

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

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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; I^2 79.90%) and moderate to severe disability (odds ratio 2.85; 95% confidence interval 2.40 to 3.40; I^2 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.¹

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.² A subgroup of this population, children with complex chronic diseases (C-CDs), who represent 0.4% to 0.7% of all children, composed 42%³ of the pediatric inpatient population and up to 53% of PICU admissions at any given time.⁴ 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 1995.⁵ 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.⁶

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.⁷

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 ($\kappa = 0.77$).

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.⁸

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 Laird⁹ 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 I^2 statistic was used to measure the proportion of heterogeneity that was not attributable to chance.¹⁰

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.¹¹

RESULTS

Search Results and Study Characteristics

The initial search strategy yielded 3116 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, 5192 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], $P < .05$, I^2 79.90%; moderate to severe disability on initial admission: OR 2.85 [95% CI 2.40 to 3.40], $P < .05$, I^2 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

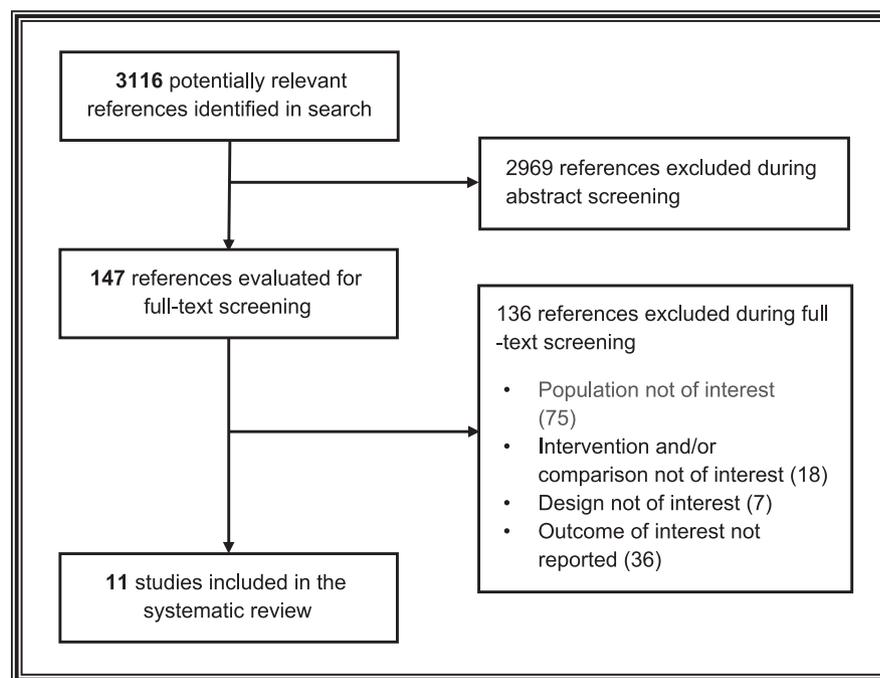


FIGURE 1 References flowchart.

(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]; $P < .05$; I^2 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]; $P < .05$; I^2 79.90%) and moderate to severe disability (OR 2.85 [95% CI 2.40 to 3.40]; $P < .05$; I^2 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

