

The epidemiology of drowning among Saudi children: results from a large trauma center

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BACKGROUND: Drowning is the third leading cause of unintentional death among children worldwide. Although natural waters pose a risk of drowning in low-income countries, swimming pools are more prevalent in high-income countries. In Saudi Arabia, injuries and drowning are a significant threat to population health. Local data is limited, which affects an understanding of the extent of the burden and the development of prevention strategies.

OBJECTIVES: Determine the epidemiological characteristics, risk factors, and clinical outcomes of drowning among children.

DESIGN: Retrospective chart review.

SETTING: Patients admitted to the tertiary care unit of a hospital in Riyadh.

PATIENTS AND METHODS: Data was collected on children who drowned (age 0-14) between January 2015 and August 2020. Cases were identified from the electronic health record system where the diagnosis was drowning. Differences in characteristics and outcomes between nonfatal cases with no neurological damage and fatal cases with neurological damage were analyzed.

MAIN OUTCOME MEASURES: Drowning mortality and morbidity.

SAMPLE SIZE: 99.

RESULTS: Of the 99 drowning cases, 22 (22.2%) had a fatal outcome or resulted in neurological damage. The most-reported drowning site was private pools (82%). The majority of cases involved children younger than the age of two (54%). Eighty-four cases (84.8%) occurred on holidays. Cardiopulmonary resuscitation was performed in 61 (61.6%) of cases. A significant association was found between the delay in initiating resuscitation and an unfavorable outcome ($P < .01$). A high Glasgow Coma Scale score upon admission was a predictor of normal recovery ($P < .01$).

CONCLUSION: These findings warrant investment to increase public awareness of the risks of leaving children unsupervised in swimming pools. In addition, there is a need to ensure early resuscitation of drowning victims by promoting life support courses in order to facilitate positive outcomes.

LIMITATIONS: The study was conducted in one tertiary center located in a non-coastal city so the results may not be generalizable.

CONFLICT OF INTEREST: None.

Drowning is a major global health issue that is regarded as one of the most preventable yet neglected public health problems.¹ Worldwide, drowning is the third leading cause of unintentional death in children and youth.² As per the most current definition stated in the Utstein-style recommended guidelines for uniform reporting of data from drowning-related resuscitation, drowning is defined as “a process resulting in primary respiratory impairment from submersion/immersion in a liquid medium.”³ Whether a person survives or not, it is still defined as drowning. Drowning is a leading cause of mortality and morbidity among infants and toddlers.⁴ Drowning mortality can be associated with several factors—lack or overestimation of swimming ability, hypothermia, tendency towards risky behavior, myocardial infarction, and developmental disorders.⁵ Moreover, according to the World Health Organization, drowning is considered one of the top five leading causes of injury-related death in children aged 1 to 14.⁴

Globally, there is a wide disparity in the burden of drowning.⁶ The incidence of drowning in low- and middle-income countries (LMICs) is more than three times that of high-income countries (HICs).⁶ Evidence suggests that drowning in natural waters, such as ponds, seas, and wells, is more prevalent in LMICs than HICs while drowning in HICs is more common in private or public pools.⁷ In addition to environmental factors, community awareness of drowning risk and public regulatory health measures may play a role in the risk of drowning in a particular country.⁴ HICs effectively establish and enforce standards for barriers around water bodies in public properties to restrict unsupervised children from accessing these sites.^{6,8} On the other hand, LMICs lag behind when it comes to enforcing such preventative strategies.¹

In Saudi Arabia, a combination of environmental factors and lack of public health investment may play a role in the risk of drowning among children.³ For example, in rural areas, open wells and water collections following heavy rain pose a risk of drowning.⁹ Furthermore, it has been reported that poor supervision by inexperienced caregivers is a risk factor for deaths in children less than five years of age.⁹ Drowning most severely affects very young children as the incidence rate is highest among youngsters from 1 to 4 years of age.^{6,8} According to a study conducted in the Aseer region, around 87% of children drowning occurred in the absence of adult supervision.¹⁰ Moreover, household-drowning accounts for 44.4% of all reported drowning events, which may suggest a lack of awareness about basic and essential safety practices among caregivers.⁷

Several factors may influence drowning outcomes.¹¹ For example, prolonged drowning is associated with unfavorable outcomes, such as neurological damage and death. In contrast, early resuscitation has been associated with positive outcomes. During the period between initial rescue and resuscitation, the chances of survival or full recovery decrease with time. Therefore, a critical requirement is for caregivers to be trained to perform cardiopulmonary resuscitation (CPR).¹¹

There are various methods to address environmental, community, and policy factors that contribute to drowning incidence or prevalence.⁹ However, addressing the drowning threat begins with understanding the risk factors associated with drowning among children.⁹ It remains unclear which risk factors are more prevalent in the Saudi population due to limited data. Furthermore, this paucity contributes to the pressing problem of neglecting drowning as a significant public health issue. Correspondingly, the study aims to determine the epidemiological characteristics, risk factors, and clinical outcomes of drowning among children in Riyadh.

