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Pediatric intermediate care and pediatric intensive care units: PICU metrics and an analysis of patients that use both☆

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ABSTRACT

Purpose: To examine how intermediate care units (IMCUs) are used in relation to pediatric intensive care units (PICUs), characterize PICU patients that utilize IMCUs, and estimate the impact of IMCUs on PICU metrics.
Materials & methods: Retrospective study of PICU patients discharged from 108 hospitals from 2009 to 2011. Patients admitted from or discharged to IMCUs were characterized. We explored the relationships between having an IMCU and several PICU metrics: physical length-of-stay (LOS), medical LOS, discharge wait time, admission severity of illness, unplanned PICU admissions from wards, and early PICU readmissions.
Results: Thirty-three percent of sites had an IMCU. After adjusting for known confounders, there was no association between having an IMCU and PICU LOS, mean severity of illness of PICU patients admitted from general wards, or proportion of PICU readmissions or unplanned ward admissions. At sites with an IMCU, patients waited 3.1 h longer for transfer from the PICU once medically cleared ($p < 0.001$).
Conclusions: There was no association between having an IMCU and most measures of PICU efficiency. At hospitals with an IMCU, patients spent more time in the PICU once they were cleared for discharge. Other ways that IMCUs might affect PICU efficiency or particular patient populations should be investigated.

1. Introduction

Intermediate care units (IMCUs) are used to provide more intensive monitoring and care to non-critically ill patients who are too sick or complex to be cared for on general wards. This includes "step-down" care for patients recovering from critical illness, "step-up" care for patients acutely worsening but not yet critically ill, and post-operative care [1,2]. IMCUs have been used at some pediatric hospitals for decades [3], and guidelines for admission to and discharge from pediatric IMCUs have been proposed [4]. Advocates of intermediate care argue that IMCUs can safely improve critical care efficiency and patient flow [5-10]. However, few studies have described the ways pediatric IMCUs are used and whether they affect critical care efficiency.

Using a multi-institutional clinical PICU database that specified whether or not each participating site had a separate IMCU, we sought to characterize the PICU patients admitted from and discharged to IMCUs, and to examine the impact of IMCUs on several PICU metrics. We hypothesized that having a separate IMCU would be associated with better metrics of PICU efficiency.

2. Patients and methods

2.1. Data source and IMCUs

We performed a retrospective, cross-sectional study of patients discharged between 2009 and 2011 from 108 North American PICUs that participated in the Virtual Pediatric Systems, LLC (VPS, Los Angeles, CA). VPS only contains data from PICU encounters. Participating sites self-disclosed whether they had a separate IMCU. VPS imposed no particular definition of an IMCU, and sites were not asked to specify what intermediate care meant for them. VPS grouped IMCUs and telemetry

Abbreviations: CCC, Complex Chronic Condition; CI, Confidence Interval; HR, Hazard Ratio; ICU, Intensive Care Unit; IMCU, Intermediate Care Unit; IQR, Interquartile Range; LOS, Length of Stay; PCPC, Pediatric Cerebral Performance Category; PCCM, Pediatric Critical Care Medicine; PICU, Pediatric Intensive Care Unit; PIM2, Pediatric Index of Mortality 2; POPC, Pediatric Overall Performance Category; SD, Standard Deviation; VPS, Virtual Pediatric Systems, LLC.

☆ This study was performed at Columbia University.

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units together as an option for location of patient admission and discharge. In order to differentiate between IMCUs and telemetry units, we assumed that non-cardiac patients were admitted from or discharged to IMCUs and that cardiac patients were admitted from or discharged to telemetry units. Cardiac patients were defined as those whose primary or secondary diagnoses were congenital or acquired diseases of the heart (Supplemental Table 1).

We compared the number of licensed pediatric beds, number of licensed PICU beds, and presence of a pediatric critical care medicine (PCCM) fellowship program at sites with and without IMCUs using Pearson's chi-square test.

2.2. IMCU utilization and patient characterization

In order to examine how IMCUs are utilized in relation to PICUs and how this varied across sites, we reported the median proportion and range of proportions of non-cardiac PICU patients admitted from and discharged to IMCUs.

We examined the characteristics of PICU patients admitted from or discharged to IMCUs. When patients had multiple PICU admissions, each was reported as a separate encounter. Patient characteristics included age, gender, number of complex chronic conditions (CCCs), and baseline and discharge Pediatric Overall Performance Characteristic (POPC) and Pediatric Cerebral Performance Characteristic (PCPC) [11]. CCCs were defined using Feudtner's definition [12] and identified among VPS diagnosis codes developed in Edwards et al. [13]. CCCs were presented as an ordinal variable (none, 1, 2, or ≥3 CCCs). Admission characteristics included Pediatric Index of Mortality 2 (PIM2) risk of mortality [14]; whether the admission was perioperative, due to trauma, or unplanned; whether the admission or discharge occurred during a night or weekend; the season of admission; and physical and medical length of stay (LOS) in the PICU.

To examine the reasons for PICU patients to require transfer from or to an IMCU, we described the admitting PICU diagnoses of patients admitted from and discharged to IMCUs. Diagnoses were categorized as respiratory, infectious, neurologic, cardiac, hemodynamic instability, endocrine, hematologic, gastrointestinal, renal, and oncologic.

