Readiness of Emergency Departments for Pediatric Patients: A Systematic Review

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Contributions:
All authors contributed to the conception and design of the work, and the acquisition, analysis and interpretation of the data. All authors drafted the manuscript, revised it critically for important intellectual content, and provided final approval of the version to be published. All authors agree to be accountable for all aspects of the work.

ABSTRACT

Background:
The majority of children that need emergency care visit general emergency departments (EDs) and urgent care centres, which have a wide range of experience with pediatric patient care. The weighted pediatric readiness score (WPRS) is currently used to evaluate EDs readiness for pediatric patients. The aim of this study was to determine if a higher WPRS was associated with decreased mortality, improved health outcomes, and healthcare utilization.

Methods:
A systematic review was completed. A comprehensive search strategy was developed and implemented in MEDLINE(OVID), Embase(Ovid), the Cochrane Library(Wiley), CINAHL(EBSCO), Global Health(Ovid), and Scopus from inception until May 25, 2020 and then an updated search was performed on June 16, 2021. Articles identified were screened for inclusion by 2 independent reviewers. Articles included in the final analysis were assessed for quality and bias using the Newcastle-Ottawa Scale.

Results:
The initial search identified 1263 articles, and the updated search identified 186 more articles. Of these articles, 6 were included in the final analysis. Three of the 6 studies showed an inverse association between WPRS and pediatric mortality (pooled OR 0.52, 95%CI 0.2 to 1.06) in random effect meta-analysis. Other studies reported that higher WPRS was associated with shorter length of stay in hospital (β –0.36, 95%CI –0.61 to –0.10) and less interfacility transfers (OR 0.55, 95%CI 0.33 to 0.93).

Interpretation:
Children presenting to EDs with higher WPRS have a lower risk of mortality. These findings can help advocate for improved pediatric readiness across EDs in order to improve outcomes.

Protocol: PROSPERO-CRD42020191149

INTRODUCTION

Children make up approximately 20% of the total emergency department (ED) visits in Canada[1] and the United States[2] each year. A portion of these ED visits are to specialized pediatric EDs, however the majority of the visits are to general EDs or urgent care centres, which have a wide range of experience with pediatric patient care.[3] Therefore, it is important to ensure all EDs are optimizing pediatric patient outcomes and safety independent of their pediatric patient volumes, location, or presentations.

There is a growing literature evaluating ED readiness to provide optimal medical care to acutely ill and injured pediatric patients. The weighted pediatric readiness score (WPRS) was developed as part of the National Pediatric Readiness Project (NPRP)[4] to assess the level of readiness of EDs to care for pediatric patients. The 100-point scale includes weighted items in the categories of pediatric specific infrastructure, administration and coordination, personnel, pediatric-specific policies, equipment, and resources.[5] The goal of the WPRS is to identify areas of improvement for EDs in order to maximize readiness to care for pediatric patients.[3–6] The NPRP assessment of EDs across the United States in 2013 identified that the median WPRS was 68.9, suggesting that many EDs are missing key components of pediatric readiness.[5]

Recent literature also suggests that higher pediatric readiness scores are associated with better pediatric patient outcomes, including a recent study by Ames et al who found that high pediatric readiness scores are associated with a 4-fold decreased risk of mortality,[7] however there is not yet consensus in the literature. Therefore, the primary objective of this study was to conduct a systematic review and meta-analysis to determine if a higher pediatric readiness score results in a decreased mortality rate for children presenting to EDs and urgent care centres. The secondary objective was to determine if higher pediatric readiness scores result in improved healthcare outcomes and healthcare utilization.

METHODS

The systematic review was reported in accordance with the PRISMA 2020 statement,[8] and the protocol was registered with PROSPERO in June 2020 (registration number CRD42020191149). The primary objective of the study was to determine if higher WPRS is associated with lower rates of mortality in children presenting to EDs and urgent care centres, by synthesising current research and conducting meta-analysis where possible. The secondary objective of this review was to determine if higher WPRS results in improved healthcare outcomes and utilization of healthcare resources.

Search strategy and study selection

A systematic search of the literature was completed to identify potentially relevant studies. An experienced health sciences librarian designed and executed the search strategy, using a combination of subject terms and keywords that were later translated for each database. A slightly modified version of a validated filter was used to focus the search on a pediatric population.[9] Searches were performed in MEDLINE (OVID), Embase (Ovid), the Cochrane Library (Wiley), CINAHL (EBSCO), Global Health (Ovid), and Scopus from inception until May 25, 2020 and then an updated search was performed on June 16, 2021. The MEDLINE

search was peer-reviewed by an independent health sciences librarian as per the PRESS guidelines.[10] Our search strategy is available in Appendix 1. The searches were designed to be broad and no restrictions were used. Identified studies were deduplicated in EndNote (Version X9).

We included studies if they met all of the following criteria: (1) conducted in an acute care facility that care for children, including EDs or Urgent Care Centres, (2) used the pediatric readiness score or WPRS, (3) compared low versus high or use versus non use of WPRS, (4) included one of the relevant outcomes, such as mortality, healthcare outcomes, or healthcare utilization, (5) observational studies, including cohort and cross-sectional studies, or controlled-clinical study, and (5) published in English language. Studies were excluded if the outcome was not relevant, did not include pediatric patients (defined as age ≤ 21 years), or if setting was outside of an acute care facility.