TABLE 1 Study Characteristics

Study, y	Country	Design	Setting	Population	N	Early Unplanned Readmissions, n (%)	Age, y
Bernard et al, ¹⁵ 2013	United States	Retrospective cohort	Tertiary care pediatric academic hospital	Patients with ≥ 1 PICU admission during a single hospitalization; admissions to the cardiac intensive care team were excluded	212	70 (33.01)	NR
Czaja et al, ¹² 2013	United States	Retrospective cohort	73 PICUs in VPS (2005–2008); most were academic centers with an accredited pediatric residency program	All patients admitted to the PICU; children who died on their first admission or who were directly discharged from the ICU were excluded	3798	1499 (39.47)	NR
De Kroon et al, ¹⁶ 2013	Netherlands	Case-control	Children's hospital	All patients admitted to the PICU	3368	1024 (NA)	NR
Edwards et al, ¹³ 2013	United States	Retrospective cohort	90 North American PICUs in VPS (2009–2011)	All patients admitted to the PICU	95 028	1161 (1.22)	0–18
Kaur et al, ¹⁴ 2018	United States	Case-control	Academic children's hospital with a 16-bed mixed medical-surgical unit	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.	256	86 (NA)	3.75 (0.8–10.1) ^a
Khan et al, ¹⁷ 2014	Pakistan	Retrospective cohort	PICU and step-down unit at a university hospital	Pediatric patients <15 y	1022	24 (2.34)	4.07 (0–8.49) ^{bc}
Kotsakis et al, ¹⁸ 2016	Canada	Case-control	Academic pediatric hospital with all subspecialty services available	Patients (index discharge) who survived to PICU discharge and were discharged to hospital wards	6370	135 (NA)	5.27 (0.96–12.87) ^a
Linton et al, ¹⁹ 2009	Australia	Case-control	Children's hospital with the largest PICU in the country; access to all medical and surgical pediatric subspecialties	Children discharged from ICU	375	114 (NA)	3.65 (0–19) ^c
Mandell et al, ²⁰ 2015	United States	Case-control	Tertiary care, academic, freestanding children's hospital	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	189	38 (NA)	7.27 (1.4–14.3) ^a
Odetola et al, ²¹ 2007	United States	Case-control (retrospective analysis of prospectively collected data)	16-bed medical-surgical PICU and a 15-bed pediatric cardiac ICU at a tertiary care university children's hospital	Data collected prospectively within the PRISM III data	8885	711 (NA)	2.93 (0.46–10.68) ^a
Wagh et al, ²² 2013	United Kingdom	Case-control (retrospective analysis of prospectively collected data)	22-bed cardiac and general PICU with ~ 1100 admissions per year	PICU episodes were evaluated; no further details provided	9471	330 (NA)	NR

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

^a Median (interquartile range).

^b Information only available for the patients who were readmitted.

^c Mean (range).

TABLE 2 Methodologic Quality Assessment

Study	Design		Selection		Comparability of Cases and Controls Based on Design or Analysis		Exposure	
	Is the Case Definition Adequate?	Are the Cases Representative?	Is the Control Definition Adequate?	Was the Control Selection Appropriate?	Ascertainment of Exposure	Same Method of Ascertainment for Cases and Controls	Nonresponse Rate	
Bernard et al, ⁵ 2013	Yes, based on medical records	Yes, consecutive patients	Patients admitted to the same PICU who required readmission >48 h later	Hospital controls	Yes, based on secure records	Yes	0	
Czaja et al, ¹² 2013	Yes, based on secure database information	Yes, consecutive patients	Patients admitted to the same PICUs who required readmission >48 h later	Hospital controls	Yes, based on secure records	Yes	0	
De Kroon et al, ¹⁶ 2013	Yes, based on secure medical records	Yes	Yes, no history of PICU readmission	Patients admitted to the same PICU who did not require readmission	Yes, based on secure medical records	Yes	0	
Edwards et al, ¹³ 2013	Yes, based on secure database information	Yes	Yes, no history of PICU readmission	Patients admitted to the PICUs (same database) who did not require readmission	Yes, based on secure records	Yes	0	
Kaur et al, ¹⁴ 2018	Yes, based on secure database information	Yes	Yes, no history of PICU readmission	Controls were selected randomly from all patients who did not require readmission	Yes, based on secure medical records	Yes	0	
Khan et al, ¹⁷ 2014	Yes, based on secure medical records	Yes	Yes, no history of PICU readmission	Patients discharged from the PICU to the step-down unit who did not require readmission to the PICU	Yes, based on secure medical records	Yes	0	
Kotsakis et al, ¹⁸ 2016	Yes, source of information unclear	Yes	Yes, no history of PICU readmission	Patients admitted to the same PICU who did not require readmission	Yes, based on secure medical records	Yes	0	
Linton et al, ¹⁹ 2009	Yes, based on secure medical records	Yes	Yes, no history of PICU readmission	Patients admitted to the same PICU who did not require readmission	Yes, based on secure medical records	Yes	0	
Mandall et al, ²⁰ 2015	Yes, based on secure medical records	Yes	Yes, no history of PICU readmission	Patients admitted to the same PICU who did not require readmission after being discharged to the pediatric ward	Yes, based on secure medical records	Yes	0	

