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Systematic Review and Meta-Analysis on the Pattern of Admissions and Treatment Outcomes in PICU

Pranavi Mokkarala[1], Manojkumar G. Patil[2], Shradha Salunkhe[*2], Shailaja Mane[2], Shivshankar Awase[1], Mahati Reddy Koralla[1]

[1]Resident, Pediatrics, Department of Pediatrics, Dr. D. Y. Patil Medical College, Hospital & Research Centre, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pimpri Pune-411018 India

[2]Professor, Pediatrics, Department of Pediatrics, Dr. D. Y. Patil Medical College, Hospital & Research Centre, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pimpri Pune-411018 India

***Corresponding Author:**

Professor, Pediatrics, Department of Pediatrics, Dr. D. Y. Patil Medical College, Hospital & Research Centre, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pimpri Pune-411018 India

Email: salunkheshradha@gmail.com

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ABSTRACT

Background: Pediatric Intensive Care Units (PICUs) provide critical care to children with life-threatening illnesses. However, admission patterns and treatment outcomes vary significantly, especially in resource-limited settings.

Objectives: This systematic review and meta-analysis aimed to evaluate the patterns of admissions and treatment outcomes in PICUs, with a focus on developing countries including India, to inform strategies that can enhance pediatric critical care delivery.

Methods: Following PRISMA guidelines, a comprehensive literature search was conducted using PubMed, Scopus, and Google Scholar. Studies focusing on PICU admissions, treatment outcomes, and mortality-related factors in resource-limited settings were included. A total of 20 studies met the inclusion criteria and were analyzed qualitatively and quantitatively.

Results: The analysis included 9,243 pediatric patients. Respiratory illnesses (19.1%–49%) were the leading cause of admissions, followed by neurological disorders (14.3%–33.2%) and sepsis (3.4%–40%). Mechanical ventilation was required in up to 100% of cases in some studies. Mortality rates ranged from 4.1% to 74%, averaging 19.8%. Key mortality predictors included sepsis, multi-organ dysfunction syndrome (MODS), prolonged mechanical ventilation, and low Glasgow Coma Scale (GCS) scores. Male patients showed higher mortality across most studies. Comorbidities such as malnutrition, acute kidney injury, and congenital heart defects were also associated with poor outcomes.

Conclusions: PICUs play a vital role in reducing pediatric mortality, but outcomes are influenced by the availability of resources, early interventions, and management of comorbidities. Strengthening infrastructure, early sepsis recognition, and critical care training are essential to improve outcomes in low- and middle-income countries.

Keywords: *Pediatric Intensive Care Unit (PICU), respiratory illness, sepsis, neurological disorders, mechanical ventilation, child mortality, comorbidities, low- and middle-income countries, critical care outcomes, systematic review.*

1. INTRODUCTION

Pediatric Intensive Care Units (PICUs) are specialized hospital units designed to provide advanced care for critically ill children with life-threatening conditions [1]. These units play a pivotal role in improving survival rates and quality of care for pediatric patients requiring intensive monitoring and complex therapeutic interventions [1]. Admission to a PICU is often necessitated by conditions such as hemodynamic instability, respiratory failure, or the need for invasive monitoring and therapeutic modalities [2]. While PICUs in high-resource settings have significantly advanced critical care practices, resource limitations in low- and middle-income countries, including India, pose unique challenges to delivering optimal pediatric care [3].

Globally, patterns of PICU admissions vary significantly, influenced by regional epidemiology, healthcare infrastructure and population demographics. Common causes of admissions include respiratory diseases, neurological disorders, sepsis, acute respiratory distress syndrome (ARDS), and trauma [3-5]. In high-income countries trauma and congenital conditions often dominate PICU admissions, whereas in resource-limited settings, infectious diseases and malnutrition remain leading causes [6]. Factors such as patient age, pre-hospital care, comorbidities, and the availability of advanced interventions like mechanical ventilation substantially influence treatment outcomes [7].

WHO emphasizes that most deaths in children under five in developing nations are due to preventable diseases, highlighting the life-saving potential of PICUs through timely, specialized care [8]. However, in sub-Saharan Africa and South Asia, including India, critical care services are often constrained by shortages of skilled personnel, equipment, and essential medications [6]. These challenges contribute to significant variability in PICU mortality rates, ranging from 2.1% in well-equipped Indian centers to over 40% in resource-limited settings in Ethiopia and Nigeria [1, 3,9-10]. In India, studies have reported mortality rates influenced by factors such as late referrals, severe sepsis, malnutrition, and the need for mechanical ventilation [11-12].

Pediatric Intensive Care Units (PICUs) play a crucial role in reducing child mortality by providing specialized and timely care for critically ill children. However, in resource-limited settings like India, there is a lack of consolidated data on PICU admissions, treatment outcomes and factors influencing mortality. Hence, present systematic review and meta-analysis aims to address this gap by providing comprehensive insights into admission patterns, demographic profiles, common causes of admissions, and clinical outcomes in PICUs. By analyzing studies from India and similar settings, the review seeks to inform evidence-based strategies to improve pediatric critical care delivery, enhance survival rates and optimize quality of care.

