31.7)
Moderate disability	17.9 (17.5–18.4)	23 (18.5–27.4)
Severe disability	8.8 (8.5–9.1)	12.6 (9.1–16.2)
Coma/vegetative state	0.2 (0.1– 0.2)	0.3 (0–0.9)
Baseline PCPC Score[c]		
No disability†	73.1 (72.6–73.6)	66.7 (61.9–71.6)
Mild disability	11.5 (11.1–11.8)	14.9 (11.2–18.7)
Moderate disability	8.6 (8.2–8.9)	8.6 (5.7–11.6)
Severe disability	6.7 (6.4–6.9)	9.5 (6.4–12.6)
Coma/vegetative state	0.2 (0.1–0.2)	0.3 (0–0.9)

Characteristic, % (95% CI)	Not readmitted n=93,867 (98.8%)	Readmitted <48 hrs n=1,161 (1.2%)
Unplanned*	72.1 (71.8–72.4)	78 (75.6–80.3)
Pre-/post-operative	33.5 (33.2–33.8)	30.9 (28.3–33.6)
Origin		
Emergency Department†	48.7 (48.4–49)	43.8 (40.9–46.6)
General ward*	11.5 (11.3–11.7)	19 (16.8–21.3)
Another ICU†	3.3 (3.2–3.5)	4.9 (3.7–6.2)
Intermediate unit	1.4 (1.3–1.5)	2 (1.2–2.8)
OR/PACU/Procedure suite†	31.1 (30.8–31.4)	27.3 (24.8–30)
Chronic/Rehabilitation facility	0.2 (0.2–0.3)	0.3 (0–0.6)
Outpatient/Home	3.3 (3.2–3.4)	2.3 (1.5–3.2)
Other	0.5 (0.4–0.5)	0.2 (0–0.6)
Trauma*	8.1 (8–8.3)	5.3 (4–6.6)
Duration of PPV, days, mean (SD)†	1.5 (6.9)	2 (5.4)
Disposition		
General ward*	64.9 (64.6–65.2)	77.9 (75.4–80.3)
Another ICU†	2.3 (2.3–2.4)	1.5 (0.8–2.2)
Intermediate unit*	11.1 (10.9–11.3)	19.4 (17.1–21.7)
OR	0.5 (0.4–0.5)	0.5 (0.1–0.9)
Chronic/Rehabilitation facility	0.9 (0.9–1)	0.5 (0.1–0.9)
Home*	19.4 (19.1–19.6)	0.1 (0–0.3)
Other†	1 (0.9–1)	0.2 (0–0.4)
Discharge season		
September – November	30.7 (30.3–30.9)	28.9 (26.3–31.6)
December – February	26 (25.8–26.3)	27.7 (25.2–30.3)
March – May†	17.9 (17.6–18.1)	20.2 (17.8–22.5)
June – August	25.5 (25.2–25.8)	23.2 (20.7–25.6)
Discharged between 5 PM & 8 AM†	29.5 (29.2–29.8)	33.6 (30.9–36.3)
Weekend discharge†	24.7 (24.5–25)	22.2 (19.8–24.5)
Admitted to PICU with		
ICU beds		
≤17	47.9 (47.6–48.2)	46.3 (43.4–49,2)
18-24*	18.3 (18.1–18.5)	12.5 (10.6–14.4)
≥25*	33.8 (33.5–34.1)	41.2 (38.3–44)
Separate intermediate care unit†	40.1 (39.7–40.4)	44.8 (41.9–47.7)
Affiliated fellowship program*	58.6 (58.3–59)	69.6 (66.9–72.2)
PIM2 risk of mortality, %, mean (SD)*	1.8 (5.3)	2.7 (6.8)
LOS, days, median (IQR)*	1.6 (0.9–3.6)	2 (1–5.1)

