ORIGINAL ARTICLE

Oman Medical Journal [2021], Vol. 36, No. 6: e320

Epidemiology of Drowning Incidents among Children at Sultan Qaboos University Hospital Oman

Niranjan Lal Jeswani[1]*, Muhammad Faisal Khilji[1], Syed Rizvi[2] and Abdullah Al Reesi[1]

[1]Department of Emergency Medicine, Sultan Qaboos University Hospital, Muscat, Oman
[2]Family Medicine and Public Health, College of Medicine and Health Sciences, Sultan Qaboos University, Muscat, Oman

ARTICLE INFO

Article history:
Received: 5 October 2020
Accepted: 24 January 2021

Online:
DOI 10.5001/omj.2021.104

Keywords:
Drowning; Emergency Medicine; Intensive Care Units; Pediatrics; Oman.

ABSTRACT

Objectives: We sought to study the epidemiology of drowning among children reported at Sultan Qaboos University Hospital in Oman. ***Methods***: We conducted a retrospective study of the patients who presented to the emergency department with a history of drowning over 10 years from January 2008 to December 2017. Patients with children aged one to 18 years old were included in the study. The data including demographics, timing and location of drowning, season, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, emergency medicine department assessment, and hospital management and outcome were collected from electronic hospital information system using a preformed proforma. The outcome was categorized into either full recovery, severe neurological injury, or brain death based on the pediatric cerebral performance category (PCPC). A good outcome represents a score of 1–3 points, and a PCPC of 4–6 points corresponds to a poor outcome. We calculated correlation for all variables with the outcome by using chi-square and Fisher's exact tests. A *p*-value of < 0.050 is taken as significant value. ***Results:*** A total of 74 patients were included in the study; 54 (73.0%) were male, and 47 (63.5%) were aged < 6 years old. More than half (59.4%) of drownings happened in swimming pool, 21 (28.4%) children were unsupervised during the incident, and 39 (52.7%) required cardiopulmonary resuscitation (CPR). Out of all studied subjects, three (4.1%) were brain dead, and two (2.7%) developed severe neurological injury. On univariate analysis, the following variables were statistically significant ($p < 0.050$), predicting the poor outcome like lack of adult supervision, duration of submersion >10 minutes, asystole, Glasgow Coma Scale < 8, temperature < 35 °C, pH < 7, anion gap > 20, blood glucose > 10 mmol/L, abnormal chest X-ray findings, rewarming, CPR, intubation, inotropic support, and pediatric intensive care unit admission. ***Conclusions:*** Our study suggests that children, especially males under the age of six with no swimming ability, need strict supervision next to bodies of water. Furthermore, preventive measures might include raising community awareness about the risk factors of drowning, commencing public CPR lessons, and strict pool safety regulation by related authorities.

Drowning is a neglected public health problem and a significant cause of disability and death among children. It constitutes the third major cause of accidental injury killer and 7% of all injury-related deaths globally.[1,2] Approximately 80% of drownings are preventable, and it is a serious cause of death, especially in children in low and middle-income countries.[1–3] According to the Center for Disease Control and Prevention, drowning is the second leading cause of accidental death, and there are two drowning-related deaths every day in children under the age of 14 years in the USA.[4] Drowning was reported as the fifth major cause of accidental death in South Africa in 2010.[5] In Bangladesh, about 50 drownings happened per day, with most drownings (80%) occurring in freshwater.[6]

The present definition of drowning was proposed by the World Congress on Drowning and World Health Organization (WHO) in Amsterdam 2002 as "the process of experiencing primary respiratory impairment from submersion in liquid medium".[7] This definition nullifies all previous definitions of drowning like dry drowning, wet drowning, near drowning, active or passive drowning, silent drowning, and secondary drowning.[7]

*Corresponding author: ✉niranjanlal76@yahoo.com

Table 1: Demographic data.

Variables	Cases n = 74 n (%)	Good outcome Full recovery, n = 69	Poor outcome BD or SND, n = 5	*p*-value
Age				
Infant (1–12 months)	2 (2.7)	2	0	0.868
Toddler (1–3 years)	30 (40.5)	27	3	
Preschool (4–6 years)	15 (20.3)	13	2	
School (7–14 years)	17 (23.0)	17	0	
Adolescent (15–18 years)	10 (13.5)	10	0	
Sex				
Male	54 (73.0)	50	4	0.667
Female	20 (27.0)	19	1	

BD: brain death; SND: severe neurological damage.