Data are presented as proportions and 95% confidence intervals (CI), medians and interquartile ranges (IQR), or means and standard deviations (SD). For the above characteristics, we compared PICU patients admitted from or discharged to IMCUs with patients admitted from or discharged to general wards using Pearson's chi-square test, Mann-Whitney *U* test, or unpaired two-tailed *t*-test. As a sensitivity analysis of our assumption that cardiac patients were admitted from or discharged to telemetry units (as opposed to IMCUs), we also described these PICU cardiac patients in each of the above analyses.

Table 1
Proportion of PICU patients admitted from and discharged to intermediate care units and telemetry units.

Unit and patient population	Median %	IQR	Range
Admission location			
Non-cardiac patient admitted from IMCU	3.3	0.5–6.1	0–10.0
Non-cardiac patient with CCC admitted from IMCU	2.1	0.4–4.2	0–5.7
Cardiac patient admitted from telemetry unit	0.5	0.1–1.6	0–7.5
Discharge location			
Non-cardiac patient discharged to IMCU	10.4	1.9–25.5	0–54.8
Non-cardiac patient with CCC discharged to IMCU	6.9	1.2–15.0	0–24.7
Cardiac patient discharged to telemetry unit	2.4	0.4–16.8	0–82.6

CCC, complex chronic condition; IMCU, intermediate care unit; IQR, interquartile range; PICU, pediatric intensive care unit.
For each site, the percentage of encounters in which the specified patient type was admitted from or discharged to the specified unit type was calculated. The denominator is the total number of encounters at a given site. The median value, IQR, and range of these percentages are shown. Only the 36 sites with an IMCU are included.

2.3. Impact of IMCUs

To explore the possible contributions of IMCUs to PICU efficiency, we analyzed PICU LOS, the acuity of patients admitted to the PICU from general wards, early readmissions to the PICU, and unplanned PICU admissions from general wards.

Three PICU LOS metrics were studied—physical LOS (time from PICU admission to PICU discharge), medical LOS (time from PICU admission until documentation of medical readiness for PICU discharge), and wait time between these two measures. Medical discharge was determined by the date/time of a medical discharge order written by a physician or alternatively by the date/time of medical discharge readiness reflected in a progress note. If such dates/times of medical discharge were not available, these data were left blank. Unadjusted comparisons were made between sites with and without an IMCU of each median LOS using Mann-Whitney *U* tests. The adjusted effects of having an IMCU on the physical and medical LOS were evaluated with Cox proportional hazard models and were reported as hazard ratios (HR). The effect of having an IMCU on wait time was estimated using a multiple linear model. Not all sites reported medical LOS, so models of medical LOS and wait time were fitted using only the subgroup of observations that reported these data. Patients who died in the PICU were excluded from LOS analyses. We hypothesized that having a separate IMCU would be associated with shorter PICU LOS and PICU discharge wait times.

Patients with CCCs are frequently cared for in PICUs. IMCUs may be more capable than general wards of caring for them, and thus allow for more efficient PICU throughput. In order to estimate the impact of IMCUs on this patient subgroup, LOS analyses were repeated using only PICU patients with CCCs.

Similarly, patients dependent on chronic ventilation via tracheostomy are not managed on the general wards in many institutions. Thus, LOS analyses were repeated using only this patient sub-group, for the subgroup of sites with data that allowed identification of patients using chronic ventilation via tracheostomy [15]. For this analysis, sites with IMCUs that accepted/transferred PICU patients on chronic ventilation were compared to sites with an IMCU that did not accept such patients combined with sites without an IMCU.

Next, we used linear mixed modeling to examine the unit-level effect of having an IMCU on an institution's mean acuity of patients admitted to the PICU from general wards. PIM2 scores were used as a surrogate for acuity. We hypothesized that mean PIM2 scores would be higher in PICUs at hospitals with an IMCU compared to PICUs in hospitals without one, reasoning that IMCUs would divert the lowest acuity patients from the PICU. We repeated this analysis for only the subset of PICU patients admitted from IMCUs with the lowest quartile PIM2 scores, as potentially the most appropriate group for IMCU care.

Given that having an IMCU may alter early PICU readmission rates by providing an additional safe location to care for patients, we used linear regression to examine the association between having a separate IMCU and the rate of PICU readmissions within 48 h.

Finally, we used linear regression to examine the association of having an IMCU with the proportion of unplanned transfers to the PICU from the general wards at each hospital. We hypothesized that, of patients admitted to the PICU from the wards, fewer admissions would have been unplanned at hospitals with an IMCU compared to hospitals without one. We reasoned that an IMCU would admit some of the lower-acuity ward patients who were acutely worsening, thus allowing the PICU to admit proportionally more planned patients.

For each model, we controlled for the patient and institutional characteristics described above, plus each unit's average daily census by quarter. Because hospitals vary in their practice patterns, admissions from the same unit were clustered as a random effect. Due to non-linearity, age and PIM2 were transformed into cubic splines. We adjusted for PICU admission origin and discharge destination, and whether the