RESEARCH ARTICLE

Outcome Differences Between Direct Admissions to the PICU From ED and Escalations From Floor

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ABSTRACT

OBJECTIVES: To compare the outcomes (mortality and ICU length of stay) of patients with direct admissions to the PICU from the emergency department [ED]) versus as an escalation of care from the floor.

METHODS: A retrospective cohort study with a secondary analysis of registry data. Patient demographics and outcome variables collected from January 1, 2015, to December 31, 2019, were obtained from the Virtual Pediatric Systems database. Patients with a source of admission other than the hospital's ED or pediatric floor were excluded. Multivariable regression analysis controlling for age groups, sex, race, diagnostic categories, and severity of illness (Pediatric Index of Mortality III), with clustering for sites, was performed.

RESULTS: A total of 209 695 patients from 121 sites were included in the analysis. A total of 154 716 (73.7%) were admitted directly from the ED, and 54 979 were admitted (26.2%) as an escalation of care from the floor. Two groups differed in age and race distribution, medical complexity, diagnostic categories, and severity of illness. After controlling for measured confounders, patients with floor escalations had higher mortality (2.78% vs 1.95%; $P < .001$), with an odds ratio of 1.71 (95% CI 1.5 to 1.9) and longer PICU length of stay (4.9 vs 3.6 days; $P < .001$). The rates of most of the common ICU procedures and their durations were also significantly higher in patients with an escalation of care.

CONCLUSIONS: Compared with direct admissions to the PICU from the ED, patients who were initially triaged to the pediatric floor and then require escalation to the PICU have worse outcomes. Further research is needed to explore the potential causes of this difference.

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The early identification of critical illness and its definitive management has been shown to improve outcomes.[1,2] A delay in ICU care when needed, thus, can be deleterious.[3] There are 3 sources of potential delays in admission to the ICU: (1) patient presentation to a facility that cannot provide the level of care the patient requires and triggers a transfer to the referral facility, (2) inappropriate initial triage to the pediatric floor, with later escalation to the ICU, and (3) deterioration (with delays in recognition) of the patient after admission to a lower acuity unit, with later escalation to the ICU. Although each may be associated with a delay in care, the causes of delay and their impact on the outcome are different between referrals and escalations.[4] Delays in referrals, optimization of transport, and regionalization of pediatric care are fields of active research.[4–6] However, data describing the relationship between mortality and escalations are dated. A few single-center studies in both the adult and pediatric fields have characterized and compared the outcomes of patients admitted from floor to the ICU.[7–10] A multicenter study that included patients from 1998 to 2004 revealed an increased risk of mortality and ICU length of stay (LOS) associated with escalations from the floor.[11] In the past, our group also has compared outcomes of patients who required escalation of care to the PICU within 24 hours of hospital admission to patients directly admitted to the PICU from the emergency department (ED). In this single-center study on 1258 patients, we showed that patients admitted to the PICU with escalations had a longer LOS but had no difference in mortality.[12]

There are significant public health importance and cost implications (a liberal PICU admission threshold may improve outcomes but may increase the cost) to determine differences in outcomes. The larger pediatric studies on outcome difference[4,11] were performed before the widespread use of pediatric emergency response teams and early warning scores. Rapid response teams have been associated with decreased incidence of out-of-ICU code events and mortality.[13,14] Presumably, with early identification of a deteriorating patient on the floor, they may reduce outcome differences between the ED and floor admissions to the PICU.

The specific aim of this study was to leverage the large data set from the Virtual Pediatric Systems (VPS) registry to compare the outcomes (mortality and ICU LOS) of patients with direct admissions to the ICU from the ED with the patients who are admitted to the PICU as escalations of care from the floor (hereafter referred to as direct admissions and escalations). We hypothesized that there are differences in a patient's disease course and outcomes on the basis of these 2 sources of admission to the PICU. Our secondary objective was to compare the degree of therapeutic intensive care interventions (intubations, central line placement, etc) between the 2 groups.

