



# Epidemiology of Diseases and Mortality in a Pediatric Intensive Care Unit in Qazvin, Iran

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## Abstract

**Background:** Depending on the level of care and the availability of pediatric intensive care unit (PICU) facilities, the mortality rate of acutely ill children varies in PICUs. Referral of patients from other medical centers, admission during working or off-work hours, and nosocomial infections are the most important risk factors for the high mortality rates in PICUs.

**Objectives:** The present study aimed to investigate the characteristics and factors related to the risk of mortality in pediatric patients admitted to the PICU of a pediatric hospital in Qazvin, Iran.

**Methods:** This cross-sectional study was performed on children admitted to the PICU of a pediatric hospital in Qazvin, Iran, between June 2017 and June 2020. During this period, a total of 1504 children, aged one month to 13 years, were admitted to the PICU, and 106 cases expired. The patients' clinical data (ie, demographic characteristics, underlying disease, cause of death, and length of hospital stay) was extracted from their medical records. A prolonged length of stay was defined as more than 28 days of PICU admission.

**Results:** A total of 106 children, with a mean age of  $3.89 \pm 3.23$  years, expired during the study, with 41 (38.7%) cases being male. Among the investigated cases, 61 (57%) were < 2 years, 18 (17%) were 2 - 5 years old, and 27 (26%) were  $\geq 6$  years. In these patients, sepsis (13/82, 15.85%) and pneumonia (10/82, 12.19%) were the main causes of death. Other mortalities (14/106) were due to infectious diseases (gastroenteritis, influenza, and coronavirus disease) and non-infectious diseases (aspiration, anaphylaxis, and electrocution). The majority of children with a prolonged length of stay were < 2 years (17/23, 74%). The length of PICU stay was shorter in children with a lower weight percentile ( $P = 0.016$ ).

**Conclusions:** Following infectious diseases, congenital abnormalities and genetic disorders were the most common causes of pediatric mortality. Chronically ill children were more likely to be underweight and develop nutritional disorders, leading to the deterioration of their condition.

**Keywords:** Case Fatality Rate, Child Mortality, Pediatric Intensive Care Unit, Body Weight, Length of Stay

## 1. Background

Mortality rates in the pediatric intensive care unit (PICU) have decreased due to the use of advanced technologies and experienced staff. Depending on the level of care and the availability of PICU facilities, the mortality rate of acutely ill children varies in PICUs (1). The mortality rate of children admitted to PICUs reportedly ranges from 1.3 to 50% (2). Neonates, infants, and children with respiratory and cardiovascular complications are more likely to have a prolonged stay in PICUs. Also, children admitted to PICUs, especially for a long period, have a higher risk of morbidity and mortality (3).

The most common cause of premature death in PICUs was multiple organ failure, followed by cardiac arrest and respiratory failure (4). Besides, the main causes of death

among children under the age of five years were complications, such as congenital anomalies, respiratory infections, and diarrhea (5). The literature suggests that about 45-85% of deceased children in PICUs have an underlying chronic disease (6, 7). Generally, the PICU mortality is higher in children under five years compared to other age groups, which may be related to susceptibility to infection, manifestations of congenital disorders, and complications of malnutrition (8).

In children admitted to PICUs, the most common symptoms are respiratory symptoms, cardiopulmonary arrest, and sepsis (withholding, end-of-life decision, and lethargy (due to an illness)). Besides, sepsis is the third most common cause of death in infants (9). In children with an underlying disease, respiratory symptoms are associated with poor outcomes (7). Neurological disorders,

followed by congenital heart defects, malignancies, and metabolic disorders, were the most common underlying diseases in these children. The average stay of patients in the PICU was six days (6, 7).

## 2. Objectives

Without accurate data on pediatric mortality rates, it is not possible to fully discover and address the factors threatening children's lives. There is also no evidence demonstrating the characteristics of children admitted to the PICU of Qazvin Children's Hospital. Therefore, the present study aimed to investigate the demographic characteristics, cause of admission, underlying disorders, length of stay, and cause of death in children who expired in the PICU.