2. METHODOLOGY

The present study adhered to the guidelines issued for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-P). Findings were systematically documented following these standards. Cochrane and PRISMA guidelines were employed as the guiding frameworks for conducting and reporting this review.

A comprehensive literature search was conducted using online databases such as PubMed, Scopus, and Google Scholar. Relevant keywords and phrases used for the search included terms like "PICU admissions," "pediatric critical care outcomes," and "factors influencing PICU mortality." Search syntaxes were customized based on database requirements to ensure relevance and accuracy. Articles in English were included to address potential linguistic barriers. Detailed information about the studies included in this systematic review is outlined in Figure 1.

Inclusion Criteria:

- Studies focusing on PICU admissions and outcomes.
- Articles reporting demographic profiles, causes of admissions, clinical outcomes, and mortality-related factors.
- Research conducted in resource-limited settings, particularly India, or in regions with comparable healthcare challenges.
- Studies published in peer-reviewed journals in English.

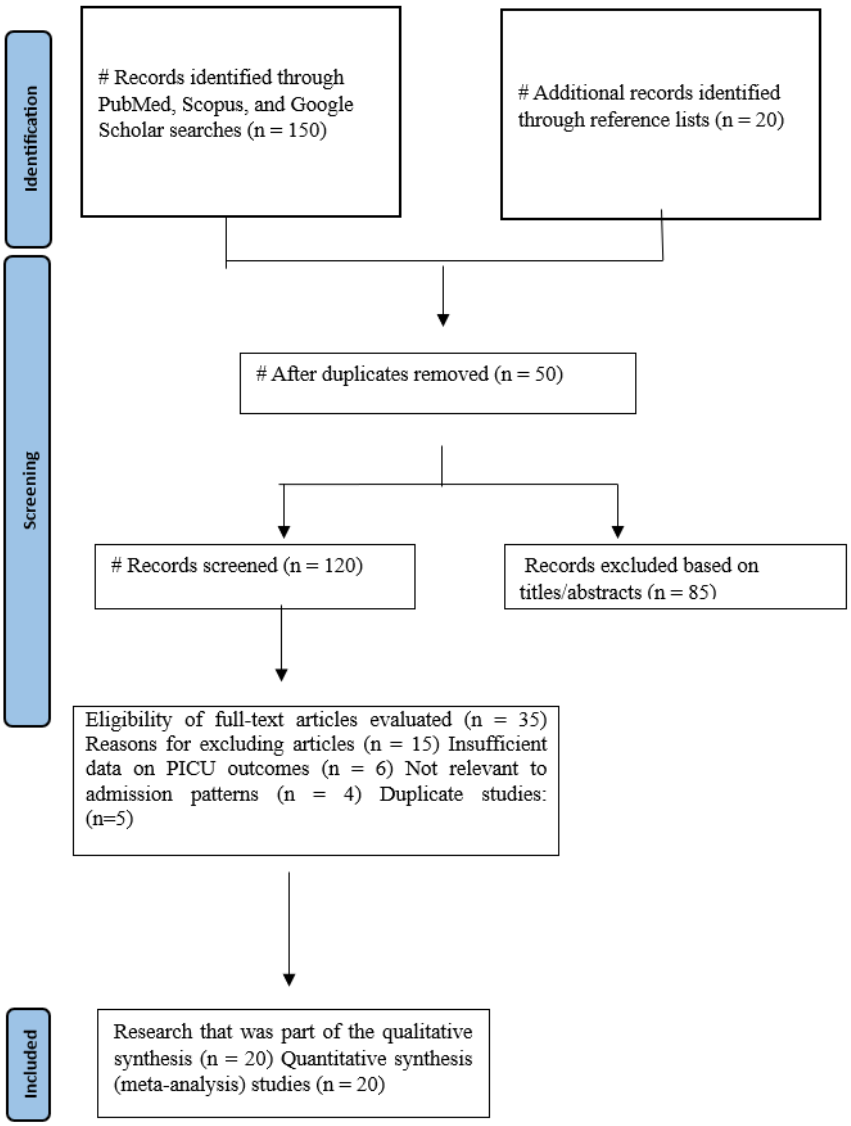
Exclusion Criteria:

- Studies focusing on neonatal intensive care units (NICUs) instead of PICUs.
- Articles lacking sufficient data on admissions and treatment outcomes.
- Non-English publications or studies without full-text availability.

Data extraction was performed systematically and summarized into two tables: Table 1 for admissions patterns and Table 2 for treatment outcomes and mortality analysis. This structured approach ensured comprehensive analysis and meaningful synthesis of the findings.