METHODS

This retrospective chart review was carried out in a tertiary care unit at King Abdullah Specialist Children Hospital in Riyadh. The hospital has 180 beds, including beds devoted to pediatric intensive care. Patient data were collected using the hospital electronic record system. We queried the system to retrieve the data on admitted and referred patients who were diagnosed as having drowned. The inclusion criteria were age 0 to 14 years of either gender who were admitted to the inpatient facility during the time period between 1 January 2015, to 31 August 2020. Research coordinators abstracted patient information individually and entered data manually into an electronic data collection form. Patients were classified as 1) non-fatal and/or not having neurological damage or 2) fatal or leading to neurological damage, and compared by several clinical and demographic factors. The study was reviewed and approved by the Institutional Review Board at the King Abdullah International Medical Research Center.

Statistical analyses were performed using STATA version 15.0 software. The qualitative data are presented as frequency and percentage; the quantitative data are shown as mean and standard deviation. The associations were evaluated by using Fisher's exact test and the t test for categorical and continuous variables, respectively. To test the differences between medians, we used the Wilcoxon rank-sum test. A *P* value of <.05 was considered indicative of significance.

RESULTS

Of 99 drowning victims, 77 (77.8%) recovered with no neurological damage, while 22 (22.2%) either died (n=15) or survived but suffered neurological damage (n=7) (**Table 1**). More than half of the drowning victims were infants and toddlers (54%). Among the cases, 95% were reported in Riyadh, and the majority were Saudi nationals (88%). In terms of prior health status, 81% were healthy, while only three patients had a pre-existing neurological disease, and the remaining patients had non-neurological conditions.

Three cases were reported as intentional drowning, but most cases (92%) were accidental (**Table 2**). Private pools were the most common site of drowning (82%). Drowning in bathtubs was reported twice, while those occurring in natural waters or water tanks were reported once each. The highest rates of drowning events occurred on holidays (84%). The majority of death or permanent neurological damage cases were non-witnessed or unsupervised events (75%). The transportation of 16

drowning cases from the scene of the incident to the hospital was longer than 90 minutes. Of these cases, two resulted in death or permanent neurological damage. Thirty-nine cases arrived at the hospital in 30 to 90 minutes, of which 12 died or had permanent neurological damage. CPR was performed in 61 cases, of which 16 (26.2%) ended in death or neurological damage; CPR was not conducted for 33 patients, among whom 4 (10.8%) died or had neurological damage. The median duration of submersion was 5.0 minutes (**Figure 1**). Patients who survived without neurological damage were submerged for significantly shorter times (**Table 2**). The combination of a short submersion time and prompt CPR produced better outcomes. Distance between the incident location and the hospital was only specified for 6 patients. Of those patients, none recovered among those who traveled >50 kilometers to the hospital.

The most frequently documented admissions were transferred to the hospital by a family member (**Table 3**).

Table 1. Demographic and clinical characteristics of pediatric patients admitted by outcome between 2015-2020.

Variables	Non-fatal and no neurological damage (n=77)	Death/ Neurological damage (n=22)	Total (n=99) ^a	P value
Gender (No.%)				
Female	31 (73.8)	11 (26.2)	42 (42.4)	.41
Male	46 (80.7)	11 (19.3)	57 (57.6)	
Age				
0-2 years	43 (79.6)	11 (20.4)	54 (54.5)	.62
Older than 2 years	34 (75.6)	11 (24.4)	45 (45.5)	
Nationality				
Saudi	67 (77.0)	20 (23.0)	87 (87.9)	.62
Non-Saudi	10 (83.3)	2 (16.7)	12 (12.1)	
Location of drowning incident				
Riyadh	76 (80.0)	19 (20.0)	95 (96.0)	.03
Outside Riyadh	1	3	4 (4.0)	
Previous health status				
Healthy	64 (79.0)	17 (21.0)	81 (81.8)	.15
Diagnosed with neurological disorder	2	1	3 (3.0)	
Diagnosed with non-neurological disorder	9 (90.0)	1 (10.0)	10 (10.1)	
Unspecified	2	3	5 (5.1)	

Data are n (%) or mean (standard deviation) unless otherwise noted. ^aColumn percentage

Table 2. Characteristics of drowning by outcome.

