AUTHOR INFORMATION

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ABSTRACT

CONTEXT: Unplanned PICU readmissions within 48 hours of discharge (to home or a different hospital setting) are considered a quality metric of critical care.

OBJECTIVE: We sought to determine identifiable risk factors associated with early unplanned PICU readmissions.

DATA SOURCES: A comprehensive search of Medline, Embase, the Cochrane Database of Systematic Reviews, and Scopus was conducted from each database’s inception to July 16, 2018.

STUDY SELECTION: Observational studies of early unplanned PICU readmissions (<48 hours) in children (<18 years of age) published in any language were included.

DATA EXTRACTION: Two reviewers selected and appraised studies independently and abstracted data. A meta-analysis was performed by using the random-effects model.

RESULTS: We included 11 observational studies in which 128,974 children (mean age: 5 years) were evaluated. The presence of complex chronic diseases (odds ratio 2.42; 95% confidence interval 1.06 to 5.55; I² 79.90%) and moderate to severe disability (odds ratio 2.85; 95% confidence interval 2.40 to 3.40; I² 11.20%) had the highest odds of early unplanned PICU readmission. Other significant risk factors included an unplanned index admission, initial admission to a general medical ward, spring season, respiratory diagnoses, and longer initial PICU stay. Readmission was less likely after trauma- and surgery-related index admissions, after direct admission from home, or during the summer season. Modifiable risk factors, such as evening or weekend discharge, revealed no statistically significant association. Included studies were retrospective, which limited our ability to account for all potential confounders and establish causality.

CONCLUSIONS: Many risk factors for early unplanned PICU readmission are not modifiable, which brings into question the usefulness of this quality measure.

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Unplanned ICU readmissions are associated with considerable increased health expenditure. In a systematic review, it was found that adult patients readmitted to the ICU had an increased length of stay and up to 10 times higher odds of death compared with those who were never readmitted. Because of the recent improvement in pediatric care and the advancement of medical technology, the number of children who survive previously fatal conditions has increased significantly, shifting the epidemiology of the pediatric population from acute and curable diseases to chronic and complex conditions. Currently, children with chronic conditions represent 15% of the total pediatric population in the United States, but this number continues to increase. A subgroup of this population, children with complex chronic diseases (C-CDDs), who represent 0.4% to 0.7% of all children, composed 42% of the pediatric inpatient population and up to 53% of PICU admissions at any given time. As this population continues to grow, the PICU use will increase dramatically, and therefore so will the risk of PICU readmission. This highlights the importance of identifying modifiable factors that could lead to the development of strategies and programs to decrease early unplanned PICU readmission while reducing expenses.

Additionally, ICU and hospital readmission rates are currently considered reliable measures of performance. Readmission to the ICU within 48 hours of discharge was determined as the highest indicator of ICU quality by the Society of Critical Care Medicine Quality Indicators Committee in 1995. The Pediatric Data Quality System Collaborative Measure Workgroup proposed unplanned PICU readmission rate as one of the quality measures to be used in a systematic review to determine quality enhancement endeavors.

Our aim for this systematic review and meta-analysis was to determine identifiable risk factors associated with early unplanned PICU readmissions.

METHODS

This systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

Eligibility Criteria

Following a predesigned protocol, we included observational studies of children (<18 years) who presented to the hospital for an early unplanned PICU readmission (≤48 hours after the initial discharge). The control group was patients who did not require early readmission.

Data Sources and Search Strategies

Comprehensive electronic search strategies were designed and conducted by a medical reference librarian (L.J.P) with input from study investigators (Supplemental Information). Controlled vocabulary supplemented with keywords was used. Databases included Ovid Medline In-Process & Other Non-Indexed Citations, Ovid Medline, Ovid Embase, Ovid Cochrane Database of Systematic Reviews, and Scopus. Additionally, we reviewed the reference lists of the eligible primary studies and narrative reviews and queried experts. Additionally, abstracts from critical care–related meetings were searched, as well as Google Scholar, to identify any unpublished literature.

Studies located in the NICU were excluded. Selection of Studies

Search output was uploaded into a Web-based system (DistillerSR; Evidence Partners, Ottawa, Canada). Two independent reviewers screened titles and abstracts. Disagreements were considered eligible for the full-text review. During this phase, we achieved substantial agreement (κ = 0.77). During the full-text screening phase, conflicts between reviewers were solved by consensus. When consensus could not be achieved, a third-party arbiter determined the final inclusion.

