

Morbidity and Mortality of Drowning Children in Jerusalem District - Retrospective Analysis

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ICU: intensive care unit
PED: pediatric emergency department

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Abstract

Background: Drowning persists as a preventable pediatric cause of severe morbidity and mortality. This study aims to investigate the risk factors, circumstances, and medical consequences associated with pediatric drowning incidents in order to identify patterns that can inform targeted interventions.

Methods: This was a retrospective analysis of a cohort of pediatric drowning cases. The study encompassed children aged 0-18 years who presented to the pediatric emergency departments (PEDs) of Hadassah Medical Centers in Jerusalem from January 1, 2004 through April 30, 2023. Inclusion criteria were individuals with main registration diagnosis containing the terms “drowning” or “submersion.”

Results: Analysis revealed 129 cases of pediatric drowning, males comprising 66% of the cohort. The average age was 4.9 years (SD = 4.5). Predominantly, drownings occurred in private (38%) or public pools (27.1%). Forty-eight percent of children required hospitalization in intensive care. Notably, children from the Arab minority were significantly younger at the time of drowning (3.8 years; $P = .04$) and were at elevated risk of severe neurologic outcomes necessitating rehabilitation ($P = .03$). Incidents occurring on weekends were associated with younger victim ages (3.5 years; $P = .04$) and with increased likelihood of outcomes necessitating rehabilitation ($P = .04$). Conversely, children from families with four or more siblings were notably older at the time of drowning (5.3 years; $P = .01$). No other statistically significant differences were observed among demographic groups.

Conclusions: Strategies aimed at promoting child health and preventing drowning must surmount feasibility barriers. Intervention efforts should be tailored to populations at heightened risk, including younger children, minority groups, and incidents occurring during weekends.

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Introduction

Drowning stands as a significant public health challenge as a leading cause of mortality and injury among the global pediatric population.^{1,2} Within Israel, during the years from 2008 through 2020, the drowning-related death rate was 0.6 to 100,000 children, with drowning constituting 33% of mortality stemming from recreational activities among children aged 0-17 years.³ Notably, the risk of fatality is heightened among children aged 0-5 years and adolescents. Drowning incidence in Israel has shown an upward trend over the past two decades.³

Several studies have demonstrated a higher prevalence of drowning within populations characterized by lower socioeconomic status, residents of peripheral regions, and minority groups.^{4,5} Governments have implemented intervention programs encompassing initiatives such as pool fencing, legislative measures concerning construction, and subsidized swimming instruction.⁶ Nevertheless, these strategies may prove insufficient preventive measures and present implementation difficulties, particularly among vulnerable populations.

The pediatric emergency department (PED) at Hadassah Medical Center (Jerusalem, Israel) receives approximately 40,000 pediatric patients annually in two campuses: Mt. Scopus in east Jerusalem and Ein Kerem in the southwest of the city. Hadassah serves as the major tertiary center in the Jerusalem region and serves children from all parts of



Jerusalem. The Jericho governorate, situated in the Palestinian West Bank some 40 kilometers east of Jerusalem, houses an estimated 50,000 residents and serves as a popular tourist destination.⁷ The pediatric emergency team at Hadassah Medical Center identified a recent upsurge in the incidence of pediatric drowning cases originating from Jericho. Consequently, a comprehensive examination encompassing all instances of pediatric drowning among individuals aged 0–18 years presenting to the Hadassah PED at Mt. Scopus and Ein Kerem, Jerusalem, over the past two decades was initiated. The principal aim of this study is to delineate the incidence of pediatric drowning within the region, with a specific focus on identifying associated risk factors. Through this endeavor, the goal is to enhance awareness across diverse populations and foster the implementation of mitigation strategies and preventive measures.

Study Design

This was a retrospective analysis of data of a cohort of pediatric drowning cases.

Methods

Study Population

A retrospective analysis was performed at Hadassah Hebrew University Medical Centers, a tertiary referral center with an estimated 40,000 PED presentations annually. Data were collected by reviewing the electronic charts of all children aged 0–18 years who arrived at PEDs of Hadassah Medical Center in Jerusalem from January 1, 2004 through April 30, 2023, with main registration diagnosis containing the terms “drowning” or “submersion.”

Data and Measures

All documented patient data including emergency room admission, pediatric ward, and/or intensive care unit (ICU) course reports were reviewed. The following data were extracted: (1) Demographic data (age, gender, ethnicity, number of siblings); geographic drowning area; and drowning scene; (2) Incident characteristics; vital signs at presentation - temperature, saturation, respiratory support; finding upon auscultation and imaging; and comorbidities; and (3) Medical outcomes, hospitalization length at ward and/or pediatric ICU, mortality, and transfer to rehabilitation facilities.