Variables	Non-fatal and no neurological damage (n=77)	Death/ Neurological damage (n=22)	Total (n=99) ^a	P value
Description of the incident				
Accidental	72 (78.3)	20 (21.7)	92 (92.9)	.31
Intentional	3	0	3 (3.0)	
Unspecified	2	2	4 (4.0)	
Drowning location				
Bathtub	2	0	2 (2.0)	.44
Private pool	63 (77.8)	18 (22.2)	81 (81.8)	
Public pool	4	0	4 (4.0)	
Natural water	1	0	1 (1.0)	
Water tank	1	0	1 (1.0)	
Fountain pool	2	3	5 (5.1)	
Unspecified	4	1	5 (5.1)	
Season of drowning				
School day	11 (73.3)	4 (26.7)	15 (15.2)	.73
Holiday	66 (78.6)	18 (21.4)	84 (84.8)	
Witnessed drowning				
Yes	16 (94.1)	1 (5.9)	17 (17.2)	.15
No	56 (74.7)	19 (25.3)	75 (75.8)	
Unspecified	5 (71.4)	2 (28.6)	7 (7.1)	
Presence of designated supervisor				
Yes	4	1	5 (5.1)	.22
No	54 (74.0)	19 (26.0)	73 (73.7)	
Unspecified	19 (90.5)	2 (9.5)	21 (21.2)	
Time between incident and emergency room arrival				
<30 minutes	16 (76.2)	5 (23.8)	21 (21.2)	.33
30-90 minutes	27 (69.2)	12 (30.8)	39 (39.4)	
>90 minutes	14 (87.0)	2 (12.5)	16 (16.2)	
Unspecified	20 (87.0)	3 (13.0)	23 (23.2)	
Prehospital cardiopulmonary resuscitation				
Performed	45 (73.8)	16 (26.2)	61 (61.6)	.15
Not performed	29 (87.9)	4 (12.1)	33 (33.3)	
Unspecified	3	2	5 (5.1)	

Table 2 (cont.). Characteristics of drowning by outcome.

Variables	Non-fatal and no neurological damage (n=77)	Death/ Neurological damage (n=22)	Total (n=99) ^a	P value
Time to initial resuscitation				
<5 minutes	34 (97.1)	1 (2.9)	35 (35.4)	<.001
5-15 minutes	23 (79.3)	6 (20.7)	29 (29.3)	
>15 minutes	5 (41.7)	7 (58.3)	12 (12.1)	
Unspecified	15 (65.2)	8 (34.8)	23 (23.2)	
Submersion time (minutes) ^b	3.5 (1-15)	12.5 (1-30)	5.0 (1-30)	<.001
Approximate distance between the location of the incident and the hospital (n=6)				
<30 kilometers	1	3	4 (4.0)	<.01
>50 kilometers		2	2 (2.0)	
Unspecified	76 (81.7)	17 (18.3)	93 (93.9)	

Data are n (%) or mean (standard deviation) unless otherwise noted. ^aColumn percentage ^bMedian (minimum-maximum), n=74, Wilcoxon rank sum test with continuity correction. Fisher's exact test for all comparisons except submersion time.