Data Analysis:

A total of 35 full-text articles were evaluated for eligibility in the systematic review. Out of these, 15 articles were excluded due to the following reasons: insufficient data on PICU outcomes (n = 6), not relevant to admission patterns (n = 4), and duplicate studies (n = 5). Consequently, 20 articles were deemed eligible and included in the final analysis.



3. RESULTS

A total of 20 studies were included in the analysis. These studies were conducted at multiple countries and incorporated diverse methodologies, with retrospective observational designs being the most common (50%). The remaining designs included cross-sectional (25%), prospective cohort (15%), and observational (10%) studies. The geographical distribution of studies highlighted significant contributions from Ethiopia (25%), India (20%), and Brazil (10%), reflecting global relevance.

Sample sizes varied significantly, ranging from 70 to 2,386 participants. The combined sample size across the studies was 9,243 participants, with an average of 462 participants per study. Male predominance was evident, comprising approximately 63.5% of the study population and male-to-female ratios consistently ranged from 1.5:1 to 2:1, underscoring a gender disparity in the populations studied.

Causes of Admission:

The primary causes of hospital admissions varied across the studies but revealed consistent patterns. Respiratory illnesses emerged as the leading cause in most studies, with rates ranging from 19.1% to 49% [5,13-16]. Neurological conditions were the second most common, accounting for 9.4% to 33.2% of cases [1,17,18]. Sepsis and other infectious diseases also contributed significantly, with prevalence rates between 3.4% and 40% [19-21]. Cardiovascular conditions were responsible for 8.5% to 12.19% of admissions [16,22], while gastrointestinal disorders accounted for 7% to 24.7% [13,24]. Trauma, surgical complications and poisoning were less frequent but notable causes, ranging from 1.4% to 7.2% in specific studies [13, 25]. Rare conditions such as meningitis and acute kidney injuries were reported in smaller proportions, with rates reaching up to 14.2% in some studies [18].

Admission and Readmission Patterns

The patterns of first-time hospital admissions and readmissions showed variation across the studies. For first-time admissions, one study reported a rate of 100% [14], indicating that all included patients were admitted for the first time during the study period. In another study, 88.1% [22] of patients were first-time admissions, while the remaining 11.9% were readmissions. The readmission rates ranged from 1.9% to 11.9% across the studies, depending on factors such as the nature of the illnesses, the effectiveness of initial treatments, and follow-up care practices.

The review encompassed 20 studies conducted across diverse geographical regions (Libya, South Africa, Iran, India, Brazil, Ethiopia, Nepal, Bangladesh). The primary causes of PICU admissions varied widely but predominantly included respiratory diseases (19.1% to 49%), central nervous system (CNS) conditions (14.3% to 33.2%), and sepsis (3.4% to 40%). A notable percentage of patients required mechanical ventilation (MV), highlighting the severity of conditions managed in PICUs.

Key findings from admission patterns:

- **Respiratory diseases**: Most studies identified respiratory conditions as the leading cause of admissions, with proportions ranging from 19.1% to 49%.
- **Neurological disorders**: CNS-related issues were the second most common cause, reported in 14.3% to 33.2% of admissions.
- **Sepsis and infections**: Sepsis accounted for 3.4% to 40% of admissions across different regions.

Table 1: Summary of Admissions Patterns

Author (year)	Study Design	Country	Sample Size	First time Admitted	Second time admitted	Cause of Admission
Dr. Susan Hassan Mausa, 2015	Retrospective Descriptive Cross-Sectional	Libya	Male: 234, Female: 171, n=405	N/A	N/A	Respiratory diseases (47%), CNS (14.7%), GI (10.8%), CV (9.9%), Endocrine (4.7%), Hematological, Renal, Surgical (2.5% each), Others (2%), Infection (0.7%)
Fallahzadeh et al., 2015	Cross-Sectional	Iran	Male: 147, Female: 109, n=256	N/A	N/A	Sepsis (14.8%), Pneumonia (14.5%), CHF (9.8%), Hepatic encephalopathy (9.8%)
Hendricks C.L., McKerrow N.H. (2016)	Retrospective Observational	South Africa	Male: 51, Female: 45, n=96	96	N/A	Respiratory (32.3%), shock (7.3%), CNS (9.4%), surgical trauma (5.2%)
Nasim et al., 2016	Retrospective Observational	Pakistan	Male: 126, Female: 117, n=243	N/A	N/A	Respiratory illnesses (27.98%), CNS diseases (18%), Sepsis/infection (14.4%), Cardiovascular (9%)