The articles identified in the literature search were first screened by title and abstracts for inclusion in the systematic review by two independent reviewers. The two independent reviewers then reviewed the full-length manuscripts for inclusion in the final analysis. Disagreements during screening were resolved by discussion between reviewers.

Data Extraction

The data from the included studies was extracted by two independent reviewers. Reviewers used a customized data extraction tool to identify key characteristics of the articles, including information on study design, objectives, population, intervention, outcomes, and conclusion details. The tool was used to pilot test five studies after which it was adopted for the entire included studies. A third reviewer examined the data to ensure accuracy and identified any errors.

Risk of bias assessment

The included articles were assessed for quality and bias using the Newcastle-Ottawa Scale (NOS),[11] a validated critical appraisal checklists for nonrandomised observational studies. The NOS rates articles on a star system in order to evaluate the selection of study groups, comparability of groups, and ascertainment of exposure or outcome of interest.[11] Two reviewers independently completed the risk of bias assessment, and disagreements were resolved by a third reviewer.

Data Analysis and Synthesis

Data were collected and managed using Excel and Covidence. Individual article characteristics were summarized and presented in tabular form, and the results were thematically compared based on the systematic review of primary and secondary objectives. We used Review Manager 5.4. to perform the statistical analysis to generate the forest plot that showed the point estimates with 95% confidence interval (CI) of the studies included in the meta-analysis.

The association between WPRS and mortality was examined in random-effects models. The pooled estimate of odds ratio (OR) with 95% CI was computed and demonstrated graphically with a diamond in the forest plot. The I^2 statistic was calculated to quantify study heterogeneity.

RESULTS

Search results

The search and study screening were conducted initially in May 2020, with an update performed in June 2021 (Figure 1). The initial systematic search of the databases identified 1263 articles. After duplicates articles were excluded (n=596), 667 abstracts were included in the initial screening process. After reviewing titles and abstracts, 12 articles were included in the full text review. Of the full text manuscripts reviewed, 9 were excluded, resulting in 3 studies included in the final analysis. Reasons for article exclusion included no abstract (n=86, 12%), no full text article (n=4, 1%), wrong population (n=407, 59%), wrong intervention (n=125, 18%), wrong control (n=9, 1%), wrong outcome (n=19, 3%), or wrong study design (n=14, 2%).

The updated search identified 186 more articles. After duplicates were excluded (n=80), 106 articles were screened for eligibility. After reviewing the titles and abstracts, 13 articles were included in the full text review. A further 10 studies were excluded based on wrong publication type (n=1), wrong study design (n=1), wrong population (n=1), wrong intervention (n=3), wrong outcome (n=3), and previously included in the initial screening (n=1). Therefore, 3 further studies were included in the final analysis from the update, resulting in a total of 6 studies included in the final analysis.

Characteristics of included studies

Characteristics of studies included in the analysis are presented in Table 1. Of the six included studies, 5 were conducted in the United States[7,12–15] and 1 in Latvia.[16] All 6 studies were completed in EDs.

Outcomes

Primary Outcome: Mortality

Three studies included the primary outcome of interest pediatric mortality[7,13,16] (Table 2). The study by Ames et al[7] compared high and low WPRS scores with EDs' mortality rates, presented as OR. The study demonstrated that critically ill children have a significantly lower risk of mortality if they present to an ED with a high WPRS (4th quartile: OR 0.25, 95% CI 0.18 to 0.37).[7] Secondary analysis showed no significant association between ED pediatric readiness scores and mortality for children with cardiac arrest (4th quartile: OR 0.23, 95% CI 0.02 to 2.16) or sepsis (4th quartile: OR 0.59, 95% CI 0.05 to 7.31). However they did identify a significant decrease in mortality risk for children with traumatic brain injury (TBI) presenting to EDs with WPRS in the 4th quartile (OR 0.21, 95% CI 0.06 to 0.78).[7] The second study by Balmaks et al[16] demonstrated that higher WPRS was associated with lower 6-month mortality (OR 0.93, 95% CI 0.88 to 0.98). The study by Newgard et al[13] evaluated the association between ED pediatric readiness and in hospital mortality among injured children presenting to trauma centres. This study also demonstrated that injured children who were treated in trauma centres with high WPRS had lower risk of mortality (4th quartile: OR 0.58, 95% CI 0.45 to 0.75).

Random effects meta-analysis was conducted to examine the association between WPRS and mortality (Figure 2). The pooled estimate of OR of the 3 included studies[7,13,16] was 0.52 (95% CI 0.26 to 1.06). I^2 was 97%, indicating high heterogeneity between the three studies.

Secondary Outcome: Healthcare Outcomes and Utilization

Four studies included the secondary outcome of interest[12,14–16] (Table 3). The study by Ray et al[12] quantified children's geographic access to EDs in the United States with high WPRS. They identified that 93.7% of children have access to an ED within a 30 minute drive.[12] 33.7% of children in the US have access to an ED with WPRS of 100th percentile, and 55.3% had WPRS score ≥ 90th percentile.[12] The study by Balmaks et al[16] showed that higher WPRS was associated with shorter ICU length of stay (β –0.06, 95% CI –0.10 to –0.01) and shorter hospital length of stay (β –0.36, 95% CI –0.61 to –0.10).