Drowning shows three age-related peaks: children younger than five years, adolescents, and the elderly. The usual places of drowning in children are swimming pools, bathtubs, buckets, and natural bodies of water. Epilepsy, medical illness, and use of alcohol or illicit drugs are risk factors for drowning in children and adolescents.[8] Lack of parent's education, infants left unsupervised, and children under five (especially males) are factors that showed the significant risk for drowning.[9]

Oman is situated on the southeastern edge of the Arabian Peninsula, covering almost all of the eastern seacoast. With such a vast coastline, drowning cases are common.[10] According to the Public Authority for Civil Defense and Ambulances (PACDA), the number of drowning related deaths is on the rise in Oman with 113 cases in 2015 and 286 cases in 2016. Most drowning incidents happened in wadis and involved those who were not able to swim.[11] Sultan Qaboos University Hospital (SQUH) is a government institution and a teaching hospital situated within the campus of Sultan Qaboos University. The hospital has a 600-bed capacity and a wide catchment area. Our study aimed to determine the epidemiology of drowning among children reported at SQUH in Oman.

METHODS

This retrospective review study was conducted from January 2008 to December 2017 at the emergency medicine department (EMD) at SQUH, Oman. We included patients aged 1–18 years who presented with a history of drowning. The SQU, College of Medicine and Health Sciences ethics committee (Reference: SQU – EC/254/17) approved the study. Patients' data were retrieved from the SQUH electronic medical record system by putting discharge code of near-drowning, non-fatal drowning, and fatal drowning. We extracted the following descriptive variables, including demographic features, timing, season, location of drowning, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, transport to other hospital, EMD assessment, and in hospital management and outcome. Patients' outcomes were categorized into either full recovery, severe neurological damage, or brain death according to pediatric cerebral performance category (PCPC). A good outcome represents a score of 1–3 points, and a PCPC score of 4–6 points corresponds to a poor outcome. Severe neurological damage indicates the patient stayed in a vegetative state. The data were presented in numbers and percentages. Association between groups were analyzed using Pearson's chi-squared and Fisher's exact tests. A p-value of < 0.050 was considered statistically significant. Data were analyzed using Software for Statistics and Data Science (STATA) version 15 (STATA Corporation, College Station, TX, USA).

RESULTS

We reviewed the charts of 74 patients who were included in the study. Fifty-four (73.0%) were male, and 47 (63.5%) were less than six years old. Of the total study subjects, 69 (93.2%) were discharged from the hospital with full recovery, three (4.1%) were diagnosed as brain death, and two (2.7%) developed severe neurological damage. Four groups

Table 2: Relation of prehospital variables to drowning outcome.

Variables	Cases n = 74 n (%)	Good outcome Full recovery, n = 69	Poor outcome BD or SND, n = 5	*p*-value
Timing of drowning				
AM	6 (8.1)	6	0	0.789
PM	68 (91.9)	63	5	
Season				
Summer	29 (39.2)	26	3	0.517
Autumn	18 (24.3)	8	0	
Winter	9 (12.2)	18	1	
Spring	18 (24.3)	17	1	
Location of drowning				
Buckets	3 (4.0)	3	0	0.087
Home swimming pool	6 (8.1)	5	1	
Public swimming pool	38 (51.3)	36	2	
Wadis	5 (6.8)	4	1	
Lake/pond	5 (6.8)	4	1	
Sea	17 (23.0)	17	0	
Lack of adult supervision				
No	53 (71.6)	52	1	0.014
Yes	21 (28.4)	17	4	
Swimming ability				
Pre-swimming age	36 (48.6)	32	4	0.571
Can swim	27 (36.5)	26	1	
Can not swim	11 (14.9)	11	0	
Medical risk factors				
No	72 (97.3)	67	5	0.928
Epilepsy	2 (2.7)	2	0	
Duration of submersion, minutes				
< 10	65 (87.8)	64	1	< 0.001
> 10	9 (12.2)	5	4	
On spot resuscitation				
No	35 (47.3)	35	0	0.090
Yes (by family or EMS)	39 (52.7)	34	5	
Initial transfer to other hospitals				
No	41 (55.4)	39	2	0.723
Yes	33 (44.6)	30	3	

BD: brain death; SND: severe neurological damage; EMS: emergency medical services.

of variables were evaluated to determine their relation to the outcome. The first group included patient's demographics such as age and sex. None were associated significantly with good or poor outcomes [Table 1]. The second group included prehospital variables such as time and season of drowning, location of drowning, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, and initial transfer to other hospitals. Out of assessed variables, 38 (51.3%) of the drowning occurred in public swimming pools, 47 (63.5%) children had no swimming ability, two (2.7%) children had diagnosed epilepsy, and 39 (52.7%) received on spot resuscitation by a family member or emergency medical services. Of the prehospital variables, lack of adult supervision (p = 0.014) and duration of submersion > 10 minutes (p < 0.001) were statistically significant and correlated with poor outcomes (brain death or severe neurological damage) [Table 2]. Of the five children who had worse consequences, four were swimming without adult supervision. There were total of 9 children that had >10 minutes submersion, out of them, 4 children had poor outcome. The third

Table 3: Relation of the assessment variable in the emergency department with drowning outcome.

