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Research Paper

Determinants of Unsuccessful Prehospital Resuscitation in Pediatric Emergencies

Negin Mousaeinejad[1,2], Shaqayeq Khosravi[1], Shabahang Jafarnejad[2], Zahra Mahyapour Lori[3], Kiana Khosravi[4], Motahare Aghajani Delavar[5,1], Zeynab Nasri-Nasrabadi[5], Sayed Mahdi Marashi[6]*

1. Emergency Medicine Management Research Center, Health Management Research Institute, Iran University of Medical Sciences, Tehran, Iran.

2. Department of Emergency Medicine, School of Medicine, Iran University of Medical Sciences, Aliasghar Children Hospital, Tehran, Iran.

3. Student Research Committee, Iran University of Medical Sciences, Tehran, Iran.

4. Patient Safety research center, Iran University of Medical Sciences, Tehran, Iran.

5. Department of Pediatrics, School of Medicine, Iran University of Medical Sciences, Aliasghar Children's Hospital, Tehran, Iran.

6. Department of Forensic Medicine, School of Medicine, Iran University of Medical Sciences, Tehran, Iran.

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ABSTRACT

Background: Children are especially vulnerable to potentially fatal injuries from illness or accidents. This study aims to examine the circumstances surrounding out-of-hospital cardiac arrest and to evaluate unsuccessful emergency rescue attempts.

Methods: This retrospective study reviewed records of patients under 18 years admitted to Iran University of Medical Sciences–affiliated hospitals from March 2013 to March 2024. The study included children who received emergency medical services and were transported during ongoing CPR.

Results: Among 134 cases, the mean age was 4.75 years and male-to-female ratio was 1.39:1. While 61.9% were Iranian, 38.1% were Afghans. Mortality was highest in infants under one year (35.1%) and in children aged 1–5 years (25.4%). The leading causes of death were underlying medical illnesses, followed by accidents, notably pedestrian collisions.

Conclusion: Cardiac arrest due to medical illnesses at home and pedestrian accidents account for a large share of unsuccessful pre-hospital resuscitations, most of which are preventable. Migrant children have a markedly higher mortality risk, likely due to socio-economic factors. These findings call for targeted injury prevention and policy reforms to address migrant populations and reduce the public health burden.

*** Corresponding Author:**

Sayed Mahdi Marashi

Department of Forensic Medicine and Clinical Toxicology, Shohadaye Haftom-e-Tir Hospital, End of Shahid Rajaee St., Shahr Ray, Tehran, Iran.

E-mail: *marashi.mh@iums.ac.ir*

Introduction

Global public health leaders have long focused on child mortality as a shared responsibility, highlighting the persistent risk of life-threatening injuries across ages, from infancy and early childhood to adolescence and young adulthood, yet mortality rates remain higher for boys across all age groups [1, 2].

Infant mortality primarily results from obstetric complications, genetic anomalies, and prematurity. Neonatal infections are also significant contributors. For infants aged 1–11 months, diarrhea, respiratory illness, and measles are the leading causes of death. Unintentional injuries, particularly drowning, are the leading causes of death in early childhood. In children over five years of age, motor vehicle accidents become the primary cause of mortality [3,4].

Most pediatric accidents are preventable. Although progress has been made in controlling infectious diseases, external injuries and accidents represent an increasing threat to pediatric and adolescent populations [4]. Life-threatening injuries impose a substantial burden in developing nations and Immediate intervention is required to mitigate these risks [5]. Conversely, the risk of death from injuries remains disproportionately higher among low- and middle-income countries compared to their wealthier counterparts [6].

Pediatric vulnerability to external threats is driven by specific cognitive and behavioral traits. These include novelty-seeking behavior, diminished hazard recognition and physical and sensory limitations. However, current literature lacks detailed data on the spatial and environmental contexts of these fatalities [7,8].

Improved access to first aid education has increased public awareness of resuscitative urgency. Community participation in CPR training is rising. This has led to an increased frequency of bystander intervention. The efficacy of tele-communicated emergency guidance further supports this trend [9, 10]. Because children generally exhibit substantial cardiopulmonary resilience, the delivery of immediate and effective resuscitative measures is frequently the decisive factor in pediatric survival.