METHODS

Study Type

This retrospective study was performed by using data obtained from the VPS database in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[15] (Supplemental Fig 3). All patients admitted to the participating ICUs of the VPS database from January 1, 2015, to December 31, 2019, were eligible for the study. Patients ≥18 years of age, admitted to pediatric cardiac ICU, postoperative cardiac patients (index admission), and duplicate admissions of the same patients were excluded from the initial data request. We further excluded patients who had missing data (sex, race, Pediatric Index of Mortality [PIM] III score,[16] admission diagnosis, or Pediatric Medical Complexity Algorithm [PMCA] category[17]). We selected patients with the source of admission from the ED or general pediatric floor (from the same hospital as the ICU) for analysis from this final cohort.

Data Source

The VPS database (https://www.myvps.org) is a Web-based database that facilitates prospective data collection. The VPS uses a standardized clinical data definition, data quality control, and data analysis. The VPS database includes admissions data from a diverse set of hospitals throughout the United States and other countries. Data are collected and entered within the database by trained analysts at individual hospitals.[18]

Patient Population and Study Variables

This study was reviewed and approved by the Institutional Review Board at the University of Illinois College of Medicine at Peoria. The requirement of informed consent was waived. Variables obtained from the VPS database included patient demographics (age groups, weight, height, sex, race, the severity of illness at the time of ICU admission PIM III[16] and Pediatric Risk of Mortality [PRISM] III[19]), admission diagnoses categories (STAR codes and *International Classification of Diseases, Ninth Revision*, and *International Classification of Disease, 10th Revision*, codes), and admission source (primary independent variable). Age was stratified as a neonate (birth to 29 days), infant (29 days to < 2 years, young child (2 years to <6 years), child (6 years to <12 years), and adolescent (12 years to <18 years). STAR codes are VPS proprietary sets of codes that categorize *International Classification of Diseases* codes into groups treated similarly in the ICU. The STAR code is mandatory data collection for VPS, whereas *International Classification of Diseases* codes are optional and not available on all patients. Both PIM III and PRISM III scores represent the severity of illness as a predictor of mortality for a heterogeneous PICU population.[20] However, they differ slightly in terms of variable selection and time period (PIM III includes vitals and laboratory values obtained within 1 hour of ICU admission,[21] whereas PRISM III includes patient data up to 4 hours of ICU admission and laboratory values from 2 hours before ICU admission to 4 hours after[22]). Because height was missing from a considerable proportion of patients (44.8% missing), BMI was not included in the final analysis model. Respiratory support requirements and duration (high flow nasal cannula [HFNC], bilevel positive airway pressure [BiPAP], continuous positive airway pressure [CPAP], intubation, and invasive ventilation), the incidence of cardiac arrest requiring cardiopulmonary resuscitation (CPR), central venous catheter placement, and the use of heliox and nitric oxide were also obtained. These procedures were selected because they are indicators of elevated ICU support levels, and relevant data were coded and reliably available for all patients. As expected, a patient could have had multiple types of procedures during their ICU stay. The VPS registry separately records the duration of mechanical ventilation and intubation. For this analysis, we used the duration of intubation to indicate invasive ventilator duration because mechanical ventilation duration may also include ventilation through a tracheostomy.

The primary predictor variable was the source of admission, classified as ED or general pediatric floor. The source of admission to the PICU in the VPS registry had 29 categories. For this analysis, all categories other than the same hospital ED and same hospital general pediatric floor were excluded. The diagnostic codes (STAR diagnostic category) included 1520 categories, which were combined into 12 organ system categories in the study. We established a priori rules for this categorization scheme because these can be highly subjective.

PMCA categories (children with complex chronic disease, noncomplex chronic disease, and children without chronic disease) were calculated on the basis of *International Classification of Diseases, Ninth Revision*, and *International Classification of Disease, 10th Revision*, codes on the basis of a publicly available SAS (SAS Institute, Inc, Cary, NC) program.[23] The PMCA was developed and validated for children 0 to 18 years of age. It is used to identify children into the 3 categories described above on the basis of billing or discharged codes by using the consensus definition of children with medical complexity described by the Center of Excellence on Quality of Care Measures for Children with Complex Needs.[24] Because of the limitations of PMCA categorization based on inpatient billing codes,[23] it was not used for adjustment in the primary analysis. However, a separate sensitivity analysis was performed after the inclusion of PMCA categories in the model.