Variables	Cases n = 74 n (%)	Good outcome Full recovery, n = 69	Poor outcome BD or SND, n = 5	*p*-value
Initial Rhythm				
Sinus rhythm	71 (95.9)	69	2	< 0.001
Asystole	3 (4.1)	0	3	
GCS score				
< 8	4 (5.4)	0	4	< 0.001
> 8	70 (94.6)	69	1	
Temperature, °C				
< 35	8 (10.8)	4	4	< 0.001
> 35	66 (89.2)	65	1	
pH				
< 7	3 (4.1)	0	3	< 0.001
> 7	71 (95.9)	69	2	
Anion gap				
< 20	62 (83.8)	62	0	< 0.001
> 20	12 (16.2)	7	5	
Blood sugar, mmol/dL				
< 10	65 (87.8)	64	1	< 0.001
> 10	9 (12.2)	5	4	
Chest X-ray				
Normal	43 (58.1)	43	0	0.024
Bilateral infiltrate	31 (41.9)	26	5	

BD: brain death; SND: severe neurological damage; GCS: Glasgow Coma Scale.

group included variables evaluated at the EMD such as initial heart rhythm, Glasgow Coma Scale (GCS) score, temperature, pH, anion gap, blood sugar, and chest X-ray. Of the variables assessed on arrival, asystole, GCS score < 8, temperature < 35 °C, pH < 7, anion gap > 20, blood sugar > 10 mmol/L, and abnormal chest X-ray findings (signs of aspiration) were found to correlate with poor outcome with statistical significance [Table 3]. On the poor outcome, two children that drowned both had sinus rhythm on arrival. Chest X-ray was done on all patients; 31 (41.9%) reported abnormal findings. The fourth group included hospital admission variables such as rewarming, cardiopulmonary resuscitation (CPR), intubation, inotropes, and pediatric intensive care unit (PICU) admission. In all, six (8.1%) patients were rewarmed, four (5.4%) required CPR, 10 (13.5%) were intubated, four (5.4%) received inotropic support, and 17 (23.0%) were admitted to the PICU. Of the variables assessed, CPR, intubation, need for rewarming, inotropes, and PICU admission were statistically significant and correlated with poor outcomes [Table 4].

DISCUSSION

Globally, the maximum drowning rates are among children one to four years old followed by children aged five to nine. Drowning accounts for 43% of deaths among children aged 1–4 years in Bangladesh and 57% of drowning incidents happened in the same age group in Saudi Arabia.[12,13] This study showed most drowning occurred in toddlers followed by school-aged children. Moreover, results showed a trend (not statistically significant) for poor drowning outcomes in children over six years old. The increased prevalence of drowning in this age group could be due to children trying to explore the world, and their cognitive abilities are not correspondent to recognize dangers, especially when left unsupervised. The study showed a sex difference of male to female ratio > 2:1, which is in line with the WHO yearly report on drowning published in 2014.[2] Majority of worse drowning outcomes occurred in males. This might be related to boys being more physically active and having greater risk-taking behavior compared to girls.[14]

The maximum drowning incidents occurred in the afternoon and evening time of summer, followed

Table 4: Relation of management variable in the hospital with drowning outcome.

Variables	Cases n = 74 n (%)	Good outcome Full recovery, n = 69	Poor outcome BD or SND, n = 5	*p*-value
Rewarming				
No	68 (91.9)	67	1	< 0.001
Yes	6 (8.1)	2	4	
CPR				
No	70 (94.6)	69	1	< 0.001
Yes	4 (5.4)	0	4	
Intubation				
No	64 (86.5)	64	0	
Yes	10 (13.5)	5	5	< 0.001
Inotropes				
No	70 (94.6)	68	2	< 0.001
Yes	4 (5.4)	1	3	
PICU				
No	57 (77.0)	57	0	0.006
Yes	17 (23.0)	12	5	

BD: brain death; SND: severe neurological damage; CPR: cardiopulmonary resuscitation; PICU: pediatric intensive care unit.

by autumn and spring. This seasonal difference is similarly reported in these regional studies.[13,15] In more than half of our study population, submersion occurred in swimming pools followed by sea, wadis, and ponds. Furthermore, in all children that suffered brain death or severe neurological damage, three patients drowned in a swimming pool, one in a wadi, and another in a pond. These results were comparable with drowning incidents reported by PACDA and with reference studies[8,16] but are in contrast with a study done in China, where 72% of drownings occurred in natural water bodies.[17] The climate of Muscat is hot and humid, with long and very hot summers. Hot weather may lead to increased water-related activities. Increased access to water is a risk factor for drowning. This may, in part, explain the relatively high incidence of drowning in artificial or natural water bodies. It is paramount that parents take care of their children while going to the swimming pool, wadis, or sea. One of the four submersions occurred where an accompanying person was not around or busy with other work, and > 60% of the victims had no swimming abilities. Out of them, four victims had brain death or severe neurological damage. These results revealed that a lack of strict safety precautions near bodies of water and poor adult supervision is associated with worse consequences.