TABLE 2 Continued

Study	Design	Selection			Comparability of Cases and Controls Based on Design or Analysis		Exposure		Nonresponse Rate
		Are the Cases Representative?	Is the Control Definition Adequate?	Was the Control Selection Appropriate?	Ascertainment of Exposure	Same Method of Ascertainment for Cases and Controls			
Odetola et al. ²¹ 2007	Case-control	Yes	Yes, based on secure database information	Patients admitted to the same PICU who did not require readmission	Yes, per design	Yes, based on secure medical records	Yes	0	
Wagh et al. ²² 2013	Case-control	Yes	Yes, based on secure database information	Yes, patients discharged from the same PICU at different time	Yes, per design	Yes, based on secure records	Yes	0	

secondary to trauma, after a surgery or procedure, in an index admission from home, or during summer. Respiratory diagnoses during the index admission increased 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.

Implications for Practice and Research

As expected, the presence of C-CDs and moderate to severe disability, which, in practice, go hand to hand, were highly associated with early unplanned readmission. This represents an immense challenge for care planning. Currently, patients with C-CDs account for >75% of all PICU resources.² Because the number of patients with C-CDs continues to grow,² we can expect the number of PICU admissions, readmissions, and secondary costs 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 subsequent complications and mortality before initial discharge could have significant impact on prognosis and future care.

Modifiable risk factors that have been associated with increased risk of hospital readmission (not specifically to the PICU) and may be applicable to the PICU setting were not evaluated in the included studies. Authors of a systematic review found that lack of adherence to treatment and follow-up recommendations, no home visitation after discharge, lack of parent participation in the development of the treatment plan, inadequate communication or involvement of primary care provider, and insurance problems were significantly associated with an increased rate of hospital readmissions.²³ System-related factors, such as number of beds, patient to nurse and/or physician ratios, and the presence of centrally coordinated care, should also be considered. Evaluating these factors in future studies may shed some light into possible strategies and programs that could modify care and decrease early unplanned

readmissions to the PICU and the associated increase in cost and mortality.

Even when early unplanned PICU readmission meets some of the criteria established by the National Quality Forum as a quality indicator, such as evidence based (proven association with increased mortality) and reliability (well defined),²⁴ its use seems unreasonable and impractical and the path of improvement is unknown. This is not limited to children. Similarly, researchers of one of the largest single-center cohort studies of adult patients focused on modifiable determinants of ICU readmission found that the only modifiable factor associated with ICU readmission was dependence on inotrope on the last day and concluded that in the absence of other modifiable factors, readmission does not fulfill the criteria for a useful quality indicator.²⁵

There is a need for prospective studies to determine causality and identify the modifiable patient- and system-related factors on which quality improvement endeavors can be developed and our current measures can be reevaluated.

Limitations and Strengths

The strengths of this systematic review relate to the measures undertaken to reduce the effect of bias and error: predefined protocol-driven procedures and duplicate review.

Key limitations of the included evidence have to be taken into account. Because of the small number of studies included, the number of trials in each comparison was markedly limited. This added to the variability in PICU populations between hospitals; the differences in the settings and risk factor definitions among the included studies limited the synthesis of findings as well as their applicability and created significant heterogeneity. We were unable to statistically evaluate the presence of publication bias. Publication bias is likely in a body of evidence that consists of unregistered observational studies. Additionally, all of the included studies were retrospective (case-control and retrospective cohort studies), which limits conclusions about causality.

