

Mortality Outcomes Following Pediatric Emergency Department Visits: A Systematic Review and Meta-Analysis

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Abstract

Background: Emergency departments with high readiness to admit children may reduce mortality rates, but comprehensive and comparative evidence is limited. This study is the first systematic review and meta-analysis conducted to determine the effect of pediatric emergency department readiness on in-hospital mortality.

Methods: A search for relevant articles was conducted up to 17 December 2025 in the international databases PubMed, EMBASE, Scopus, and Web of Science. Relevant keywords were used for the search. Current study question: In children presenting to emergency departments (Population), how is the level of emergency readiness for pediatric care (Exposure) associated with mortality (Outcome)? This section was created using the PICO approach. Data analyses were conducted using the meta-analysis packages in STATA/MP.v17 (College Station, Texas, USA).

Results: The overall in-hospital mortality rate was estimated to be about 2%. Meta-analysis showed that care at highest-readiness EDs (Quartile 4 wPRS) was associated with a significant reduction in mortality (OR=0.617; 95% CI, 0.491–0.744).

Conclusion: Increasing the level of emergency department pediatric readiness can be associated with a reduction in in-hospital mortality. These findings highlight the importance of policy to improve standards of pediatric emergency readiness in all hospitals.

Keywords: Pediatric Emergency Department, in-hospital mortality, Readiness, Children

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Introduction

Emergency departments are one of the first points of contact for children with acute illnesses and life-threatening injuries (1). The time-sensitive nature of clinical decision-making in these settings means that the quality of care provided in the emergency department plays a role in determining children's survival beyond the definitive treatment that follows (2). Pediatric emergency department visits constitute a significant portion of the burden on health systems worldwide and play a decisive role in short- and long-term health outcomes for children (3). Statistics show that more than 30 million children visit emergency departments each year for emergency care (4).

Evidence suggests that despite this high volume of pediatric emergency department visits, the provision of pediatric

emergency care is significantly heterogeneous, with 97% of pediatric emergency departments located in non-specialized pediatric hospitals, and these centers cover approximately 83% of all pediatric emergency department visits (5). Therefore, the lack of centralization of pediatric emergency care in specialized centers has created serious challenges in providing quality care, patient safety, and mortality outcomes (3, 6). Although some studies have shown that structural and functional characteristics of compartments are associated with critical patient outcomes, this evidence is largely limited to specific populations such as trauma patients or critically ill children (7).

Child mortality after visiting the emergency department is considered one of the most sensitive indicators of the

Key Messages:

↑What is “already known” in this topic:

Pediatric emergency department visits play a decisive role in health outcomes for children. However, provision of pediatric emergency care is significantly heterogeneous.

→What this article adds:

An increasing level of pediatric emergency readiness is significantly associated with a decrease in in-hospital mortality. Targeted investment in improving pediatric emergency readiness is an effective strategy to improve child survival.

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quality of the health system, and its consequences affect not only the lives of patients but also national health policies and resource allocation. Despite millions of children visiting emergency rooms each year, the data available in this area are fragmented, limited to specific populations, and lack consistent quantitative analysis (8). The role of structural and functional characteristics of emergency departments, human resource competence, access to specialized equipment, and the existence of standard protocols in reducing mortality has not yet been comprehensively investigated. The present study attempts to provide reliable evidence for the scientific community, practical implications for policymakers, hospital accreditation, and improvement of pediatric emergency care standards. Conducting a systematic review and meta-analysis focusing on mortality outcomes following pediatric emergency department visits is a scientific and policy imperative. The results of the present study can provide key evidence to guide health policies, review hospital accreditation criteria, and optimize resource allocation in emergency systems, ultimately leading to improved child survival in emergency settings. The objective of the present study was to evaluate mortality outcomes following pediatric emergency department visits.

Methods

Data Sources, Search Strategy, and Definitions

The present study was a systematic review and meta-analysis designed and reported in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. All steps, including source search, study selection, data extraction, quality assessment, and statistical analysis, were performed according to the PRISMA recommendations (9). An unrestricted search of the international databases PubMed/MEDLINE, EMBASE, Scopus, and Web of Science was conducted up to 17 December 2025 to find relevant articles. In addition to using relevant keywords for the search, the references of the articles were also checked to ensure that no studies were missed.