To reduce injuries and safeguard children, access to precise, comprehensive data is essential. The aim of this study was to investigate the conditions leading to out-of-hospital cardiorespiratory arrests in children that resulted in unsuccessful resuscitation efforts. We analyzed cases referred to general hospitals affiliated with Iran University of Medical Sciences over a 10-year period.

Materials and Methods

This is a retrospective, cross-sectional study. Inclusion criteria included children under 18 who experienced out-of-hospital cardiorespiratory arrest and received prehospital emergency services with ongoing CPR during transport, then were admitted to hospitals affiliated with Iran University of Medical Sciences between March 2013 and March 2024. All cases met criteria for out-of-hospital cardiorespiratory arrest necessitating CPR. Advanced airway management was performed by the EMS personnel by case severity, equipment, and provider judgment. Death was confirmed in the emergency department. Furthermore, an initial hospital assessment by a forensic pathologist followed by transfer to the autopsy hall was conducted. Exclusion criteria encompassed cases where return of spontaneous circulation (ROSC) occurred before or upon hospital arrival, deaths at the scene, transport by private vehicle, cases without ongoing CPR during transport, and incomplete records that prevented reliable ascertainment of the cause of death.

A variety of causes contributing to the occurrence of cardiopulmonary arrest, such as underlying diseases and types of trauma and poisoning, were examined. Statistical analysis was performed using SPSS software (version 22; Microsoft, USA). Quantitative data were reported as mean ± standard deviation and qualitative data as frequency. A p value of less than 0.05 was considered significant.

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Iran University of Medical Sciences (Approval No. IR.IUMS.REC.1403.659).

Results

The study included 134 cases with a mean age of 4.75 years. Of these, 61.9% (n=83) were Iranian, and 38.1% (n=51) were non-Iranian, mainly Afghans. The highest mortality rate was observed in infants under one year of age (n=47, 35.1%), followed by children aged 1–5 years (n=34, 25.4%), 6–10 years (n=30, 22.4%), and 11–18 years (n=23, 17.2%). Males accounted for 78 cases (58.2%) and the male-to-female ratio was 1.39:1; however, this gender preponderance was not statistically significant (p=0.489). Detailed distribution across age groups is presented in Table 1. Figure 1 is showing the main causes of death in this cohort.

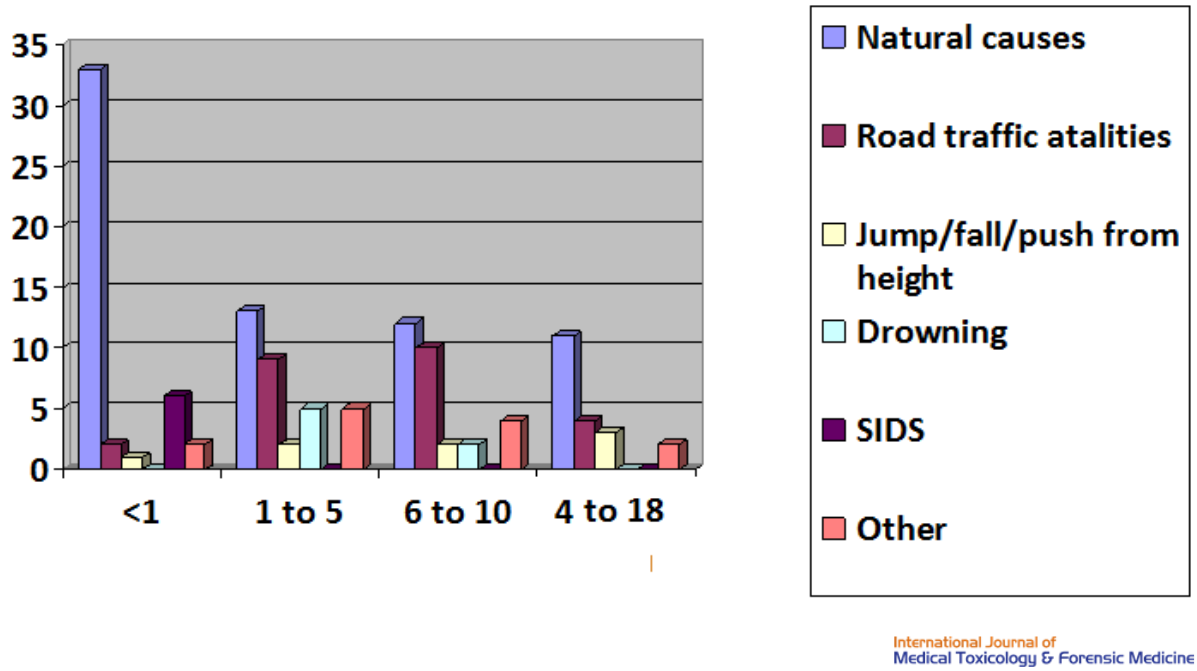

Figure 1. Distribution of primary causes of unsuccessful prehospital resuscitation in 134 pediatric cases.