Statistical Analysis

Standard descriptive analysis was conducted to describe the study cohort, and a comparative analysis was performed on the basis of admission sources. This assessment was restricted to patients with complete data regarding all variables required for the analysis (complete case analysis). No values were imputed for the analysis. The Kolmogorov–Smirnov Lilliefors test was used to assess the normal distribution of continuous variables. Because of nonnormal distribution, median and interquartile ranges were calculated for continuous variables for univariate analysis. Categorical variables are described as frequency and percentages. Univariate and multivariable analyses were conducted for outcome variables, including mortality and duration of ICU stay and the frequency and duration of aforementioned ICU interventions. Covariates for multivariable analysis included age categories, sex, race, diagnostic categories, and PIM III score. The factors included in the model were chosen on the basis of clinical relevance, with guidance from univariate statistics (both PIM III and PRISM III scores were available to us; however, there was a statistically significant difference in PIM III score, and, so, it was included in the multivariable model for severity of illness adjustment). The race was included in the analysis because of the complex relationship of racial disparities on health care access and its downstream impact on children's health and outcomes.[25] For the LOS and duration of procedures, a generalized linear model (GLM) with log link was used because of the predicted variable's nonnormal distribution. For mortality and proportions of procedures, logistic regression was used. Collinearity was assessed by using the variation inflation factor (VIF). For the LOS comparisons, only survivors were included. Because the data included sites from multiple hospitals, all analyses were conducted to account for the clustering of sites.

We conducted 3 sensitivity analyses to assess the impact of alternative design choices in the models for mortality and hospital LOS. First, we included the PRISM score instead of the PIM score in the model. The second analysis was conducted after including the BMI of available patients in the model (sample size: N = 124 296). In the third sensitivity analysis, we included complexity categories, as described previously. The sensitivity analysis results revealed no difference from the main model's conclusion and are provided in Supplemental Tables 4 through 6. Because a statistically significant difference was expected to be observed because of the large sample size,[26] we also defined a minimal clinically important difference of ≥1day for the duration for the LOS or ICU procedures. The authors defined the minimal clinically important difference by consensus. Statistical analysis was conducted by using SAS and JMP Pro version 14.2.0. All statistical tests were conducted with a 2-sided alternative hypothesis with a significance level of 5%.

RESULTS

Patient Selection

Among all the patients admitted to the participating PICUs during the study period (January 15 to December 19), the initial data were obtained on 576 394 patients. In addition, 166 994 patients with missing data were excluded. Of the remaining 409 400 patients, we selected patients (N = 209 695) for whom the admission source was either the same hospital ED (direct admissions: n = 154 716; 73.7%) or same hospital general pediatric floor (escalations: n = 54 979; 26.2%) for the analysis from 121 hospitals (Fig 1).

Demographic Comparisons

Infants (29 days to <2 years of age) comprised 35.1% of the total cohort. The 2 groups differed in the age distribution, with a higher proportion of infants in the escalations group (41.7%) then the direct admission group (32.8%; $P < .001$). Patients admitted from the ED had a slightly lower median PIM III score (−4.90 [interquartile range (IQR): −5.94 to −4.47] for direct admissions versus −4.90 [IQR: −5.90 to −4.45] for escalations; $P < .001$); the higher (more positive) number denotes a higher severity of illness. There was no difference in the PRISM III score between the 2 groups. A large majority of patients in the total cohort did not have chronic disease (81.0%). Patients' distribution based on medical complexity was also significantly different in the 2 groups, with a higher proportion of patients in the escalations group without chronic disease. The racial distribution between the groups differed, with a slightly higher proportion of Black patients in the direct admissions group (23.9% vs 19.8%; $P < .001$). The admission diagnostic category also differed between the 2 groups, with a higher proportion of patients in the escalations group having a pulmonary diagnosis (49.5% vs 39.6%). In comparison, there was a comparatively higher proportion of patients with endocrine and toxicology diagnoses in the direct admissions from the ED (Table 1).