Search terms: (("Pediatrics"[Mesh] OR "Hospitals, Pediatric"[Mesh] OR "Pediatric Emergency Medicine"[Mesh] OR "Pediatric Emergency Medicine/methods"[Mesh] OR "Pediatric Emergency Medicine/organization and administration"[Mesh] OR "Pediatric Emergency Medicine/standards"[Mesh] OR "Pediatric Emergency Medicine/statistics and numerical data"[Mesh]) AND ("Emergency Treatment"[Mesh]) AND ("Mortality"[Mesh] OR "mortality"[Subheading] OR "Child Mortality"[Mesh] OR "Hospital Mortality"[Mesh] OR "Death"[Mesh]) AND ("Survival"[Mesh] OR "Survival Analysis"[Mesh] OR "Survival Rate"[Mesh]) AND ("Critical Care Outcomes"[Mesh] OR "Patient Outcome Assessment"[Mesh] OR "Outcome Assessment, Health Care"[Mesh] OR "Fatal Outcome"[Mesh] OR "Treatment Outcome"[Mesh]))

Study Selection: Inclusion and Exclusion Criteria

Inclusion criteria included children or adolescents presenting to the emergency department; Report at least one

mortality outcome; pediatric readiness; this section was created using the PICO approach. Current study question: In children presenting to emergency departments (Population), how is the level of emergency readiness for pediatric care (Exposure) associated with mortality (Outcome)?

Exclusion criteria were: (1) reviews, in vitro studies, case reports, and literature that is unavailable or incomplete; (2) studies that do not involve human subjects; and (3) articles written in a language other than English.

Data Extraction and Organization

Two blinded and independent investigators (M.M and M.S) performed data extraction, and all data were extracted and reviewed by a third investigator (R.H) based on a pre-prepared checklist. Disagreements between investigators were discussed and resolved by a third reviewer. Study characteristics include the first author, publication year, study population, mean age, study design, Cohort Type, Population, Follow-up Duration, In-hospital Mortality, Mortality up to Follow-up Duration, Median weighted Pediatric Readiness Score (wPRS) (IQR), Quartile cut-offs (wPRS), and Mortality by Quartile.

Pediatric readiness was assessed using the weighted Pediatric Readiness Score (wPRS), a validated metric ranging from 10–100 based on 36–41 structural and process elements of ED pediatric care (e.g., equipment, medications, training, policies) (7). EDs were categorized into four quartiles by wPRS: Q1 (lowest, typically 0–58/62), Q2 (59–72), Q3 (73–87), and Q4 (highest, 88–100), with minor variations by study. These levels formed the basis for subgroup meta-analysis of mortality outcomes.

Bias Assessment

Two authors independently and blindly assessed the quality of the studies. The Newcastle-Ottawa Scale (NOS) (10) was used to assess cohort studies. Selection, comparability, and outcomes are considered by the NOS tool. The NOS instrument is scored from 0 to 9 (0–3, 4–6, and 7–9). Scores of 7–9 for the NOS indicate low risk of bias.

Statistical Analysis

Data analyses were conducted using the meta-analysis packages in STATA/MP v17 (College Station, Texas, USA). Statistical significance was set at $P < 0.05$. Heterogeneity among studies was assessed using the I^2 and τ^2 statistics. I^2 values $<30\%$ were considered low, $30\text{--}60\%$ moderate, and $>60\%$ high heterogeneity. A fixed-effect model (inverse-variance method) was initially planned for analyses with low heterogeneity. However, when substantial heterogeneity was detected ($I^2 > 60\%$), a random-effects model was applied to account for between-study variability. Accordingly, given the high heterogeneity observed in the included studies, the primary analyses were conducted using a random-effects model. Publication bias was assessed using Egger's test and visual inspection of funnel plot asymmetry. Mortality rates and pooled odds ratios (ORs) with 95% confidence intervals (CIs) were calculated accordingly. For pooling mortality proportions, a logit transformation was applied to stabilize variances

due to low event rates. Pooled estimates were then back-transformed to the original scale for interpretation.