Table 1. Distribution of Gender Across Different Age Groups.

Age group (years)	Male, n (%)	Female, n (%)	Total, n (%)
<1	29 (61.7)	18 (38.3)	47 (35.1)
1-5	19 (55.9)	15 (44.1)	34 (25.4)
6-10	18 (60)	12 (40)	30 (22.4)
11-18	12 (52.2)	11 (47.8)	23 (17.2)
Total	78 (58.2)	56 (41.8)	134 (100)

The exact prehospital CPR duration was not separately recorded in most EMS or hospital records, and available data reflected total CPR duration from initiation until death confirmation. Fifty four patients (40.3%) received CPR for 16 to 30 minutes. Other resuscitation intervals included fewer than 15 minutes (n=11, 8.2%), 31 to 45 minutes (n=30, 22.4%), 46 to 60 minutes (n=7, 5.2%), and 32 patients (23.9%) exceeding 60 minutes. Underlying medical conditions were the primary cause of mortality (n=69; 51.5%), followed by road traffic accidents (n=25, 18.7%). A comprehensive stratification of mortality causes is presented in Table 2.

Central nervous system disorders were the predominant cause of medical deaths, accounting for 15 cases (21.7%). These were followed by congenital heart anomalies and other congenital disorders (n=13, 18.8%), malignancies (n=9, 13.0%), and infectious diseases (n=8, 11.6%). Other medical etiologies were respiratory failure, renal failure, congenital hypothyroidism, and bullous pemphigoid.

Regarding road traffic accidents, pedestrian strikes were the predominant mechanism, (n=17; 65.4%), with the majority occurring in the 5–10 year age (n=9). Motorcycle related collisions and vehicle occupant fatalities accounted for 15.4% (n=4) and 19.2% (n=5), respectively. These differences were statistically significant (p=0.013). The distribution of traffic-related fatalities is illustrated in Figure 2.

The study identified five cases of suicide; among them, three involved falls from height, one was attributed to hanging, and another to methadone poisoning. The hanging case involved a 12-year-old Afghan boy, while the poisoning case concerned a 13-year-old Iranian boy. All fall-related suicides occurred from the fourth floor and involved Iranian girls aged between 12 and 16 years. There were five cases of non-suicidal poisoning, of which three were attributed to the ingestion of illicit drugs, one resulted from insecticide poisoning, and two involved carbon monoxide inhalation. Of five non-suicidal falls, the exact height was unknown in one case. Among the remaining four, one involved a fall from the second floor, one from the third floor, one from the fourth floor, and one incident involved a fall down the stairs.

The study documented a solitary homicide involving a 13-year-old male who died from stab wounds. Regarding child abuse, seven cases were identified, five due to blunt trauma, one following drowning, and another resulting from pressure asphyxia caused by an adult applying weight on the child. Four victims were Afghan refugees and three

Table 2. External Causes and Circumstances of Death by Age Group.

Cause of death	Age group (years), *n* (%)				Total
	<1	1-5	6-10	11-18	
Natural causes	33 (47.8)	13 (18.8)	12 (17.4)	11 (15.9)	69 (51.5)
Road traffic atalities	2 (8)	9 (36)	10 (40)	4 (16)	25 (18.7)
Jump/fall/push from height	1 (12.5)	2 (25)	2 (25)	3 (37.5)	8 (6)
Drowning	0	5 (71.4)	2 (28.5)	0	7 (5.2)
SIDS	6 (100)	0	0	0	6 (4.5)
Blunt trauma (Child abuse)	1 (20)	1 (20)	3 (60)	0	5 (3.7)
CO poisoning	1 (20)	3 (60)	1 (20)	0	5 (3.7)
Burns	0	1 (100)	0	0	1 (0.7)
Electrocution	0	0	0	1 (100)	1 (0.7)
Hanging	0	0	0	1 (100)	1 (0.7)
Pressure asphyxia	1 (100)	0	0	0	1 (0.7)
Choking	1 (100)	0	0	0	1 (0.7)
Drug poisoning	0	0	0	1 (100)	1 (0.7)
Stab wounds	0	0	0	1 (100)	1 (0.7)
Undetermined	1 (50)	0	0	1 (50)	2 (100)
Total	47 (35.1)	34 (25.4)	30 (22.4)	23 (17.2)	134 (100)

were Iranian.