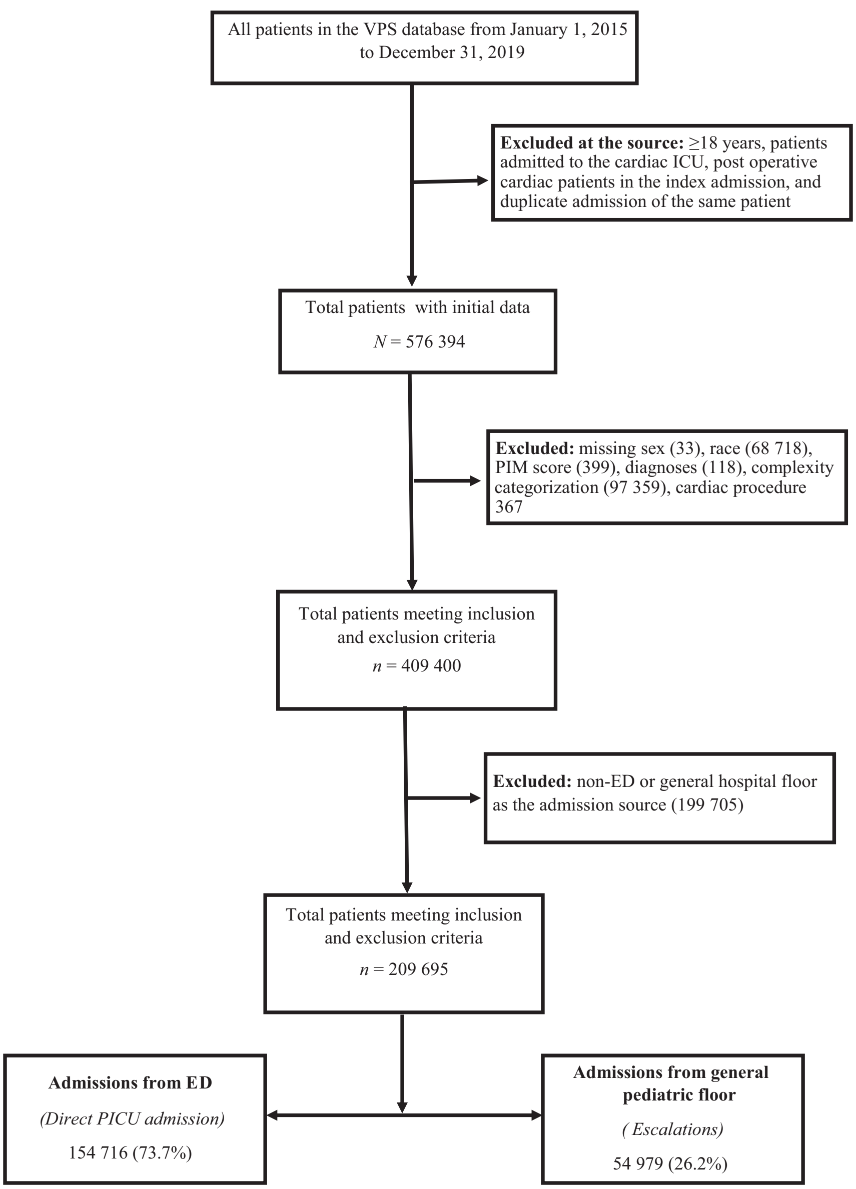

FIGURE 1 Patient recruitment flow diagram.

Outcome Differences

After controlling for age groups, sex, race, the severity of illness (PIM III), and diagnostic categories, clustered for sites, there was a statistically significant difference in mortality between the 2 groups (2.78% [95% confidence interval (CI) 2.5% to 3.1%] mortality for escalations versus 1.95% [95% CI 1.8% to 2.1%] for direct admissions; $P < .001$). Patients transferred from the general pediatric floor had an adjusted odds ratio (aOR) of 1.71 (95% CI 1.5 to 1.9) of mortality, compared with patients admitted from the ED. Among survivors (n = 205; 107), there was also a statistically significant difference in the adjusted mean ICU LOS in the 2 groups (4.9 [95% CI 4.7 to 5.1] days of adjusted mean ICU LOS for escalations versus 3.6 [95% CI 3.4 to 3.7] days for direct ED admissions; $P < .001$). Patients transferred from the general pediatric floor stayed an average of 1.3 (95% CI 1.2 to 1.4) additional days in the PICU (Fig 2, Supplemental Tables 7 and 8).