Patel et al. [28], 2017	Retrospective Observational	South Africa	Male: 71, Female: 52, n=123	N/A	N/A	RTI (66%), Toxin ingestion (17%), Blunt injury, Falls, Near drowning
Sahoo B. et al., 2017 [13]	Retrospective Observational	India	Male: 520, Female: 328, n=848	848	N/A	Infectious (20.7%), Respiratory (19.1%), CNS (14.3%), Cardiovascular (10.8%), Gastrointestinal (7%), Surgical (4.7%), Renal (3.3%), Poisoning (1.4%)
Haftu et al., 2018	Retrospective Cross-Sectional	Ethiopia	Male: 215, Female: 185, n=400	N/A	N/A	Respiratory (22.5%), CNS (20.75%), Meningitis (11%), Post-op (10.8%), Acute GN (10.3%)
Lanziotti et al. [29], 2018	Prospective Cohort	Brazil	Male = 56, Female = 47, Total n = 103	N/A	N/A	Sepsis (Respiratory focus 65%, CNS focus 12.5%)
Bhavari et al., 2019	Retrospective Observational	India	Male: 228, Female: 189, n=417	N/A	N/A	LRTI (14.7%), Febrile convulsions (14.1%), AGE (7.2%), Sepsis (3.4%)
Tazebew et al., 2019	Cross-Sectional	Ethiopia	Male: 197, Female: 133, n=330	N/A	N/A	Neurological (31.1%), Infections (13.3%), Renal (11.2%)
Mahmud Mohammed et al., 2020 [24]	Retrospective Cross-Sectional	Eritrea	Male: 116, Female: 74, n=190	N/A	N/A	Respiratory (26.3%), GI (24.7%), Neurological (11%), Sepsis
Joshi et al. [14], 2020	Cross-Sectional	Nepal	Male: 397, Female: 255, n=652	100%	1.9% re-admitted	Pneumonia (33.1%), Sepsis (18.9%), Bronchiolitis (6.7%), Meningitis (2.8%), Other infections (5.8%)

Silva et al., 2021 [23]	Prospective Cohort Study	Brazil	1368	N/A	N/A	Respiratory (41%), Sepsis (12.2%), Trauma, Neurological
Poyekar et al. [30], 2021	Retrospective Observational	India	Male: 1380, Female: 1006, Total: 2386	N/A	N/A	Respiratory infections (27.3%), Infectious diseases (20.5%), Neurological (18.2%), Gastrointestinal (10.5%), Poisoning/Bites (7.6%)
Seifu et al., 2022[22]	Retrospective Cross-Sectional	Ethiopia	Male: 197, Female: 164, n=361	318 (88.1%)	43 (11.9%)	Septic shock (27.14%), Meningitis (18.56%), CHF (12.19%), Severe Pneumonia (6.09%), ARDS (4.71%)
Gemechu et al. [18], 2022	Cross-Sectional Observational	Ethiopia	Male: 153, Female: 107, Total: 260	98.10%	N/A	CNS (33.2%), Respiratory (23.1%), Septic shock (7.3%), CHF (10.4%), AKI (14.2%)
Rahman et al. [25], 2023	Prospective Observational	Bangladesh	Male: 264, Female: 167, Total: 431	N/A	N/A	Respiratory (45.2%), Infectious (24.8%), Surgical (7.2%), Cardiovascular (4.9%), Neurological (10.4%)
Chaudhary et al. [15], 2023	Cross-Sectional Study	Nepal	Male: 156, Female: 104, Total: 260	N/A	N/A	Respiratory (49%), Neurological (18.8%), Gastrointestinal (10%), Sepsis (4.6%)
Kumar D et al., 2024 [21]	Observational Study	India	Male: 42, Female: 28, Total: 70	N/A	N/A	Sepsis (40%), LBW (32.8%), Perinatal asphyxia (31.4%), Pneumonia (20%), Preterm (18.5%)

Kebede et al., 2024 [16]	Retrospective Cross-Sectional	Ethiopia	Male: 113, Female: 98, Total: 211	N/A	N/A	Respiratory (42.9%), Neurological (17.5%), Sepsis (15.6%), Cardiac (8.5%), Renal (7.6%)

Hospital Stays:

The length of hospital stay (LOS) varied significantly across the studies. The average LOS ranged from 2 to over 7 days, depending on the patient population and severity of conditions. Some studies reported a mean LOS of 5.4 days [24], while others noted shorter median stays, such as 2.73 days [15], reflecting efficient treatment and discharge processes. Conversely, prolonged stays exceeding 7 days were often associated with severe cases and higher mortality rates, as seen in studies where 63.8% of deaths occurred in patients with extended hospitalizations [21].

Clinical Outcomes:

Clinical outcomes varied significantly across the studies. Recovery and discharge rates averaged 75.6%, with some studies reporting rates as high as 93.4% [23]. Mortality rates ranged from 4.1% [13] to 74% [21], averaging 19.8%, with sepsis, MODS, and respiratory failure being common contributors. DAMA rates remained low at 3.2% [22] and mechanical ventilation was required in 10%–100% of cases [21-22]. Inotropic and vasopressor support were needed in 32.9% [22] and 21.4% [23] of cases, respectively. Male patients consistently accounted for a higher proportion of deaths [26-27]. These findings highlight the critical role of timely and effective interventions in improving patient outcomes.