Sensitivity Analysis

Given the potential overlap of patient populations across studies derived from large U.S. trauma and emergency care databases (particularly studies by Newgard et al.), a sensitivity analysis was performed. Analyses were repeated after excluding studies with a high likelihood of overlapping datasets to evaluate the robustness of the pooled estimates. The consistency of results between the primary and sensitivity analyses was assessed.

Meta-regression Analysis

To explore potential sources of heterogeneity, meta-regression analyses were performed using study-level covariates. Prespecified variables included study population type (trauma vs. mixed/medical cohorts) and follow-up duration. These variables were selected based on their clinical relevance and potential to influence mortality outcomes. Meta-regression was conducted using random-effects models, and the significance of covariates was assessed to identify contributors to between-study variability.

Results

Figure 1 shows the flow chart of article selection. The initial search yielded 204 articles, of which 79 were excluded after title screening based on the study selection criteria. In the next step, after title screening, abstracts of 125 potentially eligible articles were reviewed, and studies

that did not meet the inclusion criteria were excluded in this section (n=81). In the next step, by reviewing the full text of 44 articles by two blind and independent authors, the most relevant articles were selected for the purpose of the study, and finally, 9 articles were included in the meta-analysis.

Characteristics of Included Studies

The present meta-analysis included a total of 9 retrospective studies. All studies were conducted in emergency room settings or trauma centers and used national or multicenter data. The study population included children with traumatic injuries, children with acute medical emergencies, or a combination of both. The overall sample size studied was 2,811,003 pediatric emergency department visits. This large sample size provided significant statistical power to detect true differences in mortality and increased the precision of the estimates. Characteristics of the included studies are reported in Table 1.

Table 2 shows the reported mortality rates in emergency departments with the highest wPRS quartile (Quartile 4) and the lowest readiness (Quartile 1).

In-Hospital Mortality

Based on meta-analysis, the in-hospital mortality rate in children receiving emergency care in ED was estimated to be about 2% (.02 95% CI; 0 - 0.04) (Figure 2). The pooled analysis included a total of 2,811,003 pediatric emergency department visits, with 33,451 deaths across the included studies. No heterogeneity was observed between studies ($I^2 = 0\%$), and the results of the studies were