The majority were females (five cases); only two males were affected. Four child abuse victims were under 2 years old and three between 5 and 10 years.

Discussion

This analysis examines the significant impact of pediatric mortality and points to the need for targeted intervention strategies. About 62% of the children who died were Iranian. However, a large group, over 38%, were foreign nationals, mostly from Afghanistan. It is hard to get an exact count of these children because many families are undocumented. Even so, estimates suggest that Afghan children make up nearly 25% of all kids in Tehran. Consequently, our findings suggest a

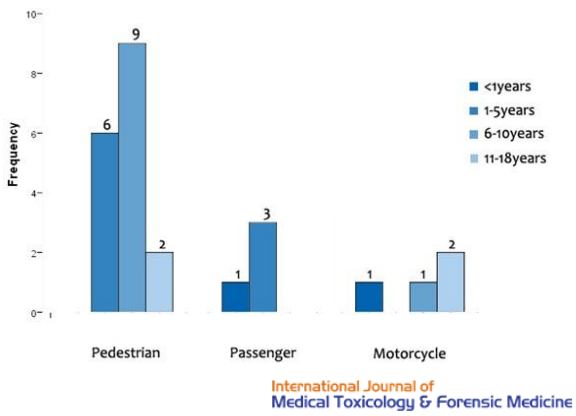

Figure 2. Categories of Road Traffic Accidents (n=25).

mortality disparity, migrant children were 1.85 times more likely to die in emergency situations. This matches what researchers have seen in Europe. This is likely due to language barriers or restricted access to primary healthcare. By the time these children get help, their condition is often very serious. These factors lead to dangerous delays in life-saving treatment. [11]. Paradoxically, recent Canadian data suggest that migrant children may face a lower risk of out-of-hospital cardiac arrest (OHCA). Experts call this the "healthy immigrant effect." This idea challenges what we usually assume about health vulnerabilities within this population [12]. In Iran, preventive healthcare is free for all children under seven. Pre-hospital emergency services are also provided at no cost. This includes immediate hospital admission and stabilization. As a result, given that the majority of Afghan migrants are Persian-speaking, barriers such as language difficulties and restricted access to primary healthcare, contrary to the findings of Nijman et al. [11], do not significantly hinder this population. Instead, this discrepancy seems to stem from legal guardians lacking awareness and attention regarding urgent health conditions. The gap in care often comes from parents not recognizing when a health issue is an emergency. Meanwhile, in developed nations, migration policies prioritize migrants' socioeconomic circumstances. This helps reduce unintended strain on their healthcare infrastructure.

The average age of patients involved in this study

was about 4.75 years. This aligns closely with previous research by Murphy et al., who documented a mean age of 4.6 years among children with trauma [13]. Oude Alink et al. reported a slightly higher average age of 6.1 years. However, more than half of their patients were very young. In fact, 53.2% of them were under 3 years old [14]. Oude Alink et al. reported a slightly higher average age of 6.1 years. However, more than half of their patients were very young. In fact, 53.2% of them were under 3 years old. Altogether, the data shows that children aged 2 to 6 are the most likely to need emergency care. This range covers early childhood through the start of school. Our study also found that most of the children who died were male. This matches what many other researchers have seen. For example, a large study in Japan looked at cardiac arrests in children. They found that boys and girls were equally likely to get CPR from bystanders. Despite this, they still reported a much higher number of deaths among boys [15]. An earlier study on pediatric trauma also showed that 62% were male. This gender ratio is very similar to what we found in our study. Interestingly, gender did not seem to affect whether a child survived. Still, the higher number of boys in these cases is a consistent trend [16]. There might be sociocultural barriers at play. For example, some people are more hesitant to perform CPR on girls. Biological factors might also matter, such as hormonal changes after puberty. These issues can change how often someone gets help [17].