## 3. Methods

This cross-sectional study was performed in the PICU of a university pediatric hospital in Qazvin, Iran, during three years (from June 22, 2017 to June 20, 2020). All children, aged between one month and 13 years who had expired in the PICU, were included in this study, and their clinical data was extracted from their records. All eligible cases were reviewed in this study. If some records were incomplete, they were removed from the final analysis. Also, pediatric patients with postoperative, traumatic, and burn injuries were excluded from the study. The medical records of children who expired during this period were reviewed for their clinical characteristics and epidemiological information. It should be noted that in this hospital, a trained pediatrician visited the seven-bed PICU daily.

A total of 1504 children were admitted to the PICU during the study, including 106 expired cases. These cases were studied for the immediate cause of death and the underlying conditions. Age categories at the time of death were < 2, 2 - 5, and  $\geq$  6 years. A prolonged length of stay (PLS) was defined as more than 28 days of hospital admission (2). The PICU length of stay was divided into < 24 hours, 1 - 7 days, 8 - 28 days, and > 28 days.

The Ethics Committee of the Research Department of Qazvin University of Medical Sciences (Qazvin, Iran) approved this study (IR.QUMS.REC.1399.151).

### 3.1. Statistical Analysis

The collected data was analyzed using SPSS version 18.0 (IBM Corp., Armonk, New York, USA). Continuous and categorical variables are presented as mean  $\pm$  standard deviation (SD) and frequency (percentage), respectively. P-values less than 0.05 were considered statistically significant.

## 4. Results

Table 1 presents the demographic characteristics of the studied patients. The PICU mortality rate was 106/1504 (7.04%). The mean age of 106 deceased children was  $3.89 \pm 3.23$  years, with 41 (38.7%) cases being male. Among these cases, 61 (57%) were < 2 years, 18 (17%) were 2-5 years, and 27 (26%) were  $\geq$  6 years (Table 1).

Table 1. Demographic Characteristics of Expired Children in the PICU<sup>a</sup>

Mortality Data	Patients
Age at death (y)	3.89 $\pm$ 3.23
< 2	61 (57)
2 - 5	18 (17)
> 5	27 (26)
<b>Sex</b>	
Female	65 (61.3)
Male	41 (38.7)
<b>Symptoms at admission<sup>b</sup></b>	
General	38 (35.8)
Respiratory	35 (33)
Neurological	15 (14.2)
Gastrointestinal	16 (15.2)
Dermatological	2 (1.8)
<b>Place of residence</b>	
Rural	31 (29.2)
Urban	75 (70.8)
<b>Underlying diseases</b>	
Developmental delay	45 (42.4)
<b>Length of PICU stay (d)</b>	
< 1	15 (14)
1 - 7	33 (31)
7 - 28	35 (33)
> 28	23 (22)
Mechanical ventilation	79 (74.5)

<sup>a</sup> Data is presented as No. (%) or mean  $\pm$  SD.

<sup>b</sup> General symptoms (fever, lethargy and malaise, apnea, cyanosis, and edema), respiratory symptoms (cough and respiratory distress), neurological symptoms (seizure and altered consciousness), gastrointestinal symptoms (vomiting, diarrhea, abdominal pain, and abdominal distension), and dermatological symptoms (petechiae).

Figure 1 demonstrates the distribution of underlying diseases among deceased pediatric patients admitted to the PICU. Eighty-two expired children (77.35%) had underlying comorbidities. In these patients, sepsis (13/82, 15.85%) and pneumonia (10/82, 12.19%) were the main causes of death. Other mortalities (14/106) were due to infectious diseases (gastroenteritis, influenza, and coronavirus disease)

and non-infectious diseases (aspiration, anaphylaxis, and electrocution). A large proportion of children who expired in the PICU had developmental delays (45, 42.4%).

The mean length of hospitalization was  $16.7 \pm 21.15$  days (range: 2 hours to 138 days). Most children with PLS were < 2 years (17/23, 74%). There were 7 (30.4%) cases of multiple congenital anomalies, followed by congenital metabolic disorders (3/23, 13%) and spinal muscular atrophy (2, 9%). A boy admitted for electrocution had the longest stay (138 days). Table 2 demonstrates the PLS distribution and its association with the weight percentile in deceased children. Among these children, 85 (80.1%) were underweight (weight percentile < 25th percentile), indicating the shorter length of PICU stay in children with a lower weight percentile ( $P = 0.016$ ).