Both studies by Lieng et al[14,15] investigated the association between WPRS and transfers between facilities. Lieng et al[14] found that a 10 point increase in WPRS is associated with lower odds of potentially avoidable transfers in injured (OR 0.92, 95% CI 0.86 to 0.98) and noninjured (OR 0.94, 95% CI 0.88 to 1.00) children. Additionally, Lieng et al[15] concluded that children presenting to small rural hospital EDs with higher WPRS are less likely to be transferred to another facility (OR 0.55, 95% CI 0.33 to 0.93).

Risk of bias across studies

The Newcastle-Ottawa Scale (NOS)[11] was used to evaluate the included studies. The results of the assessment are presented in Table 4. All 6 studies were rated as having a low risk of bias in all categories, except all scored high risk for selection bias as none could demonstrate that the outcome of interest was not present at the start of the study.

INTERPRETATION

To our knowledge, this is the first systematic review examining the impact of a higher pediatric readiness score on pediatric patient outcomes. Our findings highlight that a critically ill or injured child who presents to an ED with a high pediatric readiness score has a lower risk of mortality than a child presenting to an ED with low pediatric readiness score. Our study also identified that higher pediatric readiness scores as assessed by WPRS are associated with shorter length of stay in hospital and lower rates of interfacility transfer, which can have an impact on patient outcomes.

The three articles included in the systematic review that assessed pediatric mortality in relation to WPRS found that higher WPRS significantly lowers the risk of mortality.[7,13,16] All studies looked at a diverse range of centres and pediatric volumes, suggesting that these findings are relevant for a wide range of different EDs. When combined in the random effects meta-analysis, there was a trend towards higher WPRS being associated with lower risk of mortality. These findings have important implications for pediatric emergency medicine, as they support all hospitals advocating for improved access to pediatric specific resuscitation equipment, medication dosing, interfacility transfer guidelines, ED policies, and care coordinators.[4] As higher WPRS and being more prepared to care for critically ill and injured children directly impacts risk of mortality, emphasis should be placed on preparing all EDs for children.

The systematic review also highlighted a number of important healthcare utilization outcomes associated with pediatric readiness. Length of stay in the intensive care unit and hospital is a common quality indicator for patient care, as well as an important factor when considering hospital resource allocation.[17] Length of stay is a multifactorial measure, however if

by increasing WPRS hospital length of stay decreases this has positive impact on the patient, patient outcomes, and hospital costs and resource use.

Ill and injured children present to a wide variety of EDs. Ray et al[12] identified that 93.7% of children in the United States live within a 30 minute drive of any ED, however only 33.7% of children live within a 30 minute drive of an ED with WPRS of 100. Improving ED readiness to children in all types of centres could lead to improved mortality rates for children.[18–20] As well, if children are presenting to hospitals with low readiness scores, they are more likely to require interfacility transportation, as concluded by Leing et al.[14,15] Although sometimes necessary, interfacility patient transfers can have increased risk of psychological distress, delay in accessing care, repetition of care, communication issues, increased mortality, and increased costs.[5,21]

Limitations

There are a number of limitations to the study. One limitation is that there were relatively few studies identified during the systematic review, which limits the strength of the meta-analysis. We were also unable to conduct a meta-analysis for the secondary outcomes due to the wide range out outcomes in the included studies. However, the secondary outcomes consistently supported the improvement of WPRS in EDs. The WPRS is a relatively new score,[4,5] which may explain why there is limited published data on readiness scores and pediatric outcomes. Although we performed a comprehensive literature search and had 2 individuals screening articles, there is a possibility that relevant studies could have been missed.

Future Directions

Future research is needed to continue to explore the association between pediatric readiness scores and mortality, as well as the role of WPRS in EDs in rural or remote communities, and whether location impacts WPRS and mortality. In order to advocate for implementation of WPRS and pediatric readiness in all EDs, barriers to implementation and strategies for improvement should be explored as well. More rigorous studies of WPRS, such as randomized control trials, would be beneficial in order to identify evidence based strategies to improve WPRS and pediatric mortality.

Conclusion

Children presenting to emergency departments with higher pediatric readiness scores have a lower risk of mortality and better health outcomes. These findings can help advocate for improved pediatric readiness across EDs in order to improve outcomes.

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Table 1. Study Characteristics