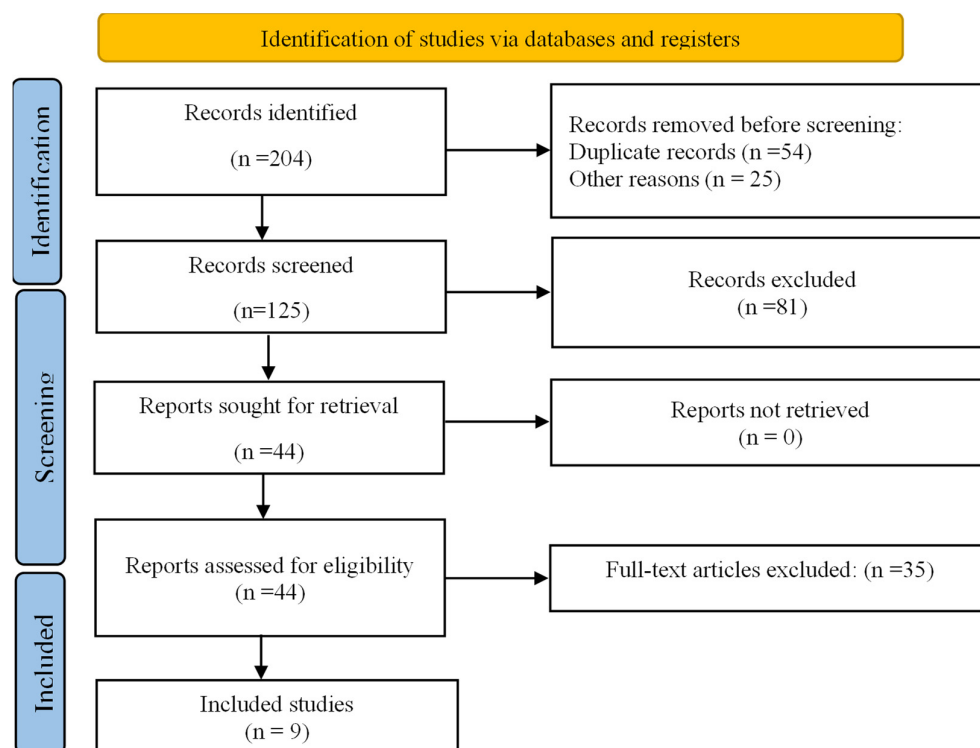


Figure 1. PRISMA 2020 Flow Diagram

Table 1. Characteristics of studies included in the systematic review.

Study	Study Design	Setting	Sample Size	Age (Median/IQR)	Cohort Type / Population	Follow-up Duration	In-hospital Mortality (n, %)	Mortality up to Follow-up Duration (n, %)
Newgard et al., 2024 (11)	Retrospective cohort	983 US EDs	796,937	Injury: 10 [4–15] Medical: 3 [0–12]	Injury & medical hospitalized children	1 year	Injury: 1820 (2.0%); Medical: 7688 (1.1%)	1-year: Injury: 1316/62 588 (2.1%); Medical: 6635/483 333 (1.4%)
Newgard et al., 2023 (7)	Retrospective cohort	417 US trauma centers	467,932	10 [4–15]	Injured children	10 years	9544 (2.0%)	1.4%
Mohammed, 2020 (12)	Retrospective cohort	Pediatric ED (country not reported)	172,691	<18 y	All pediatric ED deaths	5 years	628 (3.6%)	5-year mortality 3.63 per 1000
Jenkins et al., 2023 (13)	Retrospective cohort	US EDs	633,536	4 [0–12]	Acute medical & trauma	–	1339 1.8%	–
Newgard et al., 2022 (14)	Retrospective cohort	146 US trauma center EDs	88,071	11 [5–15]	Injured children	1 year	1768 (2.0%)	1974 (2.2%)
Newgard et al., 2021 (15)	Retrospective cohort	832 US trauma center EDs	372,004	10 [4–15]	Injured children	–	5700 (1.5%)	–
Glass et al., 2023 (16)	Retrospective cohort	765 US trauma centers	212,689	10 [4–15]	Injured children	–	4156 (2.0%)	–
Melhado et al., 2024 (17)	Retrospective cohort	630 US trauma centers	66,588	<18 y	Pediatric trauma patients	–	1.2%	–
Remick et al., 2023 (18)	Retrospective cohort	555 US trauma centers	555	<18 y	Pediatric trauma patients	–	1.59%	–

Table 2. ED Pediatric Readiness and Mortality.

Study	Median wPRS (IQR)	Quartile cut-offs (wPRS)	Mortality by Quartile
Newgard et al., 2024 (11)	73 (59–87)	Q1: 0–58, Q2: 59–72 Q3: 73–87 Q4: 88–100	Injury: Q4 vs Q1 aOR 0.40; Medical: Q4 vs Q1 aOR 0.24; Estimated lives saved: 288 (injury), 1154 (medical)
Newgard et al., 2023 (7)	81 (63–94) → 77 (64–93)	Q1: 0–58 Q2: 59–72 Q3: 73–87 Q4: 88–100	High-high vs low-low: lowest mortality; aOR highest vs lowest quartile 0.50 (2012–2014), 0.64 (2019–2021); Estimated lives saved: 643–973
Jenkins et al., 2023 (13)	74 (58–89)	Q4 vs Q1	Mortality is lower at hospitals with the highest ED readiness (Q4); Medical cohort OR 0.24, Injury cohort OR 0.39; racial disparities were reduced 3-fold in Q4
Newgard et al., 2022 (14)	88 (70–95; range 32–100)	Q4 vs Q1	aHR 0.70 (highest vs lowest quartile) for 1-year mortality; benefit persisted in subgroups (ISS≥16, AIS≥3, head AIS≥3)
Newgard et al., 2021 (15)	79 (63–93; range 29–100)	Q1:29–62 Q4:93–100	aOR for in-hospital mortality Q4 vs Q1 0.58; Additional lives saved scenarios: 31–126/year
Glass et al., 2023 (16)	79.1 (62.9–92.7)	Q4 vs Q1	Adjusted OR for mortality Q4 vs Q1 0.65; Estimated lives saved if all to high-readiness ED: 1655
Melhado et al., 2024 (17)	79 (66–93)	Q4≥93	O/E mortality is lower in the highest quartile (1.02) vs the lowest 3 quartiles (1.19–1.29); the pediatric-specific QI plan has the strongest association with reduced mortality
Remick et al., 2023 (18)	–	Q4 vs Q1	Better-than-expected survival associated with validated triage tool, disaster plan, QI, pediatric airway/resuscitation equipment; physician & nurse PECC reduced mortality OR 0.90–0.92; child maltreatment policy increased mortality OR 1.15–1.17; Level 1–2 trauma centers better survival