Data Extraction

Two reviewers extracted data independently using a predesigned piloted Web-based extraction form. For each study, we obtained study design, setting, and outcomes of interest. We obtained a full description of the study participants, including age, sex, and inclusion and exclusion criteria. We also extracted the Pediatric Overall Performance Category (POPC) score (functional status evaluation based on observer impressions that classifies patient into 6 categories: good overall performance; mild, moderate, and severe overall disability; coma or vegetative state; brain death), which was performed on initial admission.

Methodologic Quality Assessment

To assess the methodologic quality of included studies (risk of bias), we used relevant components from the Newcastle-Ottawa Scale.

Data Analysis

All the outcomes included in this review are dichotomous; therefore, we measured the effect size using odds ratio (OR) with 95% confidence interval (CI). We chose the OR because we were expecting case-control and retrospective cohort studies. Estimates from each study were pooled by using the DerSimonian and Laird random-effects model and were depicted in forest plots. The random-effects model was chosen because of the observed differences among studies in terms of settings and patient characteristics. The I² statistic was used to measure the proportion of heterogeneity that was not attributable to chance.

Sensitivity Analysis

Because there may be significant clinical differences between the 2 populations included as control arms (patients who required late readmission versus patients who were never readmitted), we decided to conduct a post hoc sensitivity analysis, removing the studies that included patients who were readmitted after 48 hours in the control arm. Additionally, we considered that using patients who required later readmission as a control group was not ideal even when it met our inclusion criteria.

Assessment of Publication Bias

Publication bias is likely in retrospective studies. However, because of the small number of included studies (even smaller number of studies for each outcome) and the high heterogeneity, a formal assessment of publication bias would be unreliable.
RESULTS

Search Results and Study Characteristics

The initial search strategy yielded 3,116 potentially eligible studies, of which 147 were evaluated in the full-text version. Finally, 11 observational studies fulfilled our eligibility criteria and were included in our review. This process is depicted in Fig 1.

In the included studies (Table 1), a total of 128,974 patients were evaluated, 5,192 of them required early unplanned PICU readmissions. The mean age of all the evaluated patients was 5.13 years (0–18 years). In cohort studies, the proportion of patients with early unplanned PICU readmission varied from 1.2% to 3.7%. In 9 studies, patients who did not require readmission were used as controls; in the remaining 2 studies, early readmissions were compared with readmissions after 48 hours.12,13

Methodologic Quality Assessment

All of the included studies were retrospective; 7 of them were case-control studies, whereas 4 had a historical cohort design. The methodologic quality of the included studies was considered moderate to good in the context of observational studies. Details of this assessment are reported on Table 2.

Observed Associations

Patient Characteristics

Male sex, age, white race, and baseline Pediatric Index of Mortality score were not statistically significantly associated with early unplanned readmission.

The presence of ≥1 C-CD (4 studies) and moderate to severe disability (2 studies) revealed the strongest association with early unplanned PICU readmissions (C-CD: OR 2.42 [95% CI 1.06 to 5.55], P < .05, I² 79.90%; moderate to severe disability on initial admission: OR 2.85 [95% CI 2.40 to 3.40], P < .05, I² 11.20%). These results are summarized in Supplemental Fig 3.

Index Admission Characteristics

Patients admitted to the PICU from the general ward had higher odds of early unplanned readmission, whereas those admitted after surgical procedures (operating room or post anesthesia care unit [PACU]) or directly from home had decreased odds (Supplemental Fig 3A). The sensitivity analysis (removing the studies that included patients who were readmitted after 48 hours in the control arm) revealed consistent results (Fig 2). The season (possibly related to the presence of circulating viral pathogens) of the index admission also seemed to impact the odds of readmission. Readmissions were more likely after spring admissions and less likely after summer admissions.

A trauma diagnosis was associated with decreased early unplanned readmission. The sensitivity analysis (removing the studies that included patients who were readmitted after 48 hours in the control arm) revealed consistent results, and we also found that a respiratory diagnosis was associated with increased readmission (Fig 2, Supplemental Fig 4).

The initial length of stay in the PICU was statistically higher in the group that was ultimately readmitted (mean difference 3.8 [95% CI 2.65 to 4.95]; P < .05; I² not applicable), although this outcome was evaluated only in 1 study.14

Discharge Characteristics

Of the discharge characteristics evaluated (evening discharge, weekends discharge, disposition to general ward), none of them revealed a statistically significant association with unplanned early readmission. These results are summarized in Supplemental Fig 3A.