Publication, Country	Study design	Study period	Type of centre, N	Study objective	Volume of ED	Number of participants	Mean age (age range)
Ray et al, 2018, United States[12]	Cross-sectional	Data collection: January 1 to August 23, 2013	ED, 4090	To determine the geographic accessibility of emergency departments (EDs) with high pediatric readiness by assessing the percentage of US children living within a 30–min drive time of an ED with high pediatric readiness.	Number of ED centres, ED Volume N = 739, Low (<4999) visits N = 490, Medium (5000–9999) visits N = 2861, High (>10 000) visits	N/A	N/A (0–17 years)
Ames et al, 2019, United States[7]	Retrospective cohort	Data collection: January 1 to August 31, 2013	ED, 426	To determine the proportion of patients presenting to EDs with various levels of pediatric readiness and to evaluate if ED pediatric readiness is associated with mortality.	Number of ED centres, annual pediatric ED volume reported in quartiles (Q1 lowest WPRS and Q4 highest WPRS): frequency (%) Low (<1800) visits: N = 107, Q1: 64 (59.8) N = 106, Q2: 52 (49.1) N = 107, Q3: 29 (27.1) N = 106, Q4: 8 (7.5) Medium (1800–4999) visits: N = 107, Q1: 26 (24.3) N = 106, Q2: 34 (32.1) N = 107, Q3: 37 (34.6) N = 106, Q4: 16 (15.1) Medium-to-high (5000–9999) visits: N = 107, Q1: 14 (13.1) N = 106, Q2: 13 (12.3) N = 107, Q3: 22 (20.6) N = 106, Q4: 20 (18.9) High (>10000) visits: N = 107, Q1: 3 (2.8) N = 106, Q2: 7 (6.6) N = 107, Q3: 19 (17.8) N = 106, Q4: 62 (58.5)	20483	Mean age reported in quartiles Q1: 8.5 ± 6.6 years Q2: 9.6 ± 6.0 years Q3: 6.9 ± 6.2 years Q4: 7.0 ± 5.9 years (0–18 years)
Balmaks et al, 2020, Latvia[16]	Prospective cohort	Data collection: June 1, 2017 to May 31, 2018 Recruitment: September 24, 2017 to April 26, 2018	ED, 16	To assess the quality of pediatric acute care and pediatric readiness and determine their association with patient outcomes using a patient registry.	Number of ED centres, ED volume: median total pediatric population/year (IQR) N = 5, Low (<1800) visits: 1238 (809–11916) N = 6, Medium (1800–4999) visits: 2746 (1965–3000) N = 4, Medium-to-high (5000–9999) visits: 7703 (5572–7160) N = 1, High (>10000) visits: 63905	254	Mean = N/A Median age = 61 months (17–159 months)
Lieng et al, 2021, United States[14]	Cross-sectional	Data collection: January 1, 2011 to December 31, 2013	ED, 283	To determine the association between potentially avoidable transfers (PATs) and ED pediatric readiness scores and the score's associated components.	Number of ED centres, ED volume N = 275, median (IQR) = 6820 (3148-11042) N = 269, median (IQR) = 6876 (3167-11046)	25601	N/A (0–18 years)
Lieng et al, 2021, United States[15]	Cross-sectional	Data collection: 2011 to 2012	ED, 54	To determine the association of pediatric readiness scores with the odds of interfacility transfer among a cohort of noninjured children (< 18 years old) presenting to EDs in small rural hospitals in the state of California.	Number of ED centres, ED volume Low WPRS ≤ 70 N = 44, median (IQR) = 2194 (1350-4412) High WPRS >70 N = 10, median (IQR) = 2696 (1618-4694)	135388	N/A (0–18 years)
Newgard et al, 2021, United States[13]	Retrospective cohort	Data collection: January 1, 2012 to December 31, 2017	ED, 832	To evaluate the association between ED pediatric readiness, in-hospital mortality, and in-hospital complications among injured children presenting to US trauma centers.	Number of ED centres, Annual pediatric ED volume in quartiles: Low (1-4,900), n (%): N = 832, Overall: 160 (19.2%) N = 217, Q1: 51 (23.5%) N = 199, Q2: 45 (22.6%) N = 221, Q3: 41 (18.6%) N = 195, Q4: 23 (11.8%) Medium (4,900-8,400), n (%): N = 832, Overall: 86 (10.3%) N = 217, Q1: 19 (8.8%) N = 199, Q2: 27 (13.6%) N = 221, Q3: 21 (9.5%) N = 195, Q4: 19 (9.7%) Medium-to-high (8,400-13,800), n (%): N = 832, Overall: 105 (12.6%) N = 217, Q1: 13 (6.0%) N = 199, Q2: 23 (11.6%) N = 221, Q3: 36 (16.3%) N = 195, Q4: 33 (16.9%) High (>13,800), n (%): N = 832, Overall: 186 (22.4%) N = 217, Q1: 9 (4.2%) N = 199, Q2: 22 (11.1%) N = 221, Q3: 67 (30.3%) N = 195, Q4: 88 (45.1%) Unknown, n (%): N = 832, Overall: 295 (35.5%) N = 217, Q1: 125 (57.6%) N = 199, Q2: 82 (41.2%) N = 221, Q3: 56 (25.3%) N = 195, Q4: 32 (16.3%)	372004	Mean = N/A Median age = 10 years (4–15 years)

Note: ED = Emergency Department, WPRS = Weighted Pediatric Readiness Score, PAT = Potentially Avoidable Transfer, IQR = Interquartile Range, N/A = Not Applicable

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Table 2. Primary Outcome: Mortality