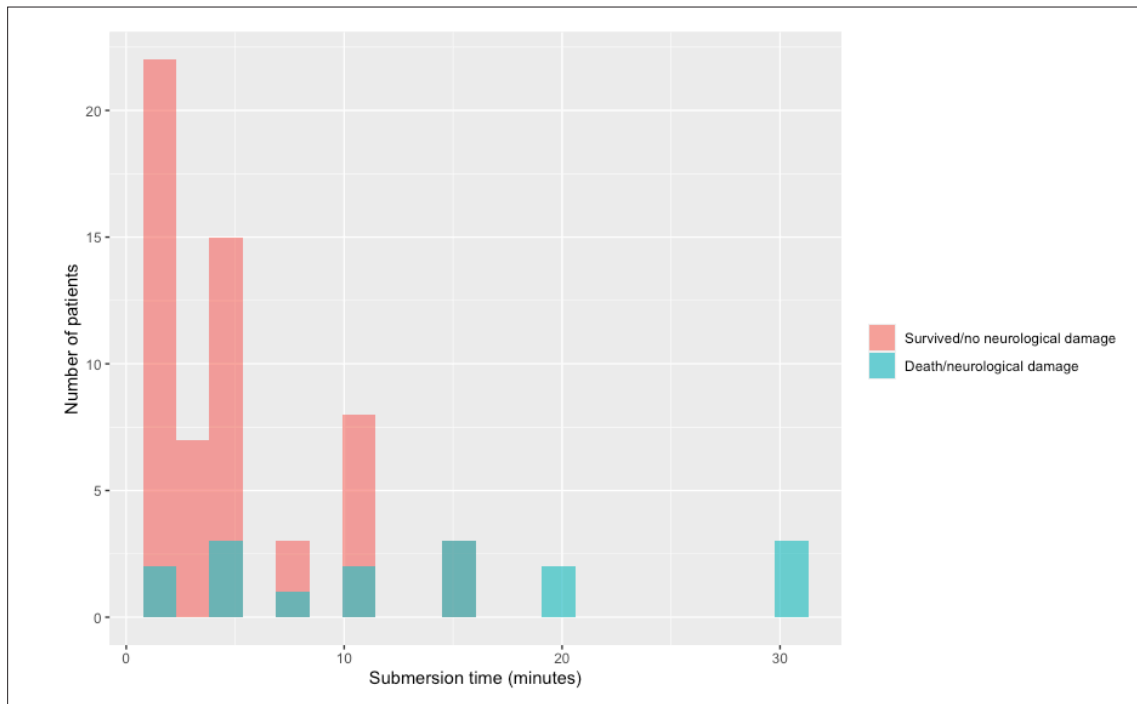


Figure 1. Submersion time by outcome (n=74).

Upon admission, the median GCS was 15 for those who recovered, while the median GCS for individuals who died or had neurological damage was 3. The patients who required intubation were more likely to have more unfavorable outcomes than those who did not require intubation (68% vs. 54.5%, $P<.01$). Of patients who required admission to the pediatric intensive care unit (22%), 12 died or had neurological damage. Complete recovery was associated with high GCS upon admission, decreased length of stay, and high GCS upon the end of care ($P<.01$). Median length of stay in the hospital for individuals who died or had neurological damage was 6.5 (as long as 304) days.

DISCUSSION

Drowning among children is a major burden on population health. In our study, one-fifth of children either died or sustained neurologic disability. Our findings may be of interest to policymakers, clinicians, and public health researchers to galvanize efforts to reduce preventable drowning. As Saudi Arabia embarks on the mission to achieve Vision 2030, these findings should be helpful in the promotion of public health.

The burden of drowning among children may be reduced by recognizing the common risk factors associated with drowning incidence. Among children, being male was a significant risk factor for drowning

Table 3. Healthcare course of patients admitted following drowning by outcome.

Variables	Non-fatal and no neurological damage (n=77)	Death/Neurological damage (n=22)	Total (n=99) ^a	P value
Source of admission ^a				
From another hospital	6 (50.0)	6 (50.0)	12 (12.1)	
Ambulance	11 (52.4)	10 (47.6)	21 (21.2)	
Family transfer	57 (92.0)	5 (8.0)	62 (62.6)	<.01
Random Rescuer	2	0	2 (2.0)	
Unspecified	1	1	2 (2.0)	
GCS upon arrival ^b				
Intubation	15	3	15 (15.2)	
Performed	8 (32.0)	17 (68.0)	25 (25.3)	<.01
Not done	69 (98.6)	1 (1.4)	70 (70.7)	
Unspecified	0	4	4 (4.0)	
PICU admission				
Yes	10 (45.4)	12 (54.5)	22 (22.2)	
No	67 (88.2)	9 (11.8)	76 (76.8)	<.01
Unspecified	0	1	1 (1.0)	
PICU length of stay				
<5 days	7 (77.8)	2 (22.2)	9 (9.1)	
5-10 days	3 (42.9)	4 (57.1)	7 (7.1)	
>15 days	0	6	6 (6.1)	.01
Unspecified	0	1	1 (1.0)	
GCS at end of care ^b	15	3	15 (15.2)	<.01
Length of stay (days) ^b	1.0 (0-17)	6.5 (0-304)	1.0 (0-304)	<.01

Data are n (%) or mean (standard deviation) unless stated otherwise. ^aColumn percentage ^bMedian (minimum-maximum), n=99. GCS: Glasgow Coma Scale, PICU: pediatric intensive care unit.

in numerous studies.¹²⁻¹⁴ As for age, the literature on drowning indicates that young age is a significant risk factor. The Centers for Disease Control (CDC) reported that drowning is responsible for more deaths among children aged 1-4 years than any other cause.¹⁵ This is consistent with our study's findings, where most victims were below five years of age. We compared infants (<2 years old) to older children in our analysis, but found no statistically significant difference between the two age groups, perhaps due to the sample size. In addition, the long-term outcomes also did not differ between these two age groups. These findings demonstrate that age alone may not be a significant predictive factor for the prognosis of drowning events in young children.