ICU Procedures and the Duration of Procedures

HFNC was the most common modality of advanced respiratory support and was used on 28.2% (n = 59 333) patients. Up to 16.4% of patients (n = 34 526) required endotracheal intubation and invasive ventilation, whereas 8.5% (n = 17 953) had central lines placed during admission (Supplemental Table 9). After controlling for age groups, sex, race, the severity of illness (PIM III), and diagnostic categories, patients admitted to the PICU as an

TABLE 1 Demographic Distribution of Direct ED to PICU Admissions and Admissions as Escalation of Care From the Pediatric Floor to the PICU

Category and Subcategory	All Patients (*N* = 209 695)	Direct ED to PICU Admissions (*n* = 154 716)	PICU Admissions as Escalation of Care From the Floor (*n* = 54 979)	*P*
Age, *n* (%)				<.001
Neonate	5626 (2.6)	3823 (2.4)	1803 (3.2)	—
Infant	73 726 (35.1)	50 755 (32.8)	22 971 (41.7)	—
Young child	43 832 (20.9)	33 291 (21.5)	10 541 (19.1)	—
Child	39 210 (18.6)	29 982 (19.3)	9228 (16.7)	—
Adolescent	47 301 (22.4)	36 865 (23.8)	10 436 (18.9)	—
Wt, median (IQR), kg	15.9 (9.0 to 36.7)	17.0 (9.6 to 39.1)	13.0 (7.2 to 30.0)	<.001
PIM III,[a] median (IQR)	−4.90(−5.93 to −4.47)	−4.90(−5.94 to −4.47)	−4.90(−5.90 to −4.45)	<.001
PRISM III, median (IQR)	0 (0 to 4)	0 (0 to 4)	0 (0 to 4)	.925
Sex, male, *n* (%)	116 890 (55.7)	86 322 (55.7)	30 568 (55.6)	.433
Medical complexity, *n* (%)				<.001
Nonchronic	169 990 (81.0)	123 668 (79.9)	46 322 (84.2)	—
Noncomplex chronic	33 902 (16.1)	27 652 (17.8)	6250 (11.3)	—
Complex chronic	5803 (2.7)	3396 (2.1)	2407 (4.3)	—
Race, *n* (%)				<.001
White	93 867 (44.7)	68 967 (44.5)	24 900 (45.2)	—
Black	48 022 (22.9)	37 124 (23.9)	10 898 (19.8)	—
Hispanic	39 014 (18.6)	28 542 (18.4)	10 472 (19.0)	—
Asian	8588 (4.0)	5842 (3.7)	2746 (4.9)	—
Other	20 204 (9.6)	14 241 (9.2)	5963 (10.8)	—
Diagnosis, *n* (%)				<.001
Pulmonary	88 571 (42.2)	61 326 (39.6)	27 245 (49.5)	—
Neurology	29 507 (14.0)	23 538 (15.2)	4969 (10.8)	—
Surgical	19 833 (9.4)	17 423 (11.2)	2410 (4.3)	—
Infection	24 946 (11.8)	16 614 (10.7)	8332 (15.1)	—
Cardiac	7374 (3.5)	4933 (3.1)	2441 (4.4)	—
Endocrine	13 137 (6.2)	11 878 (7.6)	1259 (2.2)	—
Hematology	7193 (3.4)	4139 (2.6)	3054 (5.5)	—
Toxicology	8169 (3.8)	7641 (4.9)	528 (0.9)	—
Gastrointestinal	4334 (2.0)	2808 (1.8)	1526 (2.7)	—
Renal	4434 (2.1)	2911 (1.8)	1523 (2.7)	—
Immunology	1135 (0.5)	791 (0.5)	344 (0.6)	—
Other	1062 (0.5)	714 (0.4)	348 (0.6)	—

Neonate (birth to 29 d), infant (29 d to <2 y), young child (2–<6 y), child (6–<12 y), and adolescent (12–<18 y). Values represent median and IQR for continuous variables and number (percentage) for categorical variables. —, not applicable.

[a] The median PIM is same in both groups; however, the overall difference is significant because of a difference in IQR values. More positive implies a higher severity, so escalations had higher PIM scores.

escalation of care had higher rates for all interventions except intubation and heliox treatment, compared with direct ICU admissions. The most significant difference was noted in HFNC use (Δ7.3%) and percutaneous inserted central venous catheter (PICC) line insertions (Δ8.6%), whereas the highest aORs for procedures (escalations versus direct admissions) were for hemodialysis catheter placement (aOR: 3.8 [95% CI 3.3 to 4.4]) and PICC line placement (aOR 3.0 [95% CI 2.7 to 3.3]; Table 2).