Publication	Intervention vs. Comparator	Primary outcome	Primary outcome effect estimate	Primary outcome results (unadjusted)	Variables used to adjust Primary outcome	Primary outcome results [adjusted]	Conclusion
Ames et al, 2019[7]	High WPRS vs. Low WPRS	Mortality	OR	N/A	Age, chronic complex conditions, and severity of illness	Corresponding WPRS (mean ± SD) to quartiles: Q1: WPRS (48.2 ± 6.4) Q2: WPRS (66.9 ± 4.4) Q3: WPRS (81.5 ± 3.7) Q4: WPRS (95.0 ± 3.6) WPRS associated with presenting hospital and in-hospital mortality in quartiles, OR (95% CI), P-value: Q1: 1.00 Q2: 0.52 (0.30 to 0.90), P = 0.018 Q3: 0.36 (0.22 to 0.58), P < 0.001 Q4: 0.25 (0.18 to 0.37), P < 0.001 Cardiac arrest OR (95% CI), P-value: Q1: 1.00 Q2: 0.70 (0.05 to 10.78), P = 0.802 Q3: 0.22 (0.02 to 2.57), P = 0.229 Q4: 0.23 (0.02 to 2.16), P = 0.198 Sepsis OR (95% CI), P-value: Q1: 1.00 Q2: 1.84 (0.12 to 29.21), P = 0.666 Q3: 0.57 (0.05 to 7.11), P = 0.662 Q4: 0.59 (0.05 to 7.31), P = 0.680 TBI OR (95% CI), P-value: Q1: 1.00 Q2: 0.62 (0.12 to 3.12), P = 0.560 Q3: 0.72 (0.19 to 2.73), P = 0.629 Q4: 0.21 (0.06 to 0.78), P = 0.020	This study demonstrated that critically ill children presenting to hospitals with a high pediatric readiness score is associated with decreased mortality. Efforts to increase ED readiness for pediatric emergencies may improve patient outcomes.
Balmaks et al, 2020[16]	High WPRS vs. Low WPRS	Mortality	OR	N/A	Nesting of patients in each ED, and patient demographics	WPRS associated with 6-month mortality, OR (95% CI), P-value: OR 0.93 (0.88 to 0.98), P = 0.011	This study nationally assessed that pediatric readiness in EDs, in Latvia, was associated with shorter ICU length of stay, shorter hospital length of stay, and lower 6-month mortality.
Newgard et al, 2021[13]	High WPRS vs. Low WPRS	Mortality	OR	ED pediatric readiness score association with in-hospital mortality, OR (95% CI), p-value: Non-transfer patients (n = 317,005) Q1 (least ready): referent, p = 0.077 Q2: 1.34 (0.97 to 1.86) Q3: 1.01 (0.74 to 1.36) Q4 (most ready): 0.69 (0.51 to 0.92) Transferred patients (n = 54,999) Q1 (least ready): referent, p = 0.033 Q2: 0.99 (0.65 to 1.49) Q3: 0.84 (0.58 to 1.22) Q4 (most ready): 0.59 (0.39 to 0.90)	Demographic characteristics, comorbidities, initial physiology (age-adjusted hypotension), emergent airway intervention, mechanism of injury, Injury severity score (ISS), transfer status, blood transfusion, nonorthopedic surgery, orthopedic surgery, and geographic region	ED pediatric readiness score associated with in-hospital mortality, OR (95% CI): Q1 (least ready): 1 (referent) Q2: 1.16 (0.87 to 1.54) Q3: 0.90 (0.70 to 1.17) Q4 (most ready): 0.58 (0.45 to 0.75)	In this cohort study, injured children treated in high-readiness EDs had lower mortality compared with similar children in low-readiness EDs, but not fewer complications. These findings support national efforts to increase ED pediatric readiness in US trauma centers that care for children.

Note: WPRS = Weighted Pediatric Readiness Score, ED = Emergency Department, N/A = Not Applicable, OR = Odds Ratio, Q = Quartile, 95% CI = 95% confidence interval, SD = standard deviation

Table 3. Secondary Outcome: Healthcare Outcomes and Utilization

Publication	Intervention vs. Comparator	Secondary outcome	Secondary outcome effect estimate	Secondary outcome results (unadjusted)	Variables used to adjust Secondary outcome	Secondary outcome results [adjusted]	Conclusion
Ray et al, 2018[12]	High WPRS vs. No WPRS	Access to EDs within a 30-min drive	Percentage	N/A	ED characteristics (pediatric ED, trauma center level, total volume, triage system) Hospital characteristics (bed size, inpatient pediatric ward, pediatric intensive care unit [ICU], neonatal ICU, pediatric cardiology, CT scanner, MRI) Accreditations (The Joint Commission, Accreditation Council for Graduate Medical Education) Geographic characteristics (rural/urban status, state)	National proportion of pediatric population (%) within 30 minute drive to ED with: WPRS of ≥ 83.6 (75th percentile) = 70.20% WPRS of ≥94.3 (90th percentile) = 55.30% WPRS of 100 = 33.70% No WPRS specified score threshold = 93.70%	This study nationally quantified geographic access to EDs, in the US, with high pediatric readiness for children, and indicated major gaps in access are due to the lack of an ED with high pediatric readiness. 1 in 3 children can reach an ED with a max WPRS score. 90.9% of children lived closer to at least 1 alternative ED with a WPRS below the maximum
Balmaks et al, 2020[16]	High WPRS vs. Low WPRS	Patient length of stay	Regression (β) coefficient	WPRS associated with PICU length of stay and Hospital length of stay, β (95% CI), P-value: PICU length of stay: β –0.01 (–0.02 to 0.01), P = 0.410 Hospital length of stay: β –0.03 (–0.15 to 0.09), P = 0.614	Nesting of patients in each ED, and patient demographics	WPRS associated with PICU length of stay, Hospital length of stay, β (95% CI), P-value: PICU length of stay: β –0.06 (–0.10 to –0.01), P = 0.021 Hospital length of stay: β –0.36 (–0.61 to –0.10), P = 0.011	This study nationally assessed that pediatric readiness in the ED was associated with shorter ICU length of stay, shorter hospital length of stay, and lower 6-month mortality.
Lieng et al, 2021[14]	High WPRS vs. Low WPRS	Potentially avoidable transfers (PATs)	OR	10-point increase in WPRS associated with PATs, OR (95% CI): Injured children PATs: OR 0.93 (0.90 to 0.96) Noninjured children PATs: OR 0.90 (0.88 to 0.93)	Patient demographics, injury/illness severity, complex chronic condition, pediatric volume, trauma center designation, pediatric admitting capability	10-point increase in WPRS associated with PATs, OR (95% CI): Injured children PATs: OR 0.92 (0.86 to 0.98) Noninjured children PATs: OR 0.94 (0.88 to 1.00)	Hospital ED pediatric readiness is associated with lower odds of a PAT. Having a nurse pediatric emergency care coordinator and a quality improvement plan are modifiable risk factors that EDs may target to reduce PATs.
Lieng et al, 2021[15]	High WPRS vs. Low WPRS	Interfacility transfer	OR	High pediatric readiness score >70 associated with interfacility transfers, OR (95% CI), P-value OR 0.64 (0.55 to 0.74), P < 0.01	Patient demographics, insurance, severity of illness, complex chronic condition, pediatric inpatient capabilities, pediatric volume, proportion Medicaid, index hospital-level	High pediatric readiness score >70 associated with interfacility transfers, OR (95% CI), P-value OR 0.55 (0.33 to 0.93), P < 0.05	Pediatric patients presenting to EDs at small rural hospitals with high pediatric readiness scores may be less likely to be transferred.