Statistical Analysis

Statistical analysis was conducted using SPSS version 21.0 (Statistical Package for Social Science; IBM Corp.; Armonk, New York USA). Continuous variables are presented as the mean (standard deviation/SD) and categorical variables as frequencies and percentages. A chi-square test was used to compare proportions and the Student's *t*-test was used to compare continuous parametric variables. A *P* value $\leq .05$ was considered statistically significant. All reported *P* values are two-tailed.

The study was approved by the Hadassah Medical Organization Institutional Review Board (Jerusalem, Israel), approval number: 0395-23-HMO.

Results

Across the 20-year study period, a total of 129 drowning cases were recorded, with males comprising 66% of the cohort. The average age was 4.9 years (SD = 4.5). Demographic characteristics, drowning occurrences by weekday, area, and scene are detailed in Table 1. Predominantly, most of the drownings occurred in private (38%) or public (27.1%) swimming pools. Fourteen percent

		Number	Percent/SD
Total		129	
Hospital	Hadassah Mt Scopus	73	56.6
	Hadassah Ein Kerem	56	43.3
Age (years)		4.9	4.5
Age Under 6 Years		93	72.1
Gender	Male	85	65.9
	Female	44	34.1
Ethnicity	Jewish	80	62.0
	Arab	49	38.0
Weekend		39	30.2
Drowning Area	Jericho	18	14.0
	Jewish Neighborhood	71	55.0
	Arab Neighborhood	26	20.2
	Dead Sea	9	7.0
Drowning Scene	Private Pool	49	38.0
	Public Pool	35	27.1
	Bath	18	14.0
	Bucket	7	5.4
	Ritual Bath	3	2.3
	Other	13	10.1
Neurologic Pre-Existing Condition	None	115	
	Epilepsy	5	3.9
	Other	3	2.3

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Table 1. Demographic Characteristic, Drowning Weekday, Area and Scene, Neurologic Pre-Existing Condition

of cases drowned in baths. Notably, 39% of drownings occurred during weekends, and 55% in Jewish neighborhoods.

Medical outcomes, encompassing prehospital resuscitation efforts, vital signs upon arrival, auscultation findings, imaging results, length of hospitalization, and mortality rates, are outlined in Table 2. A total of 66.7% of cases received prehospital resuscitation. Thirty-five cases required invasive ventilation. The average hospitalization length of stay was 4.4 days (SD = 10.2), while average ICU stay was 2.3 days (SD = 4.9). Eight children (6.2%) were transferred to further rehabilitation facilities. Fourteen children died (10.9% of cases).

Table 3 delineates medical outcomes for the two primary demographic groups within Israel, with specific emphasis on the 18 cases originating from Jericho. Of these cases, only one was Jewish with the remainder being residents or visitors in the region. Children from the Arab minority exhibited a notably younger average age (3.8 years; *P* = .04), had longer ICU lengths of stay (*P* = .02), and were at elevated risk of experiencing severe neurologic outcomes necessitating rehabilitation (*P* = .03). No other statistically significant differences were observed between the groups.

		Number	Percent/SD
Prehospital Resuscitation		86	66.7
In Hospital Resuscitation		38	29.5
Auscultation	Clear	62	48.1
	Crackles/ Rales	47	36.4
	Pulmonary Edema	13	10.1
Temperature		36.1	1.4
Saturation		95.9	5.2
Saturation Below 90		11	8.5
Chest X-Ray	No Findings	45	34.9
	Consolidation	32	24.8
	Pulmonary Edema	22	17.1
Respiratory Support	None	58	45.0
	Oxygen	26	20.2
	None Invasive	4	3.1
	Invasive	35	27.1
Hospitalization Length of Stay (average, days)		4.4	10.2
ICU Admission		62	48
ICU Length of Stay (average, days)		2.3	4.9
Transfer to Rehabilitation Facilities		8	6.2
Death		14	10.9

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Table 2. Clinical Presentation and Outcomes
Abbreviation: ICU, intensive care unit.

Table 4 provides a comparative analysis of demographic characteristics and outcomes based on the day of drowning. Children who drowned during weekends were younger on average (3.5 years; $P = .04$), more likely to be male ($P = .03$), had longer hospitalization length ($P = .01$), and exhibited a heightened risk of severe neurologic outcomes necessitating rehabilitation ($P = .04$). No other significant differences were noted across days of drowning.

Table 5 presents a comparison of demographic characteristics and outcomes based on the number of siblings. A cutoff of four children was used in order to differentiate families with more children as the average number of children per family in Israel is 2.43.⁸ Children from families with four or more siblings were notably older on average (5.3 years; $P = .01$). No other statistically significant differences were observed.