Pre-existing neurological conditions are another risk factor for drowning. The literature on drowning suggests that children with neurological disorders, such as epilepsy, are at a higher risk of drowning.^{16,17} A study published by the American Academy for Pediatrics (AAP) estimated the risk of drowning to be 4 to 14 times greater among children with epilepsy than those without the disease.¹⁸ However, the majority of patients in our study were medically free of disease, although this did not appear to be a protective factor against unfavorable outcomes, such as death or neurological damage. Nonetheless, having pre-existing neurological health conditions, in particular, was associated with a higher insignificant prevalence of unfavorable outcomes compared to not having a significant medical history (33.3% vs. 20.9%).¹⁸

As expected, there was a significant association with a delay in initiating resuscitation and having an unfavorable outcome ($P<.001$). On the other hand, neither prehospital cardiopulmonary resuscitation nor time between the incident and emergency department arrival showed a statistical difference in predicting outcomes of drowning victims. This finding highlights the importance of educating and training communities to perform CPR promptly whenever needed. Furthermore, most drowning events occurred while there was no designated supervisor or a nearby witness of the event. Further intervention programs need to take this into account in order to design effective measures to reduce preventable drowning.

A 10-year study on drowning among children in Washington state in the United States found that the leading risk factor associated with drowning was inadequate supervision.¹⁹ Correspondingly, the majority (73%) of drowning events in our study occurred when the child's designated supervisor was not present. This alarming fact is a call to raise community awareness about the harmful negligence of leaving children unsu-

pervised. The AAP strongly advises that parents practice "touch supervision" for young children, where they can be immediately reached at all times around or in bodies of water, baths, or swimming pools.^{20,21} Adult supervision is especially essential in the vicinity of pools, particularly those with no installed security measures. We found that most severe drowning events (18 out of 22) that were complicated with neurological outcomes or death occurred in private pools. This finding emphasizes the need for increased community awareness and action toward applying a minimum level of security measures across private properties.

Several studies that have looked into the effectiveness of pool fencing as a security measure against drowning among children have found strong evidence suggesting its utility. Findings from a multistate study conducted by the US Consumer Product Safety Commission indicated that most young children who drowned or almost drowned accessed a pool through an unfenced access point.¹² The AAP recommends that parents, caregivers, and pool owners be trained in CPR and that close access to a telephone be available for seeking emergency services in case of a drowning incident. Future studies exploring increasing pool fencing in the Saudi community via mandate or increasing awareness are needed.

An Australian study looking into drowning rates among school children found that children are more than twice as likely to drown during holidays than during school days.²² During holidays, social gatherings may lead to the distraction of parents around swimming pools, leading to drowning among children. Like other studies, we also found that drowning time, initial low GCS score, and length of hospital stay were all proportionally associated with unfavorable outcomes ($P<.01$). Similarly, the need for intubation and PICU admission, in general, are both statistically significant factors that predict adverse outcomes.

Our study has several limitations. First, our study was conducted in one tertiary center located in a non-coastal city. Therefore, our findings cannot be generalized across the whole country as other variables could contribute to drowning incidents in other regions. Second, our chart review indicates a lack of adequate documentation of patient histories, particularly for previous drowning events. In addition, we were not able to report on the adequacy or presence of pool fencing among our study population due to limited data. The significance of improved documentation needs to be recognized by healthcare providers in order to accurately describe the epidemiology of drowning in Saudi Arabia so that intervention measures can be proposed.

Furthermore, comprehensive surveillance systems are needed to understand the epidemiology, time and geographic variation as well as outcomes of drowning events in Saudi Arabia. In summary, childhood drowning is a major burden on population health. Prevention

measures should focus on ensuring that children do not swim unsupervised. In addition, there is a need to ensure early resuscitation of drowning victims by promoting life support courses and enforcing regulations around water.

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