Note: WPRS = Weighted Pediatric Readiness Score, ED = Emergency Department, PAT = Potentially Avoidable Transfers, N/A = Not Applicable, OR = Odds Ratio, β = Regression Coefficient, Q = Quartile, 95% CI = 95% confidence interval, SD = standard deviation

Table 4. Risk of Bias: Newcastle-Ottawa Quality Assessment Scale Summary

Publication	Study design	Representativeness of the exposed sample (selection bias)	Selection of the non exposed sample (selection bias)	Ascertainment of exposure (selection bias)	Demonstration that outcome of interest was not present at start of study (selection bias)	Comparability of samples on the basis of the design or analysis (comparability bias)	Assessment of Outcome (assessment bias)	Was Follow-Up Long Enough for Outcomes to Occur (follow-up bias)	Adequacy of Follow Up of Cohorts (follow-up bias)	Statistical test (statistical bias)
Ray et al, 2018[12]	Cross-sectional	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	N/A	N/A	Low risk
Ames et al, 2019[7]	Retrospective cohort	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk	N/A
Balmaks et al, 2020[16]	Prospective cohort	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk	N/A
Newgard et al, 2021[13]	Retrospective cohort	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk	N/A
Lieng et al, 2021[14]	Cross-sectional	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	N/A	N/A	Low risk
Lieng et al, 2021[15]	Cross-sectional	Low risk	Low risk	Low risk	High risk	Low risk	Low risk	N/A	N/A	Low risk

Note: N/A = Not Applicable

Figure 1. PRISMA flow diagrams of articles identified on initial (1a) and updated (1b) screening included in final analysis

Figure 1a.

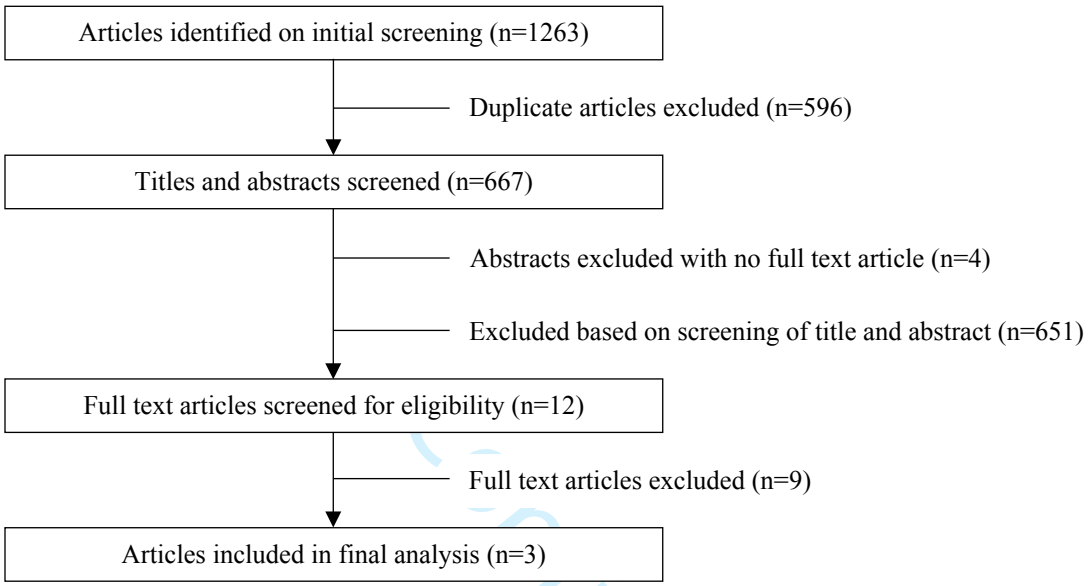


Figure 1b.