Thirty-one deceased patients (29.2%) were from rural areas, while others were from urban areas. Overall, 25 (23.6%), 22 (20.8%), 31 (29.2%), and 28 (26.4%) patients expired in the spring, summer, autumn, and winter, respectively. Nearly one-third of children (39, 36.8%) expired on weekends, public holidays, and the day before holidays. In this study, information on the parental consanguinity was available for 100 children. Overall, 46 (49%) patients had parents with a consanguineous marriage. In 32 (30.2%) cases, the parents were first cousins; in three cases (2.8%), they were second cousins; and in one case (0.9%), the parents were third cousins. Additionally, 10 (9.4%) parents were consanguineously married at some level. The majority of children whose parents were relatives resided in rural and suburban areas (32, 66.7%), while the rest of them lived in urban areas (16, 33.3%) ( $P = 0.04$ ). Congenital anomalies (10, 21.7%) and metabolic disorders (8, 17.3%) were more prevalent in these patients.

## 5. Discussion

The present study aimed to determine the main factors associated with PICU mortality to offer better healthcare services to pediatric patients. The majority of cases were < 2 years and had a longer PLS compared to other age groups. Moreover, the length of PICU stay was significantly shorter in children with a lower weight percentile. Also, sepsis and pneumonia were the main causes of death.

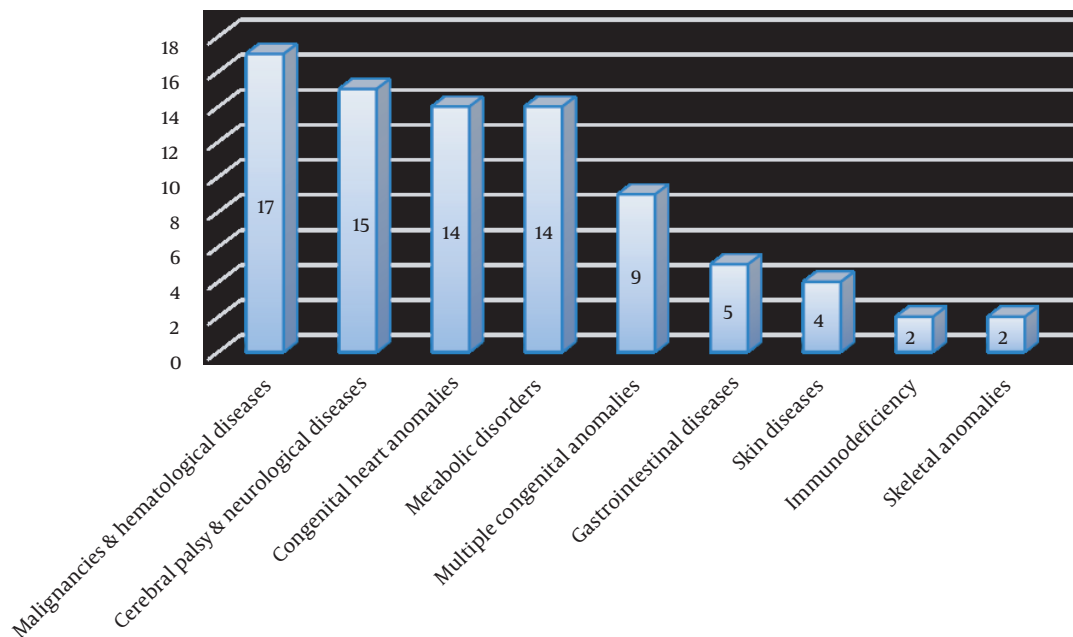
Most patients in this study were female, which contradicts the findings of studies by Novianti et al. and Meert et al. (4, 10, 11). However, other studies did not indicate any sex differences in deceased children (7, 12-14). Similarly, a study by Lornejad et al. reported lethargy, weakness, cyanosis, and respiratory symptoms as the most common patient complaints (15). In this study, the three main causes of death were sepsis in 35 patients (33%), pneumonia in 20 patients (18.8%) (16, 17), and renal failure in 12 patients

(11.3%), which is in line with the findings of a study by Seifu et al. (4) reporting septic shock as the most common cause of mortality in PICUs (Takur). Also, some evidence suggests that most children were admitted to PICUs with respiratory symptoms (6, 7, 18). Based on the results, underweight children were more likely to expire than children with normal growth and development and a shorter PICU stay.