Discussion

Numerous studies have highlighted the efficacy of preventive strategies such as pool fencing, lifeguard presence, and swimming

skill acquisition in reducing drowning incidence.⁹ However, assessing the tangible impact of these interventions on drowning-related morbidity and mortality remains challenging.^{2,10} This study aimed to discern patterns within the escalating phenomenon of pediatric drowning, revealing younger male children from minority groups to be notably vulnerable.

From the years 2004–2023, 129 drowning cases presented to the PED of Hadassah hospitals in Jerusalem. The age and gender distribution within this cohort aligned with globally reported drowning risk factors, emphasizing the heightened susceptibility of toddlers and males.^{1,2} Notably, a consistent increase in pediatric drowning events was observed over the study period, correlating with population growth (Figure 1).

Five of 123 cases had reported or suspected epilepsy (3.9%). This percentage is higher than their reported incidence in Israel, which is estimated to be 0.6% of all children under 18 years of age.¹¹ Previous studies showed an increased risk of submersion and drowning among children with epilepsy.^{9,12} This underscores the importance of tailored preventive measures for vulnerable populations with underlying medical conditions.

Arab individuals who drowned in this study were notably younger (Table 3; $P = .04$), had longer ICU lengths of stay (Table 3; $P = .02$), and exhibited a higher likelihood of subsequent transfer to a rehabilitation center (Table 3; $P = .03$). No other significant differences were observed between demographic groups. As of the end of 2022, Israel had a population of 9.56 million, with 73.6% being Jewish and 21.1% Arab.¹³ In Jerusalem, the largest city, the population in 2023 was 984,000, comprising 60.8% Jewish and 39.2% Arab residents.¹⁴ A retrospective analysis of drowning rates among Israeli children and adolescents aged 7–17 from 2008 through 2018 found no significant differences in drowning outcomes between Jewish and Arab populations. Ethnic minorities, including Arab populations, have been identified as more susceptible to drowning-related injuries and fatalities.¹⁵ Minorities have been found to be more susceptible to injury and death by drowning. An Australian review identified high-risk populations to be ethnic minorities, First Nations/Aboriginal people, migrants, and rural residents.⁴ The American Academy of Pediatrics (Itasca, Illinois USA) policy statement on prevention of drowning reports African American children to have the highest drowning fatality rates, followed by American Indian/Alaska Native (AI/AN) children.⁹ Consequently, there is a rationale for tailored and attentive drowning prevention programs for children from minority groups.

Table 3 outlines the cohort of drowning victims from Jericho. The temporary closure of public pools during the COVID-19 pandemic led to a surge in the use of private pools lacking adequate supervision. From 2021 through 2023, 11 out of 22 drowning victims at the Mt. Scopus PED originated from private pools in Jericho, three of whom died. In contrast, in 2022, there were 101 reported accidental deaths of children and adolescents under 17 in all of Israel, with drowning accounting for 16% of these fatalities. Arab children and adolescents represented 47% of these deaths, despite comprising only 24% of the youth population in Israel.³ However, this study found that the proportion of Arab drowning victims was comparable to their percentage in the population, at 38% and 39%, respectively.

The current analysis of minority populations, particularly Arab drowning victims and drowning cases originating from Jericho, revealed significant associations with younger age and a higher likelihood of requiring rehabilitation. Despite the absence of other

	Jews (n = 80)		Arabs (n = 48)		P Value	Jericho (n = 18)		Jerusalem District (n = 105)		P Value
	Number	SD	Number	SD		Number	SD	Number	SD	
Age (months)	65.8	58.4	45.9	44.8	.04	50.6	38.8	57.5	54.9	.61
Age (years)	5.5	4.9	3.8	3.7	.04	4.2	3.2	4.8	4.6	.61
Male Gender	55	69%	30	63%	.49	13	72%	69	66%	.62
Hospitalization Length (days)	3.4	9.1	6.1	11.7	.15	7.6	15.5	4	9.1	.19
ICU Length (days)	1.5	3.4	3.6	6.6	.02	3.7	5.6	2.1	4.9	.22
Hospital Admission	78	98%	47	98%	1	17	94%	105	100%	.01
ICU Admission	38	48%	24	50%	.82	12	67%	50	48%	.14
Death	7	9%	7	15%	.3	3	17%	11	10%	.38
Transfer to Rehabilitation Facilities	2	3%	6	13%	.03	3	17%	5	5%	.06

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Table 3. Comparison of Characteristics and Outcomes of Cases by Demographic Subgroup and by Drowning Location
Abbreviation: ICU, intensive care unit.