A significant difference between the adjusted duration of various ICU procedures and therapies based on admission source was also observed. Among the survived patients, the adjusted duration for BiPAP, HFNC, intubation duration, central line, and dialysis catheter duration were significantly longer in the escalations group than in the direct admissions group. A clinically significant difference (as defined by ≥1-day difference in

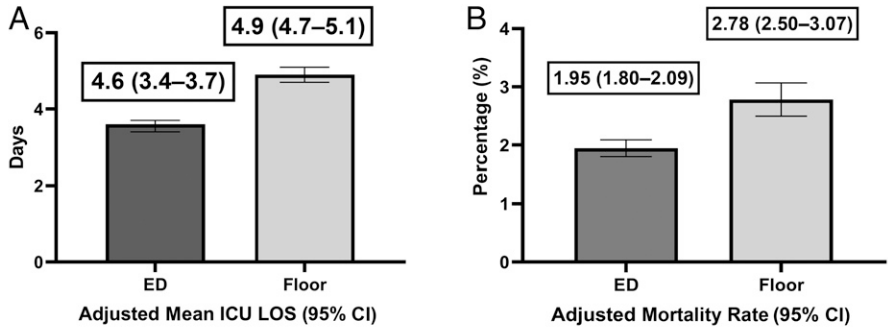

FIGURE 2 Outcome comparison based on patient's source of admission (ED [direct admissions] and pediatric floor [escalations]). A, Additional ICU LOS for escalation of care versus direct ED admissions: 1.3 (95% CI 1.2–1.4); $P < .001$; difference: +36%. B, Odds ratio for mortality for escalation of care versus direct ED admissions: 1.71 (95% CI 1.53–1.92); $P < .001$; difference in mortality: +36%. We conducted a multivariable linear regression (GLM with log link) for the LOS (survived patients only) and logistic regression for mortality, controlling for age groups, sex, race, the severity of illness (PIM III), and diagnostic categories clustered for the site. Values represent predicted least square means (also known as adjusted means) of the categorical effect when the other model factors are set to neutral values. R^2 for linear regression = 0.065. Pseudo R^2 for logistic regression = 0.389. VIF for the source of admission in respective models for LOS = 1.41 and for mortality = 1.41. Parameter estimates of the complete models are provided in Supplemental Tables 7 and 8.

duration) was observed for intubation duration (Δ 1.5 days) and dialysis catheter (Δ 1.7 days; Table 3).

DISCUSSION

In this large national study, we have shown that the patients who have an escalation of care to the PICU from the general pediatric floor have an associated higher mortality and longer ICU LOS than patients admitted directly from the ED. Although the 2 groups were different in terms of demographics and severity of illness, the difference in outcomes (mortality and LOS) was significant even after controlling for measured confounding variables. This study reveals that, despite efforts of early recognition of deteriorating patients on the pediatric floor by rapid response teams and other interventions, the outcome differences between direct admissions from the ED and admissions as an escalation of care from the floor to PICU persist.

This is the largest contemporary study in which researchers evaluate PICU patients' outcomes on the basis of the ED versus pediatric floor as admission source. These findings are in agreement with those in our previous single-center study, which has revealed an increased LOS for patients who required escalation of care.[12] A mortality difference, however, was not observed in our previous study. In addition to being underpowered to detect a mortality difference because of the small sample size, the single-center study only included patients who had an escalation of care within 24 hours of hospital admission (as opposed to escalation at any time in the current study). Our findings are also in agreement with the study by Odetola et al[11] and Gregory et al[4] from the early 2000s. Odetola et al[11] had observed a 1.65 odds ratio for mortality and a 4-day increase in ICU LOS for patients with escalations.[11] The unadjusted mortality rates in the study by Gregory et al[4] were 6.2% for floor admissions and 2.9% for ED admissions. Our observed differences in mortality are similar; however, the difference in ICU LOS is smaller in our cohort. The smaller difference in LOS

TABLE 2 Adjusted Proportion and Odds Ratio of Patients Requiring Respiratory Support and Other ICU Procedures Based on Source of Admission (ED and as Escalation of Care From the Pediatric Floor)