The overall outcomes of drowning patients are dependent on optimal prehospital care.[18] Transport to hospital with definite care as early as possible and performance of CPR at the scene or during transport correlated with good outcomes (although not statistically significant). This might be related to vigilance during transport being suboptimal and inadequate knowledge by the general population regarding basic life support. Al-Shaqsi et al,[19] reported in their study that almost 55% of the surveyed population did not know how to perform CPR. Multiple efforts have been made by experts in the field to develop individual prognostic factors to predict the negative drowning outcomes but, unfortunately, there are no validated guidelines in the literature.[20,21] However, published prognostic factors include drowning duration > 10 minutes, delayed rescue at the scene, need for CPR in the EMD, depth of coma (GCS score < 4), poor neurological response to therapy, initial arterial pH of < 7.0, and initial blood sugar level of > 12 mmol/L.[20–22] Our studies results match with other studies[21–25] regarding the predictive values of prehospital variables, initial EMD, and in-hospital management with negative drowning outcomes.

Proper understanding of submersion injuries pattern is vital for the development of preventive measures against drowning. Developed countries have conducted significant research and hence developed much improved preventive measures.

In doing so, they took strict legislative measures and conducted comprehensive health awareness campaigns.[26] The outcome of overall preventive strategies suggested by studies in developed countries is sometimes difficult to implement in developing countries due to the lack of resources. Generally, their recommendations include fencing of water bodies and improving public awareness regarding drowning.[27]

To the best of our knowledge, this is the first study with deep insight into drowning at the institutional level. There were limitations in our study. The first limitation was that the study was conducted at one tertiary care hospital. Therefore, findings might not be generalized to the whole population, and there is a need to collaborate with other hospitals and related institutional bodies to work on this subject in the future. Second, due to the retrospective nature of the study, it was difficult to compare different factors that might have affected the prevalence of drowning (such as parents education, and home and private swimming pool safety measures). Third, follow-up of discharged patients with severe neurological damage were missing.

CONCLUSION

This study suggests that children, especially males below six years of age without swimming ability, need strict supervision next to bodies of water. Furthermore, preventive measures might include raising community awareness about the risk factors of drowning, commencing public CPR lessons, and strict pool safety regulation by related authorities.

Disclosure

The authors declared no conflicts of interest. No funding was received for this study.

REFERENCES

1. World Health Organization. Global report on drowning: preventing a leading killer. [cited 2020 January 1]. Available from: https://www.who.int/violence_injury_prevention/publications/drowning_global_report/Final_report_full_web.pdf.
2. Szpilman D, Sempsrott J, Webber J, Hawkins SC, Barcala-Furelos R, Schmidt A, et al. 'Dry drowning' and other myths. Cleve Clin J Med 2018 Jul;85(7):529-535.
3. Linnan M, Rahman A, Scarr J, Reinten-Reynolds T, Linnan H, Rui-Wei J, et al. Child drowning: evidence for a newly recognized cause of child mortality in low and middle income countries in Asia. In: Special series on child injury; 2012 [cited 2019 December 30]. Available from: https://www.unicef-irc.org/publications/pdf/drowning.pdf.
4. Centers for Disease Control and Prevention. Unintentional drowning: get the facts. Secondary unintentional drowning: get the facts 24 October 2014. [cited 2019 December 30]. Available from: https://www.cdc.gov/drowning/facts/index.html.
5. Donson H, van Niekerk A. Unintentional drowning in urban South Africa: a retrospective investigation, 2001-2005. Int J Inj Contr Saf Promot 2013;20(3):218-226.
6. CIPRB. Drowning. 2013 [cited 2019 December 31]. Available from: http://www.ciprb.org/resources/fact-sheets/drowning.
7. van Beeck EF, Branche CM, Szpilman D, Modell JH, Bierens JJ. A new definition of drowning: towards documentation and prevention of a global public health problem. Bull World Health Organ 2005 Nov;83(11):853-856.
8. Mokdad AH, Forouzanfar MH, Daoud F, Mokdad AA, El Bcheraoui C, Moradi-Lakeh M, et al. Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2016 Jun;387(10036):2383-2401.
9. Peden MM, McGee K. The epidemiology of drowning worldwide. Inj Control Saf Promot 2003 Dec;10(4):195-199.
10. World Population Review. Oman population 2019. 2019 [cited 2019 December 30]. Available from: http://worldpopulationreview.com/countries/oