Mortality in Pediatric Intensive Care

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Abstract

Background: Mortality in pediatric intensive care units is a major concern in critical care medicine given the unique physiological and clinical complexities in pediatric patients. Understanding the causes and complications associated with mortality is essential to improve patient outcomes.

Aim: This study aims to evaluate the mortality profile in a pediatric intensive care unit by identifying the main causes of death and associated complications. The objective is to better understand the contributing factors to mortality in order to improve clinical management and care strategies.

Methods: We conducted a retrospective descriptive study including all patients who died in the pediatric intensive care unit at Hedi Chaker University Hospital in Sfax over a one-year period, from September 2023 to September 2024. Demographic data, clinical characteristics, underlying conditions, treatments received, and complications were collected and analyzed.

Results: A total of 41 deaths were recorded, resulting in a mortality rate of 14.08%. The highest mortality was observed in spring (21.8%) and summer (18.18%). The median age of deceased patients was 15.4 months, ranging from 7 days to 11 years, with males representing (65.9%). Most children lived in urban areas (75.6%), and 46.3% came from socioeconomically disadvantaged backgrounds. Underlying conditions were present in 26.8% of patients, and 36.6% were born to consanguineous parents. More than half (51.2%) were referred from pediatric wards. Mechanical ventilation was used in 90.2% of cases, and vasoactive drugs in 70.7%. The most common complications were cardiovascular (68.3%), metabolic (56%), hematological (56%), respiratory (46.3%), infectious (43.9%), and neurological (26.8%). Infectious causes were the leading cause of death (26.82%), including severe acute bronchiolitis (14.63%) and malignant pertussis (22%). Congenital heart diseases accounted for 7.31% of deaths.

Conclusions: This study highlights the principal causes and complications associated with pediatric mortality in intensive care. These findings provide important insights for improving risk stratification, optimizing care strategies, and ultimately reducing mortality in critically ill children.

Keywords: Child mortality, Intensive care units, Pediatrics, Risk factors, Retrospective studies.

Introduction

The study of mortality in pediatric intensive care is a crucial issue in critical care medicine, given the pathophysiological and clinical specificities of children. Thus, children's health remains a major priority for healthcare structures, requiring adapted protocols and continuous improvement of practices in pediatric intensive care. According to the World Health Organization (WHO), global infant mortality reached a historically low level in 2022, with 4.9 million deaths of children under the age of five, representing a 51% reduction since 2000[1]. However, disparities persist, particularly in sub-Saharan Africa[2], where infant mortality remains high. The pediatric mortality rate is a key indicator reflecting a country's level of social and economic development. Analyzing these rates helps assess the population's health status and evaluate the quality of care provided. Thus, the pediatric intensive care unit plays a crucial role in delivering specialized critical care to children in life-threatening conditions, thereby increasing their chances of survival[3]. In Tunisia, child health indicators, particularly under-five mortality and neonatal mortality, have significantly improved over the past decade[4].A better understanding of the circumstances and causes of mortality in pediatric intensive care will enhance patient assessment and management, thereby optimizing their short- and medium-term prognosis.

Methods

We conducted a retrospective and descriptive study on all pediatric patients who died in the intensive care unit (ICU) of Hedi Chaker Hospital between September 2023 and September 2024. The unit includes eight beds equipped with multiparametric monitors and ventilators. Medical coverage is ensured around the clock by a rotating team of physicians and nurses.

The study included all children who were hospitalized and died in our pediatric intensive care unit during the study period. Data were collected using a standardized form including demographic, clinical, and hospitalization information (age, sex, socio-economic status, origin, medical history, admission pathway, and reason for admission).

Patients were admitted through various sources, including the pediatric emergency department, other hospital wards, postoperative units, and external referrals. Clinical condition at admission, main investigations, treatments administered, and major complications were documented.

Mortality was analyzed in terms of frequency, seasonality, timing, and underlying causes. Data analysis was performed using SPSS version 20, with descriptive statistics applied to both qualitative and quantitative variables.

Results

During the study period from September 2023 to September 2024, a total of 291 children were admitted to the pediatric intensive care unit of Hedi Chaker Hospital, with 41 recorded deaths, corresponding to an overall mortality rate of 14.08%.

The median age of the deceased patients was 15.4 months (range: 7 days to 11 years), and 82.9% were under two years of age. Males accounted for 65.9% of the cases, with a male-to-female ratio of 1.9. Among these patients, 75.6% came from urban areas, 46.3% belonged to a low socio-economic background, and 36.6% were born to consanguineous parents. Pre-existing conditions were identified in 26.8% of cases, including chronic respiratory diseases (40%), congenital heart disease (20%), prematurity (20%), neurological diseases (10%), and autoimmune diseases (10%). No history of previous surgery was reported.

The majority of patients (52.9%) were admitted to the unit within 2 to 12 hours following referral. The main sources of admission were pediatric departments (51.2%), pediatric emergencies (24.4%), and transfers from other hospitals (19.5%). The average duration of illness before admission was 7.8 days (range: 1 to 30 days). Admission was for medicalreasonsin 97.6% of cases (n=40).

Reported reasons for admission included respiratory distress (51.2%), multiple combined organ failures (17.07%), and cardiocirculatory arrest (9.8%). At admission, respiratory instability was observed in 68.3% of cases, while neurological and cardiocirculatory instability were present in 34.14% of patients (Figure 1). Laboratory results revealed anemia in 48.8% of children, thrombocytopenia in 17.1%, leukopenia in 9.8%, hyponatremia in 29.3%, hypernatremia in 7.3%, hypokalemia in 26.8%,

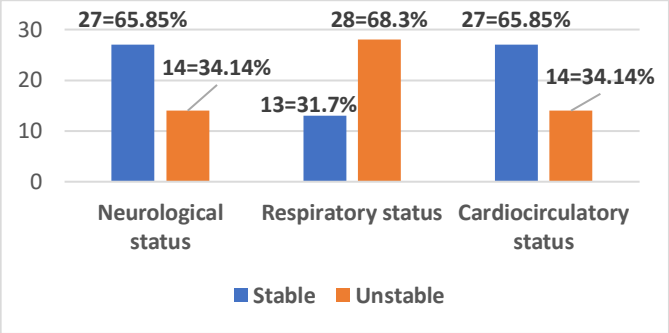

Figure 1: Clinical condition of patients upon admission.

hyperkalemia in 17.1%, metabolic acidosis in 36.8%, respiratory acidosis in 15.8%, renal

failure in 22%, liver cytolysis in 29.3%, and low prothrombin levels in 14.6%. Radiological exams included chest X-rays in 51.2% of patients, with abnormalities noted in 80.95%, such as thoracic distension, cardiomegaly, alveolar syndromes, bronchial syndromes, atelectasis, pneumonia, and pneumothorax. Transthoracic echocardiography was performed in 21.95% of cases. Brain CT scans were done in 21.95% and showed abnormalities in 55.5%, including subdural hematoma, cerebral venous thrombosis, cerebral edema, brain herniation, and cortico-subcortical atrophy. Brain MRIs were performed in 7.3% of cases and revealed cerebral atrophy, suppurative compartmentalized meningitis, and cerebral edema.

Regarding management, 68.3% of the patients required immediate intubation, and 90.2% were placed on mechanical ventilation (Table 1).

Hemodynamic support was necessary in 70.7% of cases, with the administration of adrenaline (41.4%), norepinephrine (39%), and dobutamine (24.3%). Antibiotic therapy and sedation were each administered in 92.7% of cases. Blood

transfusion was given to 48.8%, anticonvulsants to 19.5%, corticosteroids to 17.1%, and exchange transfusion was performed in 9.7%. Central venous access was placed in 75.6% of patients, urinary catheterization in 70.7%, gastric tubing in 95.1%, and chest drainage in 7.3%.

Table 1: Distribution of the population based on the type of ventilatory support.

Ventilatory support	Number	Percentage (%)
Intubation	28	68.3
NIV followed by intubation	2	4.9
Tracheostomy	1	2,4
High-flow [Airvo] followed by intubation	6	14.6
Low-flow oxygentherapy	1	2,4
Nasal cannula	3	7.3
Total	34	100,0

Complications were recorded in several domains: cardiocirculatory (68.3%), metabolic (56%), hematological (56%), infectious (43.9%), respiratory (46.3%), and neurological (26.8%). We have detailed all the complications in the following table(2).

Deaths occurred throughout the year, with seasonal peaks observed in spring (21.8%) and summer (18.18%). A significant proportion of deaths (43.9%) occurred during on-call hours (between 8 PM and 8 AM). The length of hospitalization ranged from 24 hours to 40 days, with an average stay of 11 days; five patients died within the first 48 hours. Most patients (48.78%) died after 48 hours to 14 days of hospitalization. The initial causes of death included infectious diseases (26.82%), severe acute bronchiolitis (14.63%), malignant pertussis (22%), and congenital heart disease (7.31%) (Table 3). Immediate causes of death were primarily multiorgan failure (34.1%) and septic shock (26.8%).

Table 2: Distribution of the population according to different complications.

Type of complication	Complications	Number	Percentage (%)
Respiratory	ARDS (acute respiratory distress syndrome)	*6*	*14.6*
	Ventilatory disorder	*7*	*17*
	Pneumothorax	*4*	*9.7*
	Pulmonary Hypertension (PH)	*5*	*12.2*
	Pleurisy	*3*	*7.3*
Infections	Sepsis	*4*	*9.7*
	Healthcare-associated infection	*11*	*26.8*
	Ventilator-associated pneumonia (VAP)	*3*	*7.3*
Metabolic	Renal failure	*13*	*31.7*
	Hyperglycemia >1.8g/l	*3*	*7.3*
	Hypoglycemia <0.6 g/l	*2*	*4.87*
	Hypokalemia < 3.5 mmol/l	*4*	*9.75*
	Hyperkalemia > 5.5 mmol/l	*2*	*4.87*
	Hyponatremia < 135 mmol/l	*3*	*7.3*
	Hypernatremia > 145 mmol/l /Hypercalcemia > 2.75 mmol/l	*1*	*2.4*
	Hepatic-cytolysis	*9*	*21.9*
Cardiovascular	Recovered cardiac arrest (ACR)	*13*	*31.7*
	Septic shock	*12*	*29.2*
	Cardiogenic shock	*3*	*7.3*
	Venous thrombosis	*2*	*4.8*
	Hypertensive crisis	*2*	*4.8*
Neurological	Status epilepticus	*9*	*21.9*
	Confusion	*1*	*2.4*
Hematologic disorder	Anemia	*18*	*43.9*
	SAM/DIC/Alveolar hemorrhage	*1*	*2.4*
	Thrombocytopenia	*5*	*12.2*
Pressure ulcers		*2*	*4.8*

Table 3: Analysis of Causes of Death

Causes of death	*N*	Percentage (%)
Infectious diseases	12	26.82
Severe acute bronchiolitis	6	14.63
Malignant pertussis	9	22
Respiratory causes	2	4.87
Congenital heart diseases	3	7.31
Congenital conditions	1	2.43
Neurological diseases	2	4.87
Liver diseases	2	4.87
Surgical conditions	1	2.43
Others	4	9.75
Total	41	100

Discussion

The mortality rate in pediatric intensive care units (PICU) is an essential indicator of the quality and efficiency of care. In our study, the mortality rate was 14.08%, which shows a significant improvement compared to earlier rates in our department: 34.4% in 2019 and 20.4% in 2020. However, despite this reduction, the mortality rate remains high, primarily due to limited resources, a challenge that is common in developing countries[5]. These resource constraints significantly affect patient outcomes, as seen in other studies conducted in similar settings.

A significant issue in our unit is the lack of resources, such as dialysis and extra-corporeal-membrane-oxygenation (ECMO), which limits our ability to treat critically ill patients. Infections related to care, particularly hospital-acquired infections, are exacerbated by a lack of essential medical equipment. Furthermore, transfers from other hospital departments introduce additional pathogens, contributing to increased mortality.

Our unit does not practice patient selection when PICU beds are available, meaning all children requiring intensive care are admitted regardless of severity. This approach may impact mortality rates but ensures that all children have access to the care they need.

Across many developing countries, the PICU mortality rate remains high and varies widely, ranging from 8% to 40%[10,12]. This is often due to limited access to healthcare, insufficient medical equipment, and delays in patient management[13,14]. For example, in Ethiopia, a study found the highest mortality rate at 41.7%. Other studies conducted in India, Pakistan, and Côte d'Ivoire also highlight similar challenges with high mortality rates in PICUs (Table 4). These countries struggle with the lack of specialized healthcare infrastructure, shortages in trained medical personnel, and the inability to provide comprehensive treatment. Additionally, high rates of infectious diseases, malnutrition, and socioeconomic disparities further contribute to the high mortality[15].

To reduce mortality, it is crucial to invest in improving healthcare infrastructure, equipping PICUs with necessary medical resources, and providing specialized training to healthcare staff. In contrast, developed countries report significantly lower mortality rates in PICUs. The availability of advanced medical equipment and specialized care has led to a steady decrease in mortality rates over time. In the United States, mortality rates range from 1.85% to 3.38%, and

countries like Sweden have reported as low as 1.1%. These countries benefit from well-established healthcare systems that provide timely and efficient care, which directly improves patient outcomes. Moreover, the use of advanced technologies such as ECMO, dialysis, and other critical interventions in these regions contributes to lower mortality rates.

Table 4: Comparison of Pediatric Intensive Care Unit (PICU) Mortality Rates Between Developing and Developed Countries

Study	Developing Country	Year	Mortality Rate [%]
El Halal at al [16]	**Brazil**	2002-2005	10.3
Dendir et al [10]	**Ethiopia**	2018-2020	41.7
Daher et al [7]	**Amman, Jordan**	2015-2020	6.7
Valavi et al [19]	**Iran**	2017	16.5
Josiane et al [21]	**Ivory Coast [Côte d'Ivoire]**	2019-2021	15.5
Nguefack et al [23]	**Cameroon**	2010-2014	16.6
Punchak et al [25]	**Mozambique**	2013	25
Siddiqui et al [27]	**Pakistan**	2007-2012	12.9
Burns et al [17]	**United States**	2010	2,39
Pollack et al[18]	**United States**	2014	2
Moynihan et al [8]	**Australia and New Zealand**	2006-2016	2.6
Larsson et al [20]	**Sweden**	2008-2012	1.1
Ishihara et al [22]	**Japan**	2014-2017	2.1
Ten Berge et al[24]	**Amsterdam, Netherlands**	2000-2005	4.6
Botan et al [26]	**Ankara, Turkey**	2015-2019	9.13
Li et al [28]	**China**	2015	4.9

The median age in our study was 15.4 months, with 82.9% of deaths occurring in children under 2 years, including newborns. Similar trends were observed in studies from India[6], Jordan[7], and Australia[8], where infants had the highest mortality rates. Infants are particularly vulnerable due to the immaturity of their immune and organ systems, requiring specialized care that poses risks.

In our study, 46.3% of deaths occurred in patients from low socioeconomic backgrounds. Additionally, 26.8% had underlying medical conditions, a factor associated with increased mortality[7,9,10]. Comorbidities complicate health management, leading to more frequent complications and worse outcomes.

The higher incidence of congenital abnormalities in our study, linked to consanguinity (36.6%), may also contribute to increased mortality, as in the study of Benkou and al [11]. Public and healthcare professional awareness is needed to improve prevention.