CCC, complex chronic condition; CI, confidence interval; PACU, post-anesthesia care unit; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; OR, operating room; PIM, Paediatric Index of Mortality; PCPC, Pediatric Cerebral Performance Categories; PICU, pediatric intensive care unit; POPC, Pediatric Overall Performance Categories; PPV, positive pressure ventilation; SD, standard deviation

† $P < 0.05$;

* $P < 0.001$ by chi^2 test, unpaired two-tailed t-test, or Kruskal-Wallis rank test

[a] Based on 77,954 (80%) admissions from 68 sites that supplied race

[b] Based on 42,825 (44%) admissions from 28 sites that supplied insurance

[c] Based on 31,434 (33%) admissions from 27 sites that supplied Pediatric Overall and Cerebral Performance Categories

Table 2

Adjusted odds ratios for predictor variables in models of early unplanned PICU readmission[a]

	CCC model		Functionality model[b]	
Patient or index admission variable	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
Age				
0–2 months (reference)				
2–6 months	1.47 (1.16–1.87)	0.002	1.27 (0.82–1.96)	0.29
6–12 months	1.02 (0.78–1.34)	0.86	0.81 (0.49–1.34)	0.41
2–6 months	0.83 (0.68–1.02)	0.08	0.69 (0.47–1.01)	0.06
>18 years	1.06 (0.77–1.45)	0.73	0.75 (0.4–1.39)	0.36
Complex chronic condition				
No CCC (reference)				
1 CCC	1.22 (1.05–1.41)	0.009	–	
≥2 CCC	1.72 (1.46–2.01)	<0.001	–	
Discharge POPC Score				
No disability (reference)				
Mild disability	–		1.98 (1.45–2.7)	<0.001
Moderate disability	–		2.44 (1.65–3.63)	<0.001
Severe disability	–		3.24 (1.61–6.5)	0.001
Coma/vegetative state	–		2.05 (0.26–16.3)	0.59
Discharge PCPC Score[c]				
No disability (reference)				
Mild disability	–		1.12 (0.81–1.55)	0.49
Moderate disability	–		0.8 (0.52–1.25)	0.34
Severe disability	–		0.76 (0.37–1.59)	0.47
Unplanned index admission	1.37 (1.17–1.61)	<0.001	1.75 (1.3–2.37)	<0.001
Trauma	0.67 (0.51–0.87)	0.003	0.79 (0.5–1.24)	0.31
Duration of PPV, days				
Not on PPV (reference)				
<1.5	0.77 (0.63–0.95)	0.016	1.0 (0.69–1.44)	0.99
≥1.5	1.12 (0.9–1.4)	0.29	0.94 (0.63–1.42)	0.78
Disposition				
General ward (reference)				
Another ICU	0.37 (0.22–0.6)	<0.001	0.56 (0.27–1.16)	0.11
Intermediate unit	1.29 (1.08–1.53)	0.004	1.59 (1.09–2.32)	0.017
Operating room	0.66 (0.29–1.5)	0.32	0.56 (0.14–2.31)	0.43
Chronic/Rehabilitation facility	0.37 (0.16–0.85)	0.018	(0–∞)	0.99
Home	0.004 (0.001–0.03)	<0.001	0.01 (0.002–0.08)	<0.001
Other	0.16 (0.41–0.66)	0.011	(0–∞)	0.99
Discharge season				
September – November (reference)				

	CCC model		Functionality model[b]	
Patient or index admission variable	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
December – February	1.09 (0.93–1.27)	0.29	0.86 (0.65–1.15)	0.32
March – May	1.19 (1.00–1.41)	0.044	1.18 (0.87–1.58)	0.29
June – August	0.99 (0.84–1.16)	0.87	0.83 (0.62–1.11)	0.21
Weekend discharge	0.84 (0.73–0.97)	0.018	0.74 (0.57–0.97)	0.029
Admitted to PICU with				
ICU beds				
≤17 (reference)				
18–24	0.64 (0.5–0.82)	<0.001	0.48 (0.31–0.74)	0.001
≥25	1.02 (0.83–1.27)	0.83	1.3 (0.93–1.82)	0.13
Affiliated fellowship program	1.25 (1.03–1.53)	0.027	0.65 (0.44–0.95)	0.026