Need for Mechanical Ventilation (MV):

The need for mechanical ventilation (MV) varied significantly across the studies, reflecting the severity of conditions among the patients. MV was required in 10% [15] to 100% of cases [21], with higher usage rates reported in studies involving severe illnesses such as sepsis, respiratory failure, and multi-organ dysfunction syndrome (MODS). One study documented universal MV use (100%) in critically ill patients [21], while others reported moderate rates, such as 57.9% [22] and 34.15% [27]. The consistent reliance on MV underscores its critical role in managing life-threatening conditions and supporting patients with compromised respiratory function.

Comorbidities and Critical Care Needs:

Comorbidities significantly impacted patient outcomes, with conditions such as sepsis, MODS, malnutrition, and renal failure frequently reported [22,24]. Inotropic support was required in 32.9% of cases [22] and vasopressor use was noted in 21.4% [23], reflecting the severity of illnesses. Transfusions were needed in 13.1% of patients [18], primarily in those with critical conditions. These findings highlight the complex care needs of patients requiring intensive medical interventions to manage comorbidities and stabilize critical conditions

Factors Responsible for Mortality:

The primary factors contributing to mortality included sepsis, MODS, and respiratory failure, which were consistently reported across studies [5, 26]. Prolonged mechanical ventilation and low Glasgow Coma Scale (GCS) scores were also significant predictors of poor outcomes [16]. Gender-specific analysis revealed higher mortality rates among males [26-27]. Other contributing factors included acute kidney injuries [24] severe malnutrition [22] and delayed access to critical care [1], underscoring the importance of early and effective interventions in reducing mortality.

Mortality Rates:

Mortality rates ranged widely from 4.1% [13] to 74% [21], with an average of 19.8%. Key mortality predictors included sepsis [23,26], prolonged MV [21], low Glasgow Coma Scale (GCS) scores [16] and significant comorbid conditions [24]. Male patients were disproportionately affected, accounting for the majority of deaths [26-27].

The mean length of stay (LOS) varied from 2.73 to 8.52 days. Mortality rates ranged from 4.1% to 74%, with the highest rates observed in studies involving patients with prolonged ventilation and multiple comorbidities.

- **Recovery rates**: Most studies reported recovery rates exceeding 70%, with a significant proportion being discharged.
- **Mortality factors**: Key factors associated with higher mortality included:
    - Requirement for mechanical ventilation (up to 100% in severe cases).

- Sepsis, multiorgan dysfunction syndrome (MODS), and malnutrition.
- Lower Glasgow Coma Scale (GCS) scores and late referrals.

- **Comorbidities**: Conditions such as severe malnutrition, congenital heart defects (CHD), and acute renal injury were strongly linked to poor outcomes.

Table 2: Treatment Outcomes and Mortality Analysis

Author (year)	**Hospital Stays**	**Clinical Outcomes (all things from studies)**	**Need of M/V**	**Comrbidity**	**Need of Inotropic**	**Need of Transfusion**	**Need of Vasopressor**	**Factors Resposinbile with Mortality**	**Mortality Rate**
Dr. Susan Hassan Mausa, 2015	Mean LOS: 6.8 days; Majority stayed 1-7 days (86.6 %)	Recovered: 311 (76.8%), Referral: 49 (12%), DAMA: 16 (4%), Deaths: 29 (8.5%)	Yes: 30 cases (7.4%)	Sepsis, MODS	N/A	N/A	N/A	Pneumonia (20.7%), aspiration pneumonia, CHD	Male: 15 deaths, Female: 14 deaths, Total: 29 deaths (8.5%)
Siddiqui et al. [26], 2015	Mean: 8.52 ± 9.53 days, Range: <1–68 days	Total deaths: 256 (100%) \Multi-organ dysfunction syndrome (MODS): 48% \Sepsis-related deaths: 14.8% \ Respiratory failure deaths: 31.2% \ Congenital heart disease deaths: 27.6% \Hepatic failure deaths: 9.8% \ Neurological complications: Common in chronic cases	Yes (all patients)	Yes (70.7%)	N/A	N/A	N/A	Sepsis, respiratory failure, congenital heart disease, MODS	Male: 147 deaths, Female: 109 deaths, Overall: 256 deaths (100%)
Hendricks C.L., McKerrow N.H. (2016)	4 days	n= 81 patients (84.4%) recovered, n= 5 patients (5.2%) transferred to other hospitals, n=15 deaths (15.6%)	Yes	Yes	N/A	N/A	N/A	Severe malnutrition, respiratory illness, shock	15.60%

Nasim et al. [27], 2016	Majority > 24 hours	Recovered: 174 (71.6%), DAMA: 3 (1.2%), Referred: 7 (2.8%), Deaths: 59 (24.3%)	Yes: 83 (34.15 %)	N/A	N/A	N/A	Yes: 49 (20.16 %)	Sepsis, poor status at admission, MODS	Male: 32 deaths, Female: 27 deaths, Overall: 59 deaths (24.3%)
Patel et al. [28], 2017	Median: 7 days (Range: 1-33)	Recovered and discharged: 92% (112/123) \Deaths: 11 patients (9%) \Neurological deficits: 4 patients \Discharge to rehabilitation center: 5 patients	Yes (89%)	N/A	N/A	N/A	N/A	RTI, age < 4 years, head injury, female gender	Male: 4 deaths, Female: 7 deaths, Overall: 9%
Sahoo B. et al. [13], 2017	Mean 3.7 days	recovered: 70.3%, Transferred: 24%, DAMA: 1.4%, Deaths: 4.1%	Yes (72 cases)	MODS (25%), Sepsis (20.7%)	N/A	N/A	Yes	Sepsis with MODS, encephalitis, pneumonia, CHD	Male: 19 deaths (3.65%), Female: 16 deaths (4.87%), Total: 35 deaths
Haftu et al., 2018	Mean: 4.9 days, majority (61%) stayed 2–7 days	Recovered: 336 (84%), Deaths: 34 (8.5%)	Yes (4%)	Yes (45.8%)	Yes	N/A	Yes	Use of inotropes, MV, comorbid illness, low GCS <8	Male: 18 deaths, Female: 16 deaths, Overall: 8.5%
Lanziotti et al. [29], 2018	Median PICU LOS: 9–14 days	Fast response: 4.5% mortality; biphasic: 42.8%	Yes (69%)	Yes (33%)	N/A	N/A	Yes (71%)	Persistently elevated CRP, nosocomial infection	Male: 7, Female: 5, Total: 12 (11.7%)
Bhavari et al., 2019	N/A	Recovered: 357 (85.6%), DAMA: 36 (8.6%), Deaths: 24 (5.8%)	N/A	N/A	N/A	N/A	N/A	Respiratory diseases, febrile convulsions	Male: 13 deaths, Female: 11 deaths, Overall: 24 deaths (5.8%)

Tazebew et al. [1], 2019	Median LOS: 3 days, <7 days for 84.2%	Survived: 227 (68.8%), Deaths: 102 (30.9%)	Yes (10%)	N/A	N/A	N/A	N/A	Sepsis, late transfers, <24hr deaths, comorbidity	Male: 67 deaths, Female: 35 deaths, Overall: 102 deaths (30.9%)
Mahmud Mohammed et al. [24], 2020	Mean: 5.1±5.4 days, Majority: 2–7 days	Recovered: 141 (74.2%) \Deaths: 49 (25.3%) \Complications: Sepsis, MODS, renal failure	N/A	Yes (49.5%)	N/A	N/A	N/A	Acute renal injury, septic shock, hepatic failure	Male: 30 deaths, Female: 19 deaths, Overall: 49 deaths (25.3%)
Joshi et al. [14], 2020	Mean LOS: 5.72 ± 5.78 days	Improved: 484 (74.23%), Deaths: 120 (18.46%), DAMA: 46 (7.05%)	N/A	Yes (21.62 %)	N/A	N/A	N/A	Sepsis, co-morbidities, acute leukemia, young age	Male: 70 deaths, Female: 50 deaths, Overall: 120 deaths (18.46%)
Silva et al., 2021 [23]	Median LOS: 4-5 days	Survived and Discharged: 93.4% \ Deaths: 6.6% \Night-time Mortality: 8.5% vs. Daytime Mortality: 5.3% \Early Mortality (<48 hrs): 4.2% \Neurological Complications: Present in 9.8% of cases \Sepsis Mortality: Highest among admissions with PRISM II >20	Yes (60.7 %)	Yes (38%)	Yes	N/A	Yes	Night-time admissions, Sepsis, PRISM II score >20	6.6% Total
Poyekar et al. [30], 2021	Mean LOS: 4.81 ± 4.89 days	Discharged: 2027 (85%), Expired: 215 (9%), DAMA: 8 (0.3%), PICU discharge: 136 (5.7%)	N/A	N/A	N/A	N/A	N/A	Sepsis, severe respiratory infection, meningitis	Male: 110 deaths, Female: 105 deaths, Overall: 215 deaths (9%)