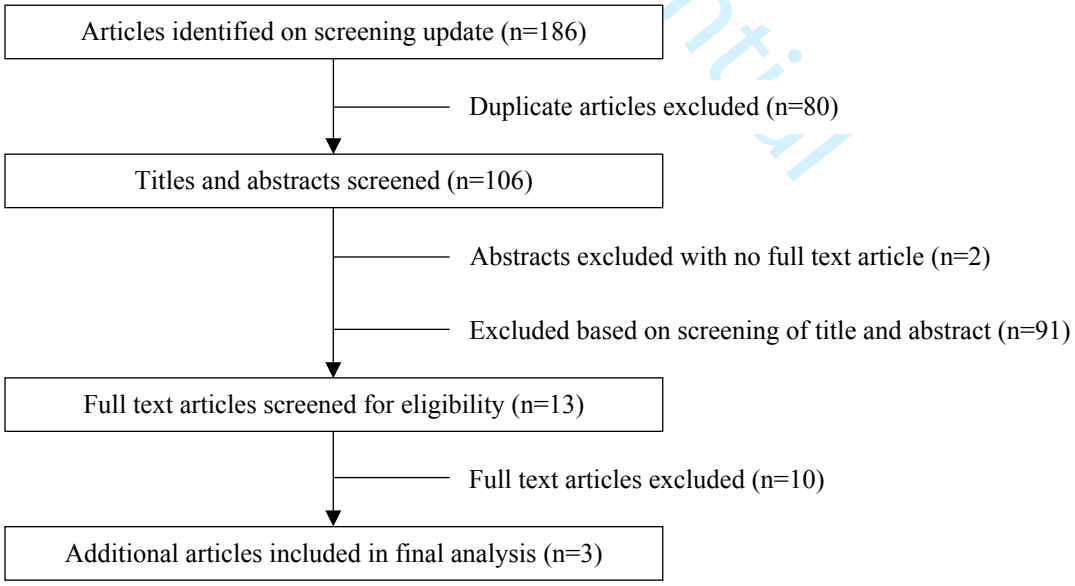
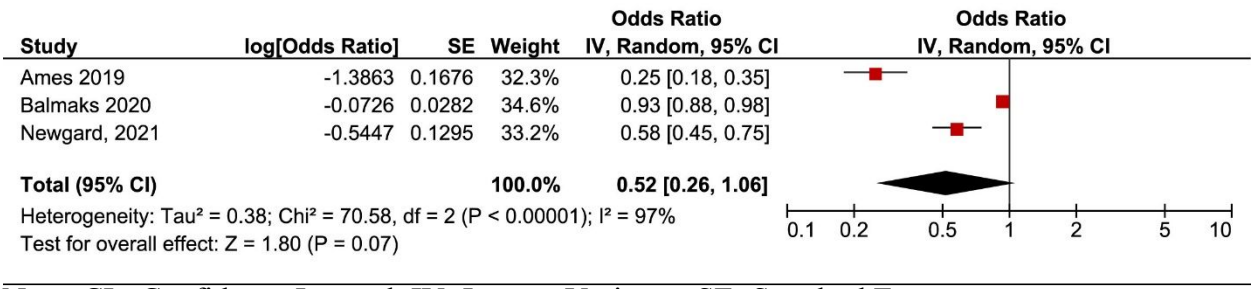


Figure 2. Random effects meta-analysis of the association between mortality and weighted pediatric readiness score



Note: CI= Confidence Interval, IV=Inverse Variance, SE=Standard Error

Appendix 1. Search Strategy

Database(s): Embase 1974 to 2020 May 22, Ovid MEDLINE(R) ALL 1946 to May 22, 2020

Search Strategy:

#	Searches	Results
1	exp Emergency Service, Hospital/	81863
2	exp Emergency Medicine/	54555
3	Emergencies/	79791
4	exp Emergency Medical Services/	238598
5	Trauma Centers/	106172
6	Triage/	79729
7	Emergency Treatment/	27354
8	Emergency Services, Psychiatric/	2627
9	Ambulatory Care/	78649
10	(emergenc$ adj5 (care$ or centre$ or center$ or department$ or diagnos$ or doctor$ or health care or healthcare or hospital$ or medicine$ or nurs$ or patient$ or physician$ or resident$ or room$ or service$ or therap$ or treatment$ or unit$ or ward$ or visit$)).mp.	677281
11	(trauma adj5 (care$ or centre$ or center$ or department$ or diagnos$ or doctor$ or health care or healthcare or hospital$ or medicine$ or nurs$ or patient$ or physician$ or resident$ or room$ or service$ or therap$ or treatment$ or unit$ or ward$ or visit$)).mp.	174419
12	((urgent or ambulatory or outpatient) adj3 (care$ or visit$ or service$)).tw,kf.	103007
13	(emergency or emergencies or trauma).jw.	303584
14	emergency.in.	315103
15	or/1-14 [Emergency Room Concept]	1295542
16	((Infan$ or newborn$ or new-born$ or perinat$ or neonat$ or baby or baby$ or babies or toddler$ or minors or minors$ or boy or boys or boyfriend or boyhood or girl$ or kid or kids or child or child$ or children$ or schoolchild$ or schoolchild or school child or school child$ or adolescen$ or juvenil$ or youth$ or teen$ or underage or pubescen$ or pediatric$ or paediatric$ or peadiatric$ or prematur$ or preterm$) adj5 (ready or readiness or preparedness)).tw,kf.	4993
17	(WPRS and P?ediatric$).tw,kf.	18
18	peds ready.tw,kf.	3
19	or/16-18 [Pediatric Readiness Concept]	4993
20	15 and 19 [Peds Readiness and ER]	673
21	20 use medall	271
22	exp emergency health service/	238598
23	exp emergency medicine/	54555
24	exp emergency/	92866
25	exp emergency treatment/	375865
26	exp emergency ward/	220551
27	ambulatory care/	78649
28	(emergenc$ adj5 (care$ or centre$ or center$ or department$ or diagnos$ or doctor$ or health care or healthcare or hospital$ or medicine$ or nurs$ or patient$ or physician$ or	