CCC, complex chronic condition; CI, confidence interval; PACU, post-anesthesia care unit; ICU, intensive care unit; IQR, interquartile range; OR, odds ratio; PICU, pediatric intensive care unit; PPV, positive pressure ventilation

[a] Models also adjusted for length of stay and PIM2 score as cubic splines and for an interaction between them

[b] Based on 31,434 (33%) index admissions from 27 sites that supplied POPC and PCPC

[c] PCPC level 5 (coma/vegetative state) was perfectly collinear with POPC level 5 (also coma/vegetative state), which is a testament to the accuracy of the submitted data. Because of this collinearity, one or the other had to be eliminated; we chose PCPC level 5 to omit.

Table 3

Comparison of outcomes of index admissions and early unplanned readmissions

Characteristic, % (95% CI)	All index admissions n=97,527[a]	Index admissions that preceded unplanned readmission n=1,161	Unplanned readmissions n=1,161
Discharge POPC Score[b]			
No disability‡*	39.9 (39.4–40.5)	23.6 (19.1–28.1)	19.8 (15.6–24)
Mild disability	29.3 (28.8–29.8)	38.6 (33.5–43.8)	34.5 (29.5–39.5)
Moderate disability‡*	18.8 (18.3–19.2)	25.1 (24–32.9)	29.6 (24.8–34.4)
Severe disability	9 (8.7–9.4)	12.4 (9.9–15.9)	11.8 (8.4–15.2)
Coma/vegetative state	0.3 (0.2–0.4)	0.3 (0–0.9)	0.3 (0–0.9)
Brain death	2.6 (2.5–2.8)	–	4 (1.9–6.1)
Discharge PCPC Score[b]			
No disability‡O	68.9 (68.3–69.4)	63.1 (58–68.2)	55.1 (49.9–60.4)
Mild disability‡	12.5 (12.1–12.9)	17.3 (13.3–21.3)	21 (16.7–25.3)
Moderate disability	8.9 (8.6–9.2)	10.1 (6.9–13.3)	12.4 (8.9–15.8)
Severe disability*	6.8 (6.5–7.1)	9.2 (6.2–12.3)	7.2 (4.5–9.9)
Coma/vegetative state	0.3 (0.2–0.4)	0.3 (0–0.9)	0.3 (0–0.9)
Brain death	2.6 (2.5–2.8)	–	4 (1.9–6.1)
Disposition			
General ward†O	63.4 (63.1–63.7)	77.9 (75.4–80.3)	66.8 (64.1–69.6)
Another ICU	2.3 (2.2–2.4)	1.5 (0.8–2.2)	1.9 (1.1–2.7)
Intermediate unit‡	10.9 (10.7–11.1)	19.4 (17.1–21.7)	18.3 (16–20.5)
OR†	0.4 (0.4–0.5)	0.5 (0.1–0.9)	0.9 (0.3–1.4)
Chronic/Rehabilitation facility	0.9 (0.8–0.9)	0.5 (0.1–0.9)	1 (0.4–1.6)
Home‡O	18.6 (18.4–18.9)	0.1 (0–0.3)	7.1 (5.6–8.5)
Morgue/Medical examiner†	2.5 (2.4–2.6)	–	4 (2.8–5.1)
Other	1 (0.9–1.1)	0.2 (0–0.4)	0.1 (0–0.4)
LOS, days, median (IQR)‡O	1.7 (0.9–3.8)	2 (1–5.1)	3.1 (1.8–6.2)
Duration of PPV, days, mean (SD)	1.5 (8)	2 (5.4)	2 (6.4)
PIM2 risk of mortality, %, mean (SD)*	2.5 (8.9)	2.7 (6.8)	2.2 (6.9)
PICU mortality†	2.5 (2.4–2.6)	–	4 (2.8–5.1)