Category	Direct Admissions From the ED (*n* = 154 716), % (95% CI)	Admissions as Escalation of Care From Floor (*n* = 54 979), % (95% CI)	Difference, % (95% CI)	*P*	Procedure (Escalations Versus Direct Admissions), Odds Ratio (95% CI)
BiPAP	10.5 (7.6 to 13.3)	13.6 (11.3 to 16.0)	3.2 (1.7 to 4.6)	<.001	1.4 (1.2 to 1.7)
CPAP	5.3 (2.9 to 7.6)	8.5 (5.7 to 11.4)	3.3 (2.9 to 4.2)	<.001	1.8 (1.5 to 2.1)
HFNC	26.1 (23.4 to 29.0)	33.4 (30.1 to 36.8)	7.3 (5.5 to 9.1)	<.001	1.7 (1.5 to 1.9)
Intubation	16.3 (15.0 to 17.5)	17.0 (15.9 to 18.1)	0.7 (−0.1 to 1.6)	.082	1.1 (0.9 to 1.2)
CPR	0.6 (0.5 to 0.7)	1.0 (0.8 to 1.3)	0.4 (0.3 to 0.6)	<.001	1.8 (1.6 to 2.1)
Central line placement	8.0 (7.2 to 8.8)	10.0 (8.9 to 11.1)	1.9 (1.3 to 2.6)	<.001	1.3 (1.2 to 1.5)
PICC line	5.5 (4.8 to 6.3)	14.2 (12.8 to 15.5)	8.6 (7.7 to 9.5)	<.001	3.0 (2.7 to 3.3)
Heliox	0.9 (0.6 to 1.2)	1.1 (0.7 to 1.4)	0.14 (−0.1 to 0.3)	.191	1.2 (0.9 to 1.4)
Nitric oxide	0.5 (0.4 to 0.7)	1.0 (0.7 to 1.3)	0.5 (0.3 to 0.6)	<.001	1.9 (1.6 to 2.2)
Bronchoscopy	1.2 (0.9 to 1.5)	2.4 (1.8 to 3.1)	1.3 (0.9 to 1.7)	<.001	2.2 (1.9 to 2.5)
Hemodialysis/plasmapheresis	0.9 (0.7 to 1.0)	3.0 (2.5 to 3.4)	2.1 (1.8 to 2.5)	<.001	3.8 (3.3 to 4.4)

Proportions were adjusted for age categories, sex, race, diagnostic categories, and PIM III score, clustered by site.

TABLE 3 Multivariable Analysis for Procedure Duration Based on Source of Admission to the PICU

Category	Unit	Direct Admission From ED, Predicted Mean[a] (95% CI)	Admissions as Escalation of Care From the Floor, Predicted Mean[a] (95% CI)	Difference, Predicted Mean[a] (95% CI)	*P*
BiPAP	d	2.7 (2.3 to 3.2)	3.1 (2.7 to 3.5)	0.4 (0.1 to 0.6)	.017
CPAP	d	1.8 (1.5 to 2.0)	2.1 (1.8 to 2.3)	0.3 (0.0 to 0.6)	.065
HFNC	d	1.8 (1.6 to 1.9)	2.3 (2.1 to 2.5)	0.5 (0.3 to 0.7)	<.001
Intubation duration	d	5.0 (4.8 to 5.2)	6.6 (6.2 to 6.9)	1.5 (1.2 to 1.9)	<.001
Central line duration	d	7.4 (7.0 to 7.8)	8.2 (7.8 to 8.7)	0.8 (0.5 to 1.2)	<.001
PICC line duration	d	8.7 (8.1 to 9.3)	8.8 (8.2 to 9.4)	0.1 (−0.3 to 0.6)	.559
Heliox duration	d	0.9 (0.7 to 1.0)	1.1 (0.9 to 1.2)	0.2 (0.0 to 0.4)	.066
Nitric oxide	d	5.4 (4.6 to 6.2)	6.1 (4.8 to 7.3)	0.7 (−0.6 to 1.9)	.299
Dialysis catheter	d	6.7 (5.8 to 7.6)	8.4 (7.7 to 9.1)	1.7 (0.5 to 2.9)	.005

Procedure duration was controlled for age, sex, race, severity of illness (PIM III), and diagnostic categories, clustering for site (survived patients only).
[a] By multivariate linear regression (GLM with log link).

might be due to a much larger sample size in our population-based study or an overall emphasis on reducing ICU and hospital LOS in the current health care environment.[27,28] The higher degree of the duration of interventions required for escalation of care patients has also been shown before[29] and may impact the ICU LOS of these patients.