resident$ or room$ or service$ or therap$ or treatment$ or unit$ or ward$ or visit$)).mp. 677281
29 (trauma adj5 (care$ or centre$ or center$ or department$ or diagnos$ or doctor$ or health care or healthcare or hospital$ or medicine$ or nurs$ or patient$ or physician$ or resident$ or room$ or service$ or therap$ or treatment$ or unit$ or ward$ or visit$)).mp. 174419
30 ((urgent or ambulatory or outpatient) adj3 (care$ or visit$ or service$)).tw,kw. 103297
31 (emergency or emergencies or trauma).jw. 303584
32 emergency.in. 315103
33 or/22-32 [Emergency Room Concept] 1533859
34 ((Infan$ or newborn$ or new-born$ or perinat$ or neonat$ or baby or baby$ or babies or toddler$ or minors or minors$ or boy or boys or boyfriend or boyhood or girl$ or kid or kids or child or child$ or children$ or schoolchild$ or schoolchild or school child or school child$ or adolescen$ or juvenil$ or youth$ or teen$ or underage or pubescen$ or pediatric$ or paediatric$ or peadiatric$ or prematur$ or preterm$) adj5 (ready or readiness or preparedness)).tw,kw. 5020
35 (WPRS and P?ediatric$).tw,kw. 18
36 peds ready.tw,kw. 3
37 or/34-36 [Pediatric Readiness Concept] 5020
38 33 and 37 [Peds Readiness and ER] 745
39 38 use oemezd 448
40 21 or 39 719
41 remove duplicates from 40 473
42 41 use medall 267
43 41 use oemezd 206

Reporting checklist for systematic review (with or without a meta-analysis).

Based on the PRISMA guidelines.

		Reporting Item	Page Number
Title			
Title	#1	Identify the report as a systematic review	1
Abstract			
Abstract	#2	Report an abstract addressing each item in the PRISMA 2020 for Abstracts checklist	2
Introduction			
Background/rationale	#3	Describe the rationale for the review in the context of existing knowledge	3
Objectives	#4	Provide an explicit statement of the objective(s) or question(s) the review addresses	3
Methods			
Eligibility criteria	#5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses	4
Information sources	#6	Specify all databases, registers, websites, organisations, reference lists, and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted	3
Search strategy	#7	Present the full search strategies for all databases, registers, and websites, including any filters and limits used	3, Appendix
Selection process	#8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and, if applicable, details of automation tools used in the process	4

Data collection process	#9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and, if applicable, details of automation tools used in the process	4
Data items	#10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (for example, for all measures, time points, analyses), and, if not, the methods used to decide which results to collect	4
Study risk of bias assessment	#11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and, if applicable, details of automation tools used in the process	4
Effect measures	#12	Specify for each outcome the effect measure(s) (such as risk ratio, mean difference) used in the synthesis or presentation of results	4
Synthesis methods	#13a	Describe the processes used to decide which studies were eligible for each synthesis (such as tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5))	4
Synthesis methods	#13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics or data conversions	4
Synthesis methods	#13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses	4
Synthesis methods	#13d	Describe any methods used to synthesise results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used	4
Synthesis methods	#13e	Describe any methods used to explore possible causes of heterogeneity among study results (such as subgroup analysis, meta-regression)	4

Synthesis methods	#13f	Describe any sensitivity analyses conducted to assess robustness of the synthesised results	4
Reporting bias assessment	#14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases)	4
Certainty assessment	#15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome	4
Data items	#10b	List and define all other variables for which data were sought (such as participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information	4
Results			
Study selection	#16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram (http://www.prisma-statement.org/PRISMAStatement/FlowDiagram)	5, Figure 1
Study selection	#16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded	5, Figure 1
Study characteristics	#17	Cite each included study and present its characteristics	5, Table 1
Risk of bias in studies	#18	Present assessments of risk of bias for each included study	6, Table 4
Results of individual studies	#19	For all outcomes, present for each study (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (such as confidence/credible interval), ideally using structured tables or plots	5-6, Table 2, Table 3, Figure 2
Results of syntheses	#20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies	5-6, Table 4
Results of syntheses	#20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (such as confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect	5-6, Figure 2

Results of syntheses	#20c	Present results of all investigations of possible causes of heterogeneity among study results	5-6, Figure 2
Results of syntheses	#20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesised results	5-6, Figure 2
Risk of reporting biases in syntheses	#21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed	6, Table 4
Certainty of evidence	#22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed	5-6, Figure 2
Discussion			
Results in context	#23a	Provide a general interpretation of the results in the context of other evidence	6-7
Limitations of included studies	#23b	Discuss any limitations of the evidence included in the review	7
Limitations of the review methods	#23c	Discuss any limitations of the review processes used	7
Implications	#23d	Discuss implications of the results for practice, policy, and future research	7
Other information			
Registration and protocol	#24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered	2
Registration and protocol	#24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared	2
Registration and protocol	#24c	Describe and explain any amendments to information provided at registration or in the protocol	N/A - no amendments to protocol
Support	#25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review	1
Competing interests	#26	Declare any competing interests of review authors	1

Availability of data, code, and other materials	#27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review	Appendix 1