Our study found that the highest mortality rates were observed in the spring (21.8%) and summer (18.18%), despite the highest number of admissions occurring in the winter. This discrepancy can be explained by the nature of the admissions: winter admissions are mainly related to bronchiolitis, which typically has a favorable prognosis and low mortality. In contrast, the spring and summer months saw more severe cases that contributed to higher mortality rates such as neurological-diseases. In many developing countries, seasonal outbreaks of infectious diseases like malaria or respiratory infections exacerbate mortality. For example, in Niger, the rainy season leads to a surge in malaria cases, significantly increasing PICU admissions and mortality[29]. Similarly, in France, the winter flu season is associated with higher PICU

admissions and mortality, particularly in vulnerable populations[30].

In our study, the average length of stay in the PICU before death was 11.25 days, which is higher than the median lengths reported in other studies[31,32]. This prolonged stay is often associated with severe underlying conditions such as multiple organ failure, severe infections, or unresponsive conditions to initial treatments. Prolonged stays in the PICU are a significant risk factor for increased mortality[10,19], as children often experience complications like nosocomial infections, metabolic imbalances, and physical deterioration caused by prolonged use of medical devices. Additionally, prolonged hospitalizations may reflect poor prognoses and progressive organ dysfunction, further increasing the risk of death.

In our study, the majority of deaths occurred between 8:00 PM and 8:00 AM, which aligns with findings from other studies that suggest mortality rates can be influenced by healthcare staff work shifts[33]. This period typically coincides with reduced staffing and limited access to critical resources and emergency medications. During night shifts, fewer medical staff are available, which may affect the quality of care, particularly for patients in critical conditions. Additionally, some medications and diagnostic tests are less accessible during these hours, which can further hinder patient management and negatively impact clinical outcomes.

Infectious diseases were the leading cause of death in our study, accounting for 26.82% of cases. Among these, severe acute bronchiolitis and malignant pertussis were separately analyzed, representing 14.63% and 22% of deaths, respectively. While bronchiolitis generally has a favorable prognosis, during epidemic periods, it can still contribute to significant mortality in our department. Malignant pertussis, however, has a much worse prognosis, with mortality rates exceeding 70%. This emphasizes the importance of vaccination for preventing pertussis, especially in neonates and young infants.

In addition to infections, congenital heart diseases were another significant cause of death in our study, accounting for 7.31% of fatalities. Congenital heart conditions are common in both developing and developed countries and are often associated with high mortality rates. Similarly, other studies have found that cardiac diseases, particularly congenital heart anomalies, are frequent causes of death in PICUs[12,34]. Limited access to pediatric cardiac surgery in developing countries contributes to the higher mortality rates for these conditions.

In our hospital, the absence of a liver transplant program limits our ability to provide critical care for children with severe liver conditions, and this significantly impacts the prognosis of these patients.

Overall, the causes of mortality in PICUs vary between countries depending on factors such as medical infrastructure, the availability of specialized treatments, and the prevalence of specific diseases. In countries with limited resources, infections, malnutrition, and congenital diseases are leading causes of death,

while in developed countries, advanced medical care can reduce the mortality associated with these conditions.

Study limitations

This retrospective study provides valuable insights into pediatric intensive care unit (PICU) mortality and highlights key factors potentially associated with poor outcomes. Its strength lies in the detailed review of real-world clinical data. However, limitations include the incomplete documentation of some medical records and the inherent selection bias of retrospective designs. Moreover, causal relationships cannot be established, emphasizing the need for prospective studies to validate these findings.

Conclusion

Pediatric intensive care is a crucial discipline dedicated to managing children in life-threatening conditions. A thorough understanding of the epidemiological profile of patients admitted to pediatric intensive care units (PICUs) is essential for tailoring interventions to the specific needs of this population. The establishment of dedicated pediatric units, separate from adult services, has significantly improved the quality of care, thereby reducing complications related to intensive care.

A detailed analysis of mortality causes and rates in pediatric intensive care helps optimize therapeutic strategies and strengthen care protocols, ultimately improving patient survival. Identifying mortality risk factors in PICUs is a key step in ensuring high-quality care, maximizing survival chances, and preventing complications. This enables clinicians to adopt targeted approaches adapted to each patient's specific needs.

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