homogeneous in terms of mortality rates.

Subgroup analysis

Subgroup meta-analysis based on four levels of ED Pediatric Readiness shows that there is a statistically significant relationship between the level of ED readiness and in-hospital mortality, and this relationship gradually and

progressively strengthens with increasing levels of readiness (Figure 3).

At ED Quartiles 1, the odds ratio for mortality was OR = 1.00 (95% CI: 0.98–1.02) as a reference ($I^2 = 0\%$). At ED Quartiles 2, the odds ratio for mortality was estimated to be OR = 0.996 (95% CI: 0.679–1.313). Although the point estimate is close to 1, the very high heterogeneity in this group ($I^2 = 99.4\%$, $\tau^2 = 0.283$) suggests that the effect

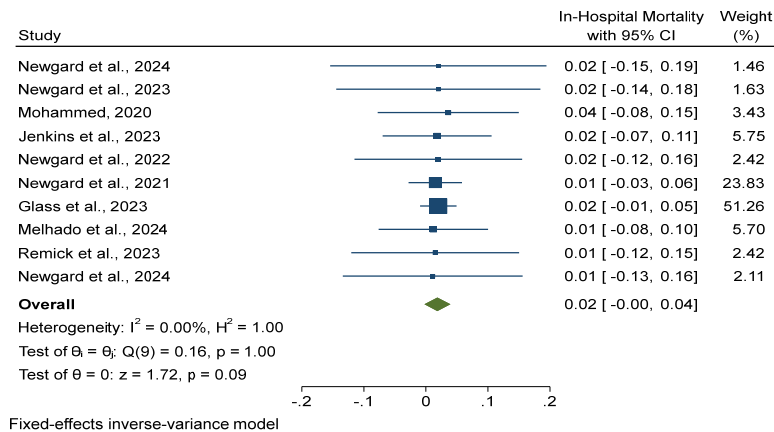


Figure 2. Forest plot of In-Hospital Mortality among Children receiving emergency care in ED.