Although we did not analyze the causes of the difference in outcomes in our study, the potential hypothesis may include subtle differences in disease characteristics in the 2 populations as well as early interventions and closer monitoring because of a 24 × 7 attending presence in many hospitals for ICU patients[30,31] and better nurse staffing in PICUs, compared with that of pediatric floors.[32] The patients who required escalation of care from the pediatric floor to the ICU would comprise 2 groups of patients. First would be those patients who were stable for pediatric floor admission; however, they had a sudden acute deterioration requiring an ICU admission. The second group would be those patients whose critical illness was not appropriately identified in the ED and were triaged to the pediatric floor.[33] In this study, we could not differentiate the 2 groups; however, a recent study by Czolgosz et al[7] revealed that patients who were inappropriately triaged by ED error performed worse than patients who were appropriately triaged but had an ICU admission because of disease progression.

Early warning and rapid response teams are expected to identify the deterioration of patients on the pediatric floors. Although early warning scores have gained acceptance in pediatric practice, their implementation is expected to be variable in the 121 sites included in this analysis. In addition, early warning scores have variable sensitivity and specificity in detecting a deteriorating patient on the basis of hospital setting and environment,[34] and have not been shown to impact mortality independently.[35] Our data also suggest that there may be further scope of improvement in the assessment of deteriorating patients on the pediatric floor. Modalities such as structured assessment and communication algorithms to identify deteriorating patients on the floor have been shown to impact their outcomes[36] and offer an additional avenue for intervention.

Admission to the PICU versus admission to the general pediatric floor is a vital triage decision for ED physicians.[37–39] A more extended observation period in the ED may improve such triage decisions; however, they would impact ED throughput.[40] The cost of 1 ICU bed is significantly more than that of a general floor bed.[41] Although patients who require escalation of care have a longer LOS, the potential cost of liberal direct admission policies to the hospital may outweigh the benefit of cost savings of a shorter LOS of direct admissions because escalations happen only in a small proportion of patients.

Our study has limitations inherent to large database reviews. First, the 2 groups had significant demographic, severity of illness, and diagnostic differences. Although we attempted to adjust for all measurable confounders, it is possible that patients admitted as an escalation from the floor had characteristics that were not measured in our study and may have introduced bias. Second, a complete case analysis such as ours assumes data are missing completely at random. If the missing completely at random assumption is not met, it can introduce bias. Third, although we have demonstrated a difference in outcomes based on admission sources, this difference's underlying reason is still unknown. Fourth, ICU LOS can be affected by circumstances other than patient clinical readiness to leave the ICU; these factors should be identical in patients with all types of admission sources; however, the impact of social factors on the difference in LOS was not included in our analysis. Fifth, because of the unavailability of a specific age and lack of height in a large proportion of patients, we could not adjust for obesity in the main model. However, a sensitivity analysis with a smaller subset of patients with BMI revealed similar results.

Similarly, outcomes were not adjusted for differences in medical complexity in the main model. However, sensitivity analysis including PMCA categories revealed similar differences in the 2 groups. Sixth, the mortality difference was statistically significant; however, because overall mortality was relatively low, there may be less clinical significance of this difference. Lastly, multiple other factors associated with PICU staffing and time of admission, which were not included in the analysis,[42] have been associated with PICU mortality.

CONCLUSIONS

The PICU admission source (ED versus general floor) is an independent predictor of LOS and mortality. Patients transferring from the general floor to the PICU have worse outcomes. These results have important implications for intrahospital unit placement. It can provide a foundation for further research and quality improvement projects to improve ED triage decisions and, potentially, further improvement in the identification of deteriorating patients on the pediatric floor. In this study, we excluded patients with other sources of admission to the PICU (transfers, intermediate care, and postoperative patients). On the basis of the differences in outcomes observed in this study, there may be outcome differences between other admission sources, which require comprehensive evaluation in further studies.

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