Seifu et al., 2022 [22]	1–7 days (Majority)	Survived: 183 (50.7%), Deaths: 158 (43.8%), DAMA: 13 (3.6%), Referred: 7 (1.94%)	Yes (57.9 %)	Yes (significant)	N/A	N/A	Yes	Septic shock, mechanical ventilation, inotropes, comorbidity	Male: 84 deaths, Female: 74 deaths, Overall: 158 deaths (43.8%)
Gemechu et al. [18], 2022	Median LOS: 6.0 days (Range: 0.5–60 days)	Discharged: 65.4% (170), Deaths: 21.1% (55), DAMA: 0.8%; Transferred to pediatric ward: 65.4%	Yes (11.2 %)	31.90%	13.10 %	N/A	N/A	Mechanical ventilation, cardiopulmonary resuscitation (CPR), septic shock	Male: 34 deaths, Female: 21 deaths, Total: 55 deaths (21.1%)
Rahman et al. [25], 2023	N/A	Discharged: 310 (71.9%), Deaths: 97 (22.5%), DAMA: 24 (5.6%)	N/A	N/A	N/A	N/A	N/A	Respiratory dysfunction, cardiovascular, neurological causes	Male: 53 deaths, Female: 44 deaths, Overall: 97 deaths (22.5%)
Chaudhary et al. [15], 2023	Mean LOS: 2.73 days \nMedian: 2 days	Discharged: 231 (88.85%), Deaths: 16 (6.2%), DOPR: 5 (1.92%), LAMA: 4 (1.54%), Referrals: 4 (1.54%)	Yes (10%)	N/A	Yes	N/A	N/A	Sepsis, pneumonia, meningitis/encephalitis, mechanical ventilation need	Male: 10 deaths, Female: 6 deaths, Overall: 16 deaths (6.2%)
Kumar D et al., 2024 [21]	>7 days in 63.8% of deaths	Survived: 23 (26%), Deaths: 47 (74%) \nComplications: VAP (8.1%), ET Tube obstruction (35%), Re-intubation (20%)	100% (all ventilated)	N/A	N/A	N/A	N/A	Prolonged ventilation, sepsis, LBW, perinatal asphyxia	Male: 36 deaths, Female: 11 deaths, Overall: 47 deaths (74%)
Kebede et al., 2024 [16]	LOS: <2 days (23.7 %), 2–7 days (52.6 %), 8–	Discharged/Transferred: 149 (70.6%) \n- Deaths: 62 (29.4%) \n - Respiratory illnesses: 22 deaths (35.5%)	Yes (45.5 %)	Yes (20.4%) Severe malnutrition (74.4%)	Yes (35.1 %)	N/A	N/A	Mechanical ventilation, inotrope need, LOS <2 days,	Male: 35 deaths \nFemale: 27 deaths \nOverall: 62 deaths (29.4%)

	14 days (15.2 %)	\n - Neurological cases: 13 deaths (21%) \n - Sepsis: 15 deaths (24.2%) \n - Others (cardiac, renal): 12 deaths (19.3%) \n- DAMA (Discharged Against Medical Advice): 22 (10.4%)						GCS ≤13	

4. DISCUSSION

This systematic review and meta-analysis provide a comprehensive overview of the patterns of admissions and treatment outcomes in Pediatric Intensive Care Units (PICUs) across diverse geographical and resource settings. The findings reveal a multifaceted picture of pediatric critical care, emphasizing the global burden of respiratory illnesses, neurological conditions and sepsis as leading causes of PICU admissions. These insights underscore the critical role of PICUs in addressing pediatric morbidity and mortality, particularly in low- and middle-income countries (LMICs).

According to all the demonstrated studies respiratory illnesses consistently emerged as the primary cause of PICU admissions, with proportions ranging from 19.1% to 49%. This aligns with the global burden of pediatric respiratory diseases, where conditions such as pneumonia, bronchiolitis and acute respiratory distress syndrome (ARDS) predominate [31-32]. In LMICs, infectious respiratory diseases remain a significant challenge due to delayed access to healthcare, malnutrition and inadequate vaccination coverage [33]. Neurological conditions, including central nervous system (CNS) infections, seizure disorders and meningitis, were the second most common cause, accounting for 14.3% to 33.2% of admissions. This were similar to the study done by Abbas et al. During their study period, 231 (19.3%) patients were admitted with acute neurological illnesses in PICU [34]. Sepsis and other infectious diseases also contributed substantially, with rates varying between 3.4% and 40%. Comparable findings were observed in the study conducted by de Souza DC et al., which analyzed 1,090 patients. Among these, 464 were diagnosed with sepsis, with the prevalence rates for sepsis, severe sepsis, and septic shock reported as 42.6%, 25.9%, and 19.8%, respectively [35]. These findings emphasize the need for early identification and effective management of infectious and neurological conditions to improve PICU outcomes.

Regional variations in admission causes were evident. High-income countries reported higher proportions of trauma and congenital anomalies, reflecting advanced pre-hospital care and neonatal screening programs [6]. Conversely, LMICs faced a higher burden of infectious diseases, malnutrition, and preventable conditions [37-38]. This disparity highlights the influence of healthcare infrastructure and socioeconomic factors on PICU admission patterns.

Treatment Outcomes:

The analysis revealed significant heterogeneity in treatment outcomes across the included studies. Similar outcomes were noted in the study done by Ko MS et al. and Procter et al. [39-40]. Recovery and discharge rates averaged 75.6%, with some studies reporting rates as high as 93.4% in well-equipped settings [23]. The present study, reporting a mortality range of 4.1% to 74% with an average of 19.8%, showed notable differences compared to both Siddiqui NU et al. and McCrory MC et al. findings. Siddiqui et al. reported a PICU mortality rate of 12.9% primarily associated with sepsis and CNS conditions [42], while McCrory et al. observed a much lower PICU mortality of 2.31% [41]. McCrory's study highlighted that mortality varied based on admission timing, with higher rates during morning and midday admissions, particularly on weekends, emphasizing the influence of admission timing on outcomes [41]. These disparities underscore the role of patient characteristics, clinical conditions and institutional factors in shaping mortality rates across studies.