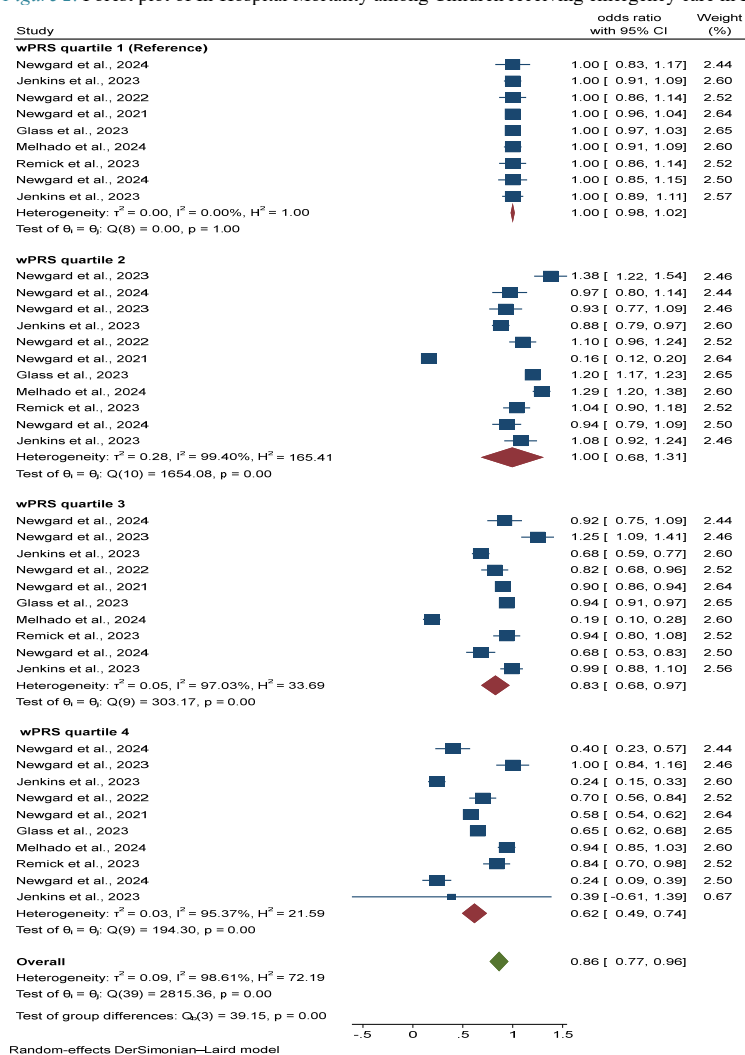


Figure 3. Forest plot of in-Hospital Mortality among Children across Quartiles of Emergency Department (ED) Pediatric Readiness

of emergency readiness at this level is highly variable between studies, and the results are not uniform. Therefore, there is no conclusive evidence for mortality reduction at this level.

At ED Quartiles 3, the odds ratio for mortality was significantly reduced, with OR = 0.827 (95% CI: 0.683–0.971). This finding suggests that at this level, higher emergency readiness is associated with a significant re-

duction in in-hospital mortality. Despite high heterogeneity ($I^2 = 97.0\%$, $\tau^2 = 0.051$), the direction of the effect in most studies is towards a reduction in mortality, and the final confidence interval is below 1.

The strongest protective effect was observed at ED Quartile 4, which represents the highest level of preparedness. The odds ratio for mortality at this level was estimated to be $OR = 0.617$ (95% CI: 0.491–0.744), indicating a significant and clinically important reduction in in-hospital mortality. Although heterogeneity remained high ($I^2 = 95.4\%$, $\tau^2 = 0.034$), the mortality-reducing effect at this level was consistently observed in most studies.

In the overall analysis of all subgroups with a random-effects model, the overall odds ratio for in-hospital mortality was $OR = 0.864$ (95% CI: 0.769–0.959), indicating a significant reduction in mortality with increasing levels of quartiles of ED pediatric readiness. The overall heterogeneity was very high ($I^2 = 98.6\%$), fully justifying the use of a random-effects model. The test of difference between subgroups was also significant ($Q_b = 39.15$, $P < 0.001$), indicating that the level of emergency readiness significantly moderates the effect of mortality and that the reduction in mortality gradually increases as one moves from low to high levels.

Sensitivity Analysis

Sensitivity analyses were performed to evaluate the potential impact of overlapping datasets, particularly among studies derived from large U.S. trauma registries (e.g., Newgard et al.). After excluding studies with a high likelihood of population overlap, the pooled effect estimates remained consistent in both direction and magnitude with the primary analysis. The overall association between higher pediatric emergency department readiness and re-

duced in-hospital mortality persisted, indicating that the main findings are robust and not substantially influenced by potential duplication of data sources.

Meta-regression Analysis

Meta-regression analyses were conducted to investigate sources of heterogeneity. Study population type (trauma vs. mixed/medical cohorts) was found to contribute to between-study variability, with trauma-focused studies generally showing more consistent effect estimates. Follow-up duration had a less pronounced impact on heterogeneity. However, a substantial proportion of heterogeneity remained unexplained, suggesting that additional factors such as differences in healthcare systems, measurement of pediatric readiness, and study design may also play a role.