CI, confidence interval; PACU, post-anesthesia care unit; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; OR, operating room; PIM, Paediatric Index of Mortality; PCPC, Pediatric Cerebral Performance Categories; POPC, Pediatric Overall Performance Categories; PPV, positive pressure ventilation

† $P < 0.05$;

‡ $P < 0.001$ comparing all index admissions and readmissions by chi^2 test, unpaired two-tailed t-test, or Kruskal-Wallis rank test

* $P < 0.05$;

^{O}P < 0.001 comparing index admissions that led to readmissions and their matched readmission by McNemar's chi^{2} test, paired t-test, or Wilcoxon signed-rank test

^{a}Includes 95,028 index admissions in other analyses and 2,486 index admissions that resulted in death

^{b}Based on 32,228 (33%) index admissions of patients (31,434 in other analyses and 854 that resulted in death) and 348 (30%) readmissions from 27 sites that supplied POPC and PCPC

Table 4

Acute diagnoses present on index admission and on unplanned readmissions among patients with an unplanned readmission

Diagnosis, % (95% CI)[a]	Index admissions that preceded readmission n=1,161	Unplanned readmissions n=1,161
Adverse event or complication	6.1 (4.7–7.5)	6.4 (5–7.8)
Arrest, cardiac or respiratory	4.8 (3.6–6.1)	4.2 (3.1–5.4)
Cardiovascular, any	17.1 (15–19.3)	19.8 (17.5–22.1)
Arrhythmia	3.1 (2.1–4.1)	4.7 (3.4–5.9)
Heart failure	2.8 (1.9–3.8)	3.5 (2.5–4.6)
Hypertension, systemic†	2.2 (1.3–3)	3.8 (2.7–4.9)
Hypotension without shock	2 (1.2–2.9)	2.3 (1.4–3.2)
Shock	2.9 (2–3.9)	2.7 (1.7–3.9)
Fluid/electrolyte abnormality	9.6 (7.9–11.3)	9.2 (7.5–10.9)
Gastrointestinal, any	13.4 (11.5–15.4)	14.3 (12.3–16.3)
Liver failure	0.6 (0.2–1)	0.4 (0.1–0.8)
Infection, any	34.2 (31.5–36.9)	35.8 (33.1–38.6)
CNS	3.2 (2.2–4.2)	3.4 (2.4–4.5)
Gastrointestinal	1.1 (0.5–1.7)	1 (0.4–1.5)
Respiratory	23.6 (21.2–26)	24.1 (21.7–26.6)
Sepsis, bacteremia, viremia, fungemia	6.2 (4.8–7.6)	6 (4.7–7.4)
Neurological, any*	20.7 (18.3–23)	27.7 (25.2–30.3)
Cerebrovascular event	3.2 (2.2–4.2)	4.7 (3.5–6)
Encephalopathy†	6.3 (4.9–7.7)	9.3 (7.6–11)
Increased intracranial pressure/cerebral edema	2.5 (1.6–3.4)	2.2 (1.3–3)
Seizure*	13.2 (11.2–15.1)	19.6 (17.3–21.8)
Renal, any	5.2 (3.9–6.4)	6.5 (5–7.9)
Renal failure	2.4 (1.5–3.3)	2.6 (1.7–3.5)
Respiratory, any*	45.5 (42.6–48.3)	55.6 (52.8–58.5)
ARDS/ALI	18 (15.8–20.2)	15.8 (13.7–18)
Bronchospasm	4.1 (3–5.3)	3.6 (2.5–4.7)
Pneumothorax/pleural effusion†	4.4 (3.2–5.6)	7.2 (5.7–8.7)
Upper airway obstruction†	3.4 (2.4–4.5)	5.5 (4.2–6.8)

ALI, acute lung injury; ARDS, acute respiratory distress syndrome; CNS, central nervous system; CI, confidence interval

† $P < 0.05$;

* $P < 0.001$ by chi^2 test

[a] Patients may have had more than one acute diagnosis