Evidence suggests that the PLS of dying pediatric patients in PICUs is increasing over time. Regarding the mean PICU stay, the current study reported similar results to those reported in studies by Novianti et al. and Naghib et al. (11, 12) whereas Punchak et al. (14) reported a shorter length of stay (two days). The rate of PLS varies in different reports due to differences in the severity of illness, diversity of diagnoses, and experience level of personnel in different centers. In this study, the number of patients with PLS (22%) was higher than that of a study by Miura et al. (2.4%) (3). Multiple congenital anomalies were the most common diagnosis in the present study and the study by Naghib et al. (12). Also, undernutrition was detected in the majority of deceased children with a shorter PICU stay due to malnutrition and immunodeficiency.

Few studies have investigated the PICU mortality in different seasons. In the current study, there was no significant difference regarding the mortality rate in terms of season, which is in line with the findings of a review study by Williams and colleagues. It is worth mentioning that 37.62% (412/1095) of children expired on pre-holidays or holidays. However, the mortality rate was almost equal in working and off-work hours, which contradicts their results (19). Generally, the rate of consanguineous marriage is high in Iran, especially in rural areas (20), which suggests the importance of genetic counseling, particularly for consanguineous marriages (21) and residents of rural areas. Nearly one-third of the population in this province (Qazvin, Iran) is settled in rural areas, and 29.2% of deaths occur in these areas. Therefore, there was no significant difference in the mortality rate of critically ill children residing in urban and rural areas.

Based on the current findings, underweight children were more likely to die than children with normal growth and development; they also had a shorter PICU stay. In this regard, Nangalu et al. found that child mortality was higher in the first 24 hours of admission in underweight infants, which is in line with the findings of the present study (22). In a study by Ventura, undernutrition was a risk factor for a longer PICU stay and survival (23). The mortality rates of underweight children and children with malnutrition were higher than the general PICU population. Chronic illness, anorexia, and frequent hospitalization were expected in underweight children and children with malnutrition. It is known that malnutrition reduces



**Figure 1.** Prevalence of underlying diseases in 82 out of 106 deceased children in the PICU

**Table 2.** The Length of Hospital Stay and Its Association with the Weight Percentile in 106 Deceased Children<sup>a</sup>

Length of PICU Stay (d)	Weight Percentile			P-Value
	< 25 (N = 85)	25 - 90 (N = 16)	> 90 (N = 3)	
< 1	13 (15.35)	2 (12.5)	0	
1 - 7	25 (29.4)	3 (18.8)	3 (100)	0.016
8 - 28	32 (37.65)	3 (18.8)	0	
> 28	15 (17.6)	8 (50.0)	0	

<sup>a</sup> Values are expressed as No. (%).

the level of immunity and makes these children susceptible to infections. Therefore, in addition to treating and controlling the underlying disease, improvement of the nutritional value of foods consumed by children, promotion of healthy diets, and replacement of micronutrients (24) should be considered.

The present study had several limitations. Although the studied center is the main pediatric referral hospital in Qazvin, Iran, the external validity of the current study was limited to the gathered data from a single center. Given the retrospective design of this study, some information may be missing. Also, no data was available concerning the patient outcomes after hospital discharge; specifically, data related to deaths after discharge might have been lost. Nevertheless, some aspects of this study require further investigation. Due to the lack of sufficient data in Iran, follow-up

studies on pediatric patients who expire in PICUs or survive are highly recommended. Moreover, longitudinal follow-up studies are needed in Iran to assess the quality of life and educational level of the parents, long-term survival, and comorbidities of PICU survivors.

### 5.1. Conclusions

Following infectious diseases, congenital abnormalities and genetic disorders were the most common causes of pediatric mortality. In this study, a high percentage of children had an underlying congenital disease. Since consanguineous marriage is common in this region, genetic counseling before marriage can be a reasonable approach. It has been shown that nutritional disorders are more common in chronically ill children and contribute to the deterioration of their condition. Underweight children were

more prone to critical diseases, with a shorter PICU stay and more susceptibility to infections; the PICU mortality was also higher in these children. Therefore, proper nutrition and supply of proteins and micronutrients are essential.

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## Footnotes

**Authors' Contribution:** Z.P.: study concept and design, critical revision of the manuscript for important intellectual content, and study supervision; M.J.: administrative, technical, and material support; and B.A.: analysis and interpretation of data, statistical analysis, and drafting of the manuscript. All the authors participated in collecting clinical data.

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