	Weekday (n = 87)		Weekend (n = 39)		P Value
	Number	SD	Number	SD	
Age (months)	64.2	58.7	42.3	38.1	.04
Age (years)	5.4	4.9	3.5	3.2	.04
Male Gender	58	67%	18	46%	.03
Jewish Ethnicity	53	61%	19	49%	.21
Hospitalization Length (days)	2.9	4.3	7.7	16.7	.01
ICU Length (days)	1.8	4.2	3.3	6.2	.13
Hospital Admission	84	97%	39	100%	.27
ICU Admission	39	45%	22	56%	.26
Death	10	11%	2	5%	.28
Transfer to Rehabilitation Facilities	2	2%	4	10%	.04

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Table 4. Comparison of Demographic Characteristics and Outcomes by Day of Drowning
Abbreviation: ICU, intensive care unit.

significant differences between groups, these findings highlight the need for targeted interventions addressing cultural and socioeconomic disparities in drowning risk.

A total of 66.7% of this cohort had initial prehospital resuscitation by parent, bystander, or skilled rescuer (Table 2). Previous studies proved immediate intervention by a parent or bystander to be associated with lower odds of severe outcome.¹⁶

Forty-eight percent of children required ICU admission (Table 2). Eight children (6.2%) were transferred to a rehabilitation facility after their admission. These findings align with previous studies and demonstrate the heavy burden of drowning.¹⁷

There were 14 deaths from drowning in this cohort (10.9%). During a similar period (2008–2020), there were 222 drowning fatalities under the age of 17 years in all of Israel.³ A systematic literature review of drowning in the Eastern Mediterranean region from 2022¹⁰ showed that all-age fatal drowning rates varied from a low of 0.48 per 100,000 (United Arab Emirates; 2002) to a high of

18.5 per 100,000 (Egypt; 2014). Variation in rates may result from demographic and geographic differences between countries in this area.

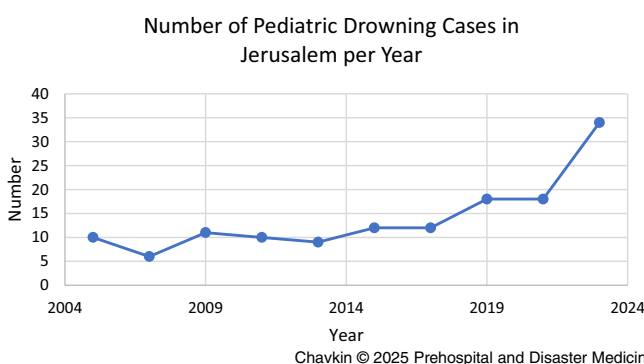
The current study also identified weekends as a high-risk period for drowning incidents, potentially attributed to reduced supervision and staffing levels in pediatric emergency settings during these times. Children who drowned during weekends were significantly younger (Table 4; $P = .04$), had longer hospitalization length ($P = .01$), and had higher risk for need of further rehabilitation ($P = .04$). Crowded pools that may lead to longer immersion time till rescue may also contribute to severity of outcomes during weekends. However, further studies are needed to investigate this assumption.

Additionally, children from larger families were found to be relatively older at the time of drowning (Table 5; $P = .01$). It may suggest complex supervision dynamics within these households, as described in other studies.^{18,19}

	3 Siblings or Fewer (n = 44)		4 Siblings or More (n = 52)		P Value
	Number	SD	Number	SD	
Age (months)	34.1	29.1	63.4	54.3	.01
Age (years)	2.8	2.4	5.3	4.5	.01
Male Gender	28	64%	33	63%	.92
Jewish Ethnicity	21	48%	33	63%	.14
Hospitalization Length (days)	6.4	15.6	3.6	5.1	.23
ICU Length (days)	2.6	5.4	2.2	4.6	.72
Hospital Admission	44	100%	51	98%	.35
ICU Admission	23	52%	29	56%	.7
Death	3	7%	8	15%	.22
Transfer to Rehabilitation Facilities	5	11%	1	2%	.07

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Table 5. Comparison of Demographic Characteristics and Outcomes by Number of Siblings
Abbreviation: ICU, intensive care unit.



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Figure 1. Number of Pediatric Drowning Cases in Jerusalem per Year.

Strengths and Limitations

Strengths of this study include the inclusion of a large cohort spanning two decades, providing valuable insights into local drowning trends. However, limitations include missing data due to

the retrospective nature of the research and potential selection bias towards severe cases transferred to the institution for specialized treatment.

Conclusion

These findings underscore the urgent need for targeted preventive strategies addressing the unique risk profiles of vulnerable populations, including young children, minorities, and individuals with underlying medical conditions. Implementation of accessible and affordable swimming lessons, along with heightened awareness among caregivers and primary care physicians, is crucial in mitigating the tragic toll of pediatric drowning incidents. Appropriate fencing and supervision are simple measures that are applicable to every water source that children may reach. Overcoming feasibility barriers for at-risk populations should be prioritized in public health initiatives aimed at reducing drowning morbidity and mortality. Further research is warranted to explore the relative risk and outcomes of drowning incidents among children from larger families and minority groups, facilitating suitable preventive interventions.

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