Publication bias

Publication bias was assessed using visual inspection of funnel plots and Egger's regression test. Funnel plots for the overall and subgroup analyses were generated (Figure 4). Visual inspection suggested approximate symmetry in the overall analysis, although some asymmetry was observed in higher ED readiness quartiles. Egger's regression test did not indicate statistically significant small-study effects ($\beta = -0.35$, SE of $\beta = 0.265$, $z = -1.31$, $P = 0.189$), suggesting no evidence of publication bias. Given the high heterogeneity between studies in subgroup analyses, the observed funnel plot asymmetry reflects underlying clinical and methodological variability between studies rather than true effects of small studies or publication bias.

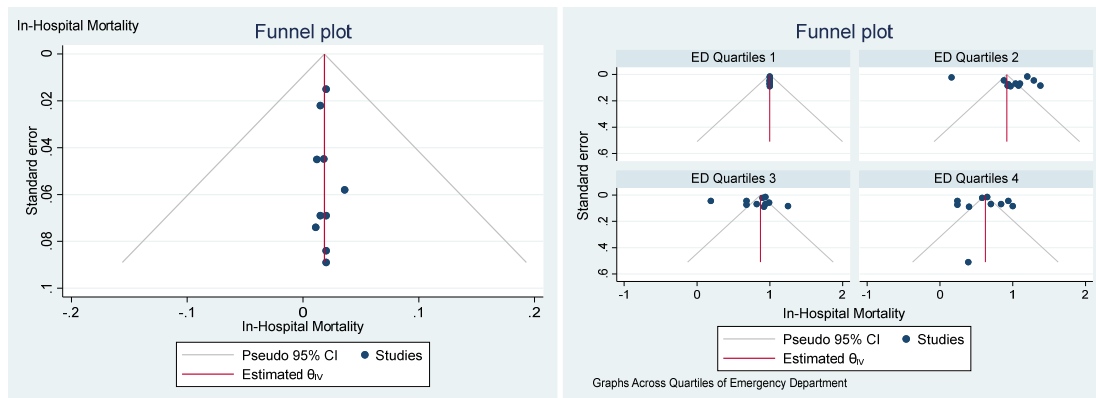


Figure 4. Funnel plot assessing potential publication bias in the meta-analysis of in-hospital mortality

Table 3. Quality assessment of included studies (NOS)

Study	Selection (0–4)	Comparability (0–2)	Outcome / Exposure (0–3)	Total NOS Score (0–9)	Quality Rating
Newgard et al., 2024 (11)	4	2	3	9	High
Newgard et al., 2023 (7)	4	2	3	9	High
Mohammed, 2020 (12)	3	1	2	6	Moderate
Jenkins et al., 2023 (13)	4	2	3	9	High
Newgard et al., 2022 (14)	4	2	3	9	High
Newgard et al., 2021 (15)	4	2	3	9	High
Glass et al., 2023 (16)	4	2	3	9	High
Melhado et al., 2024 (17)	3	2	2	7	Moderate
Remick et al., 2023 (18)	4	2	3	9	High

Bias assessment

All studies had large sample sizes and appropriate cohort designs; most studies adjusted for major confounders, except for the study by Mohammed (2020), which was limited. Most studies had careful follow-up and appropriate statistical models. The quality of 7 studies was assessed as high and 2 studies as moderate (Table 3).

Discussion

The present study is the first systematic meta-analysis to specifically examine the effect of Emergency Department Pediatric Readiness on in-hospital mortality in a pediatric population. Unlike previous studies that were mainly conducted in single centers or large observational cohorts, this meta-analysis provided valid quantitative and aggregated evidence about the relationship between emergency readiness and mortality outcomes by pooling data from multiple studies with very large sample sizes. The present meta-analysis shows that, overall, increasing the level of pediatric emergency readiness is associated with a significant reduction in in-hospital mortality. This finding remained stable in the random-effects model, even with very high heterogeneity between studies, supporting the robustness of the conclusions.