Over 90% of failed resuscitations lasted longer than 15 minutes. This shows how difficult pediatric emergencies are to manage. There are both clinical and logistical hurdles to clear. Doctors often try CPR for a long time on children. However, the chances of success usually drop as time goes on [18].

Our study shows that most child cardiac arrests happen because of medical issues. Road accidents are the second most common cause. Other researchers have found similar results; for instance, Irvine et al. [19] reported that nearly half of cases stemmed from underlying medical conditions. Our data shows that diseases of the central nervous system are the most common cause of death. Congenital heart anomalies, cancer, and infections follow closely behind. In contrast, Somma et al. found that cardiac and respiratory events were the most common causes of OHCA [20]. It is important to note that their study only looked at children older than one, which differs from our study group. Nevertheless, these distributions of causes highlight the complex, multifactorial nature of pediatric mortality. Because of this, we need a variety of multifaceted prevention and emergency intervention strategies in children.

Research shows that pediatric OHCA due to traffic accidents generally has a poor prognosis [21]. Our findings show that most children killed in traffic are pedestrians. This matches global trends. Children between 5 and 10 years old are at the highest risk. This is likely due to increased independence and limited hazard perception [22]. While regional variations exist, the danger for child motorcycle and vehicle occupants remains significant. The danger often linked to inadequate restraints or protective gear.

Our findings align with global data identifying methadone or illicit drugs, insecticide poisoning, and carbon monoxide inhalation as important causes of pediatric toxicities. Gummin et al. reports that common poisons include analgesics, cosmetics, cleaning agents, and gases, notably carbon monoxide, with opioids like methadone increasingly linked to severe cases [23]. The rising incidence of opioid poisoning underscores the urgent need for preventive measures and public health initiatives to protect children from these deadly exposures.

We documented eight fatalities due to falls. Chalmers et al. found that falls from over 2.25 meters raise injury risk thirteen fold [24]. Many such deaths occur in low income urban areas from poor quality housing, often from the second floor or higher [25]. Falls from the second to fourth floors correlate with severe trauma. These heights are associated with increased mortality rates. Only one fatality in this study resulted from a stair fall. Stair falls typically involve lower heights. However, they can still result in severe injuries, particularly in young children, due to the mechanics of the trauma [26].

Pediatric homicides usually involve penetrating trauma such as stab wounds or firearm injuries. Violence-related injuries represent a considerable portion of pediatric trauma deaths. International data show these rates vary by environment. Reported figures range from 1.5% to over 24% [27]. Our finding of a single homicide case suggests a lower incidence of violence related deaths within our population. While the sample size and statistical population encompass only a fraction of trauma cases that received CPR prior to hospital admission, and do not account for definitive deaths occurring at the scene, it is highly probable that the true figures surpass these estimated statistics.

These findings align with global data on child abuse. Blunt trauma specifically accounted for high mortality rates in these cases [28]. Infants and toddlers are highly vulnerable due to physical fragility and caregiver dependence. These factors increase their susceptibility to life-threatening abuse. A predominance of female subjects was observed in this cohort. This aligns with research indicating higher risks for specific types of abuse among girls. Conversely,

some studies report equal gender distribution in abuse cases. These disparities vary by region and the specific nature of the maltreatment [29, 30]. Migrant children face a disproportionately high risk of fatal child abuse. This urgently requires addressing the combined cultural, socioeconomic, and mental health factors in migrant communities.

Total CPR duration, from prehospital initiation to termination of CPR in the emergency room, was categorized as reported; separate prehospital-only duration was not consistently documented in records. Prehospital CPR is standardly delivered by national EMS personnel; however, individual-level training details were unavailable in retrospective records. Prehospital advanced airway management were performed in some cases per national EMS protocols, but procedure-specific data were unavailable in our records. Scene-to-hospital transport times were not reliably documented and thus could not be analyzed. This study was restricted to unsuccessful prehospital cases; comparative data on in-hospital arrests or overall pediatric mortality in Tehran/Iran were not analyzed.

Conclusion

Unsuccessful pre-hospital pediatric CPR is often linked to cardiac arrests occurring at home or resulting from accidents. Chronic medical conditions account for most in-home pediatric deaths. Nevertheless, infectious diseases cause 12% of these fatalities. Pedestrian accidents account for an additional 12% of total mortality. This figure highlights the need for targeted prevention strategies.

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Conflicts of Interest

The authors report there are no competing interests to declare.

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