DISCUSSION

Main Findings

To our knowledge, this is the first systematic review and meta-analysis to be used to evaluate the risk factors associated with early unplanned PICU readmission. We found that the presence of C-CDs (OR 2.42 [95% CI 1.06 to 5.55]; P < .05; I² 79.90%) and moderate to severe disability (OR 2.85 [95% CI 2.40 to 3.40]; P < .05; I² 11.20%) had the highest association with early unplanned PICU readmission. Other significant risk factors were an unplanned index admission, an index admission from a general medical ward, length of the initial admission to the PICU, and an index admission during the spring. Conversely, early unplanned PICU readmission was less likely in children with a normal to mild POPC score, after an index admission that was...
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<th>Study, y, Country</th>
<th>Design</th>
<th>Setting</th>
<th>Population</th>
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<tbody>
<tr>
<td>Bernard et al,15 2013</td>
<td>Retrospective cohort</td>
<td>Tertiary care pediatric academic hospital</td>
<td>Patients with ≥1 PICU admission during a single hospitalization; admissions to the cardiac intensive care team were excluded</td>
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<tr>
<td>Czaja et al,12 2013</td>
<td>Retrospective cohort</td>
<td>75 PICUs in VPS (2005–2008); most were academic centers with an accredited pediatric residency program</td>
<td>All patients admitted to the PICU; children who died on their first admission or who were directly discharged from the ICU were excluded</td>
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<tr>
<td>De Kroon et al,16 2013</td>
<td>Case-control</td>
<td>Children’s hospital</td>
<td>All patients admitted to the PICU</td>
</tr>
<tr>
<td>Edwards et al,13 2013</td>
<td>Retrospective cohort</td>
<td>90 North American PICUs in VPS (2009–2011)</td>
<td>All patients admitted to the PICU</td>
</tr>
<tr>
<td>Kaur et al,14 2018</td>
<td>Case-control</td>
<td>Academic children’s hospital with a 16-bed mixed medical-surgical unit</td>
<td>All patients (0–17 y) who required unscheduled readmission to the PICU within 48 h were included. Controls were selected randomly from all patients who did not require readmission</td>
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<tr>
<td>Khan et al,17 2014</td>
<td>Retrospective cohort</td>
<td>PICU and step-down unit at a university hospital</td>
<td>Pediatric patients &lt;15 y</td>
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<tr>
<td>Kotsakis et al,18 2016</td>
<td>Case-control</td>
<td>Academic pediatric hospital with all subspecialty services available</td>
<td>Patients (index discharge) who survived to PICU discharge and were discharged to hospital wards</td>
</tr>
<tr>
<td>Linton et al,19 2009</td>
<td>Case-control</td>
<td>Children’s hospital</td>
<td>Children discharged from ICU</td>
</tr>
<tr>
<td>Mandell et al,20 2015</td>
<td>Case-control</td>
<td>Tertiary care, academic, freestanding children’s hospital</td>
<td>All patients ≤18 from the PICU to the pediatric ward; patients who were discharged directly from the PICU to home or transferred to another PICU were excluded</td>
</tr>
<tr>
<td>Odetola et al,21 2007</td>
<td>Case-control (retrospective analysis of prospectively collected data)</td>
<td>16-bed medical-surgical PICU and a 15-bed pediatric cardiac ICU at a tertiary care university children’s hospital</td>
<td>Data collected prospectively within the PRISM III data</td>
</tr>
<tr>
<td>Wagh et al,22 2013</td>
<td>Case-control (retrospective analysis of prospectively collected data)</td>
<td>22-bed cardiac and general PICU with ~100 admissions per year</td>
<td>PICU episodes were evaluated; no further details provided</td>
</tr>
</tbody>
</table>

NA, not available; NR, not reported; PRISM, Pediatric Risk of Mortality; VPS, Virtual Pediatric ICU Performance Systems.

* Median (interquartile range).

b Information only available for the patients who were readmitted.