Subgroup analysis based on the fourth quartiles of ED pediatric readiness showed that at the second ED wPRS, although the point estimate was biased towards a reduction in mortality, the wide confidence interval prevented a definitive conclusion. In contrast, at the third ED wPRS, a significant reduction in mortality was observed, and this effect was most pronounced at the highest level of quartiles of ED pediatric readiness (fourth wPRS), such that the probability of in-hospital mortality was significantly reduced. This gradual pattern suggests that improvements in pediatric emergency department structure, processes, and resources are likely to cumulatively impact vital patient outcomes.

The high level of heterogeneity observed across studies ($I^2 > 95\%$) reflects important clinical and methodological differences, including variation in patient populations (trauma vs. medical conditions), follow-up periods, and definitions of outcomes. While such heterogeneity may limit the precision of pooled effect estimates, the consistent direction of association across studies strengthens confidence in the overall conclusion that higher pediatric emergency department readiness is associated with reduced mortality. Clinically, this suggests that improvements in emergency department readiness are beneficial across diverse healthcare settings, although the magnitude of effect may vary depending on patient characteristics and local system factors.

Studies by Newgard et al. over the years have repeatedly shown that centers with higher wPRS experience lower mortality in children (7, 11, 14, 15). Studies have also reported that the presence of components such as a pediatric emergency care coordinator, dedicated equipment, standardized protocols, and quality improvement programs is associated with better outcomes (13, 16, 18). By integrating this evidence, the present study demonstrates

that the observed effect is not limited to one study or a specific care system, but rather is generally replicated across different systems.

From a clinical and health policy perspective, the findings of the present meta-analysis are of particular importance. The results show that simply transferring children to the emergency department is not enough, but the quality and readiness of the pediatric emergency department in these centers play a decisive role in survival. This is especially important for areas with limited access to super specialty centers and can lead to improved outcomes through improving quartiles of ED pediatric readiness.

Despite its strengths, this study has limitations that should be considered when interpreting the results. First, all included cohort studies were retrospective, and it is not possible to infer a definitive causal relationship. Second, there was a high statistical heterogeneity between studies, likely due to differences in outcome definitions, sample collection periods, and how emergency readiness was measured. Although the use of a random-effects model moderates this heterogeneity to some extent, it can still affect the precision of the effect estimate. Third, some studies used overlapping data or similar databases, which may have biased some care systems. Fourth, individual patient data were not available, and it was not possible to fully adjust for all potential confounders. Although formal statistical tests and funnel plots did not demonstrate significant publication bias, the relatively small number of included studies may limit the power of these methods to detect asymmetry.

Present results have important implications for national policy. Hospital accreditation organizations could apply pediatric emergency readiness standards to all hospitals that admit children, and similar accreditation practices could be considered. Also, pediatric emergency readiness can be linked to value-based payment models to create an incentive to improve readiness levels, especially since more than 60% of children presenting to emergency departments are covered by public insurance. In addition, public dissemination of emergency readiness level information can help emergency departments, physicians, and families direct patients to facilities with the highest level of preparedness, although this option may lead to unintended consequences such as reduced visits to poorly prepared EDs, reduced clinical experience of staff in that department, and creating inequities in the quality of care. The best solution is to create policies and incentives to increase the level of pediatric emergency readiness in all hospitals, including rural and border areas.

Conclusion

The present meta-analysis showed that increasing the level of pediatric emergency readiness is significantly associated with a decrease in in-hospital mortality. These findings support targeted investment in improving pediatric emergency readiness as an effective strategy for improving child survival and pave the way for future studies, particularly policy-based interventions and quasi-experimental studies.

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Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

Concept – S.M.H.K., M.M.; Design – S.M.H.K., M.M., M.S., R.H.; Supervision – S.M.H.K.; Funding – S.M.H.K., M.M., M.S., R.H.; Materials – S.M.H.K., M.M., M.S., R.H.; Data collection and/or processing – S.M.H.K., M.M., M.S., R.H.; Data analysis and/or interpretation – S.M.H.K., M.M., M.S., R.H.; Literature search – S.M.H.K., M.M., M.S., R.H.; Writing – S.M.H.K., R.H.

Ethical Considerations

Not applicable.

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No fund was received for the present study.

Data Availability

Data will be available upon reasonable request from the corresponding author.

AI Use Statement

We have not used any AI in the present study.

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