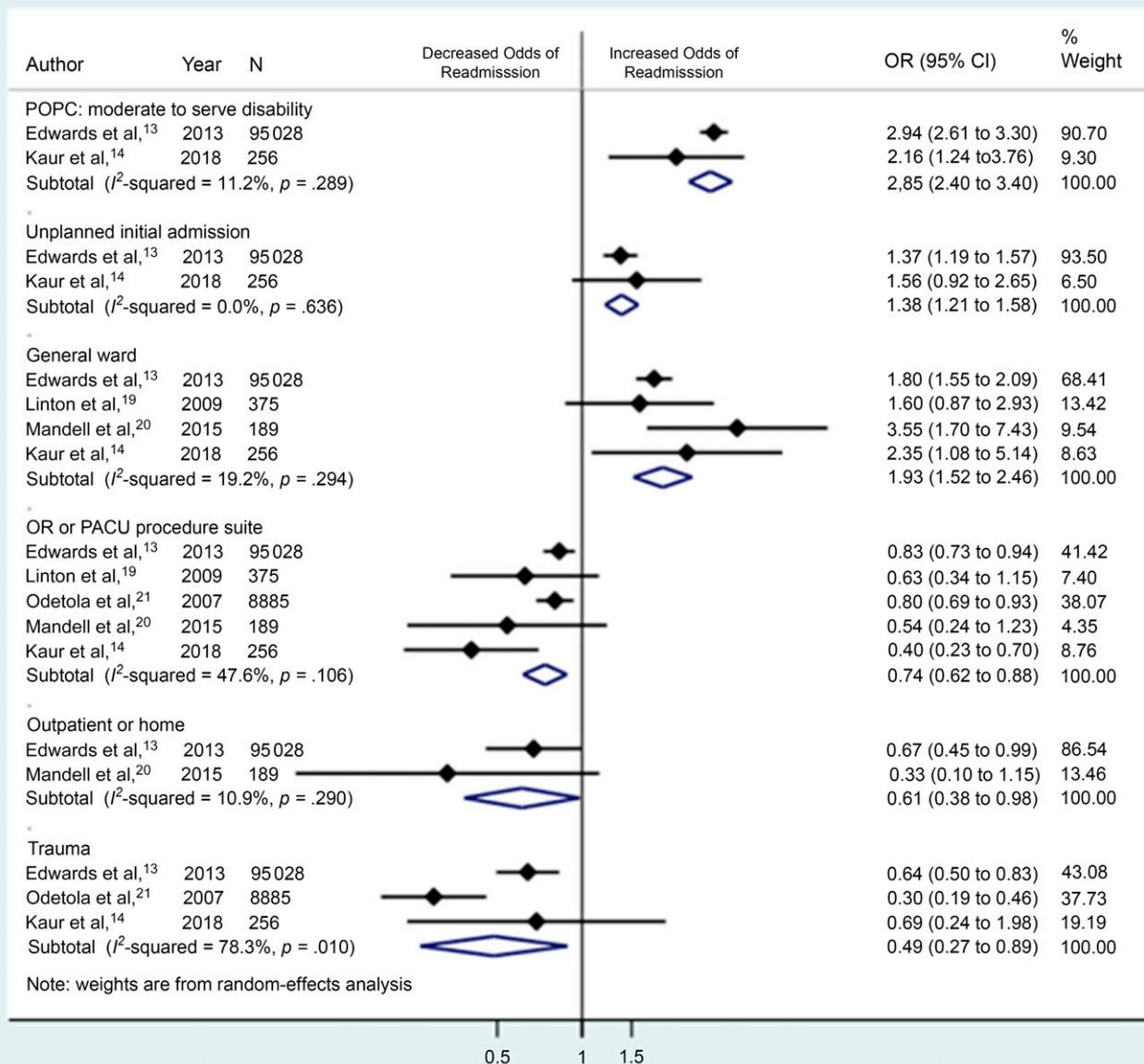


FIGURE 2 Index admission characteristics: sensitivity analysis. Studies that included patients who were readmitted after 48 hours in the control arm were removed in our sensitivity analysis.

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.

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