c Mean (range).
<table>
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<tr>
<th>Study</th>
<th>Design</th>
<th>Is the Case Definition Adequate?</th>
<th>Are the Cases Representative?</th>
<th>Is the Control Definition Adequate?</th>
<th>Was the Control Selection Appropriate?</th>
<th>Ascertainment of Exposure</th>
<th>Same Method of Ascertainment for Cases and Controls</th>
<th>Nonresponse Rate</th>
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<tr>
<td>Bernard et al.¹⁵ 2013</td>
<td>Retrospective cohort</td>
<td>Yes, based on medical records</td>
<td>Yes, consecutive patients</td>
<td>Patients admitted to the same PICU who required readmission &gt;48 h later</td>
<td>Hospital controls</td>
<td>Yes, per design</td>
<td>Yes, based on secure records</td>
<td>Yes 0</td>
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<tr>
<td>Czaja et al.¹² 2013</td>
<td>Retrospective cohort</td>
<td>Yes, based on secure database information</td>
<td>Yes, consecutive patients</td>
<td>Patients admitted to the same PICUs who required readmission &gt;48 h later</td>
<td>Hospital controls</td>
<td>Yes, per design</td>
<td>Yes, based on secure records</td>
<td>Yes 0</td>
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<tr>
<td>De Kroon et al.¹⁹ 2013</td>
<td>Case-control</td>
<td>Yes, based on secure medical records</td>
<td>Yes</td>
<td>Patients admitted to the PICU who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure medical records</td>
<td>Yes 0</td>
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<tr>
<td>Edwards et al.¹³ 2013</td>
<td>Retrospective cohort</td>
<td>Yes, based on secure database information</td>
<td>Yes</td>
<td>Patients admitted to the same PICUs who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure records</td>
<td>Yes 0</td>
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<tr>
<td>Kaur et al.¹⁴ 2018</td>
<td>Case-control</td>
<td>Yes, based on secure database information</td>
<td>Yes</td>
<td>Patients admitted to the PICU who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure medical records</td>
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<tr>
<td>Khan et al.¹⁷ 2014</td>
<td>Retrospective cohort</td>
<td>Yes, based on secure medical records</td>
<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure medical records</td>
<td>Yes 0</td>
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<tr>
<td>Kotsakis et al.¹⁸ 2016</td>
<td>Case-control</td>
<td>Yes, source of information unclear</td>
<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure medical records</td>
<td>Yes 0</td>
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<tr>
<td>Linton et al.¹⁹ 2009</td>
<td>Case-control</td>
<td>Yes, based on secure medical records</td>
<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission</td>
<td>Yes, per design</td>
<td>Yes, based on secure medical records</td>
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<tr>
<td>Mandell et al.²⁰ 2015</td>
<td>Case-control</td>
<td>Yes, based on secure medical records</td>
<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission after being discharge to the pediatric ward</td>
<td>Yes, per design</td>
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TABLE 2 Continued

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<th>Study</th>
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<th>Comparability of Cases and Controls Based on Exposure</th>
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<tr>
<td>Odetola et al</td>
<td>Case-control</td>
<td>Yes, based on secure medical records</td>
<td>Yes, no history of PICU admission</td>
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<td>2007</td>
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<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission</td>
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<tr>
<td>Wagh et al</td>
<td>Case-control</td>
<td>Yes, based on secure medical records</td>
<td>Yes, patients discharged from the same PICU at different time</td>
<td>Yes</td>
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<td>2013</td>
<td></td>
<td>Yes</td>
<td>Patients admitted to the same PICU who did not require readmission</td>
<td>Yes</td>
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As expected, the presence of chronic medical conditions and moderate to severe disability, which, in the absence of other factors, can increase the odds of a child having an early unplanned readmission compared with children who were never readmitted. Discharge after hours or on weekends did not increase readmission odds.

Limitations and Strengths

The strengths of this systematic review include the following:

1. Methodological rigour: The review used a systematic approach to identify, select, and assess studies.
2. Comprehensive search: The review included a comprehensive search of multiple databases.
3. Quality assessment: The review included a quality assessment of the included studies.
4. Meta-analysis: The review included a meta-analysis of the included studies.

Limitations of this systematic review include the following:

1. Language bias: The review was limited to English-language studies.
2. Heterogeneity: The review included studies with varying methodology and outcomes.
3. Publication bias: The review may have missed studies that were not published.
4. Risk of bias: The review may have underestimated the risk of bias in the included studies.

Implications for Practice and Research

There is a need for prospective studies to determine causality and identify modifiable patient and system-related factors that contribute to early unplanned PICU readmission. Current research is focused on modifiable determinants of early PICU readmission. Future research should include patients with chronic conditions who account for more than 75% of all PICU admissions. Because the number of patients with chronic conditions continues to grow, we can expect the number of PICU admissions to increase in the near future. Changes are required to appropriately manage resources and adequately monitor quality of care in this population. Identifying risk factors leading to readmission and mortality before initial discharge could have a significant impact on prognosis and future care.

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CONCLUSIONS

The presence of C-CDs and disability seems to be the highest determinant of early unplanned PICU readmission.

Future prospective studies with clear and standardized definitions of C-CDs and the power to establish causality are key in the development of strategies to decrease early unplanned PICU readmission while decreasing expenses.

REFERENCES


Is Unplanned PICU Readmission a Proper Quality Indicator? A Systematic Review and Meta-analysis


*Hospital Pediatrics* originally published online January 27, 2021;

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<th>Updated Information &amp; Services</th>
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