Mechanical ventilation (MV) was a critical intervention in managing critically ill children, with usage rates ranging from 10% to 100%. The need for MV was higher in cases involving respiratory failure, sepsis, and multi-organ dysfunction syndrome (MODS). Prolonged MV and low Glasgow Coma Scale (GCS) scores were associated with poor outcomes, highlighting the importance of early ventilatory support and comprehensive monitoring. Inotropic and vasopressor support were frequently required, reflecting the severity of hemodynamic instability in these patients. In comparison, the study by Siddiqui et al. reported that all critically ill children initially received aggressive supportive care, including mechanical ventilation [42]. This consistency in the reliance on MV across both studies underscores its pivotal role in the management of

critically ill pediatric patients, particularly in severe and complex cases.

Comorbidities such as severe malnutrition, acute renal injury and congenital heart defects (CHD) significantly influenced outcomes. These conditions often necessitated complex medical interventions, including transfusions, prolonged MV, and inotropic support. Studies consistently reported higher mortality rates among male patients, potentially due to gender-specific health-seeking behaviors or biological differences in disease susceptibility. Similarly, prior research noted that coexisting diseases significantly impacted acute illness severity, complications, and clinical outcomes in PICU patients. A study reported an overall mortality rate of 71.75% among patients with comorbidities, markedly higher than rates observed in the west of Scotland (24–53%) [43]. This disparity was attributed to resource limitations and delayed treatment for comorbidities in certain healthcare settings [44]. Both findings highlight the critical role of addressing comorbidities and optimizing resource allocation to improve PICU outcomes

Factors Influencing Mortality:

Sepsis, MODS, and respiratory failure were the leading contributors to mortality in PICUs. These conditions highlight the need for robust infection control measures, early sepsis recognition, and timely initiation of life-saving interventions. Delayed referrals, resource constraints, and inadequate critical care infrastructure in LMICs further exacerbated mortality rates. Studies from Ethiopia, India, and Nigeria reported mortality rates exceeding 40%, emphasizing the urgent need for capacity-building in pediatric critical care. Similarly, the study by Seifue et al. demonstrated a significant association between PICU mortality and severe (GCS < 8) or moderate (GCS 9–12) levels of consciousness compared to mild levels (GCS 13–15), with p-values of <0.001 and 0.007, respectively [22]. This finding aligns with the study by Haftu H et al. at Ayder Referral Hospital in North Ethiopia [5]. Both studies emphasize the critical role of early identification and management of high-risk conditions, such as altered consciousness, in improving pediatric critical care outcomes.

Prolonged length of hospital stays (LOS) was associated with higher mortality, particularly in resource-limited settings where extended care often reflects severe illness or delayed recovery. Conversely, shorter median LOS, as seen in some studies, indicated efficient management and discharge processes. However, prolonged stays also highlighted gaps in healthcare systems, including inadequate post-discharge follow-up and rehabilitation services.

Siddiqui NU et al. found higher mortality odds for PICU stays of 2–7 days (AOR = 7.3, p = 0.007) and other shorter durations compared to >28 days [42], contrasting with Vincent JL et al., who reported higher mortality for stays >28 days [10]. Siddiqui attributed this to the higher use of mechanical ventilation in shorter stays (p < 0.001), highlighting the complexity of LOS as a mortality predictor influenced by illness severity and interventions [42].

Implications for Practice:

1. **Strengthening PICU Resources:** Enhancing PICU capacity, particularly in LMICs, is crucial for reducing pediatric mortality. Investments in skilled personnel, equipment, and essential medications can significantly improve outcomes.
2. **Early Identification and Intervention:** Timely recognition and management of respiratory illnesses, sepsis, and neurological conditions are pivotal. Implementing standardized protocols for early sepsis detection and ventilatory support can reduce morbidity and mortality.
3. **Training and Capacity Building:** Comprehensive training for healthcare professionals in managing critical pediatric conditions is essential. This includes simulation-based training for early resuscitation and critical care interventions.
4. **Focus on Comorbidities:** Addressing malnutrition, congenital anomalies, and other comorbidities through integrated care models can improve overall survival rates.
5. **Policy and Advocacy:** Policymakers should prioritize pediatric critical care in national health agendas, ensuring equitable access to PICU services across all regions.

5. CONCLUSION

Present systematic review and meta-analysis highlight the critical role of PICUs in managing life-threatening pediatric conditions. Respiratory illnesses, infections and neurological disorders remain leading causes of admissions, with significant variability in outcomes influenced by resource availability and early interventions. Addressing gaps in healthcare infrastructure, particularly in LMICs, and implementing evidence-based strategies can enhance survival rates and optimize the quality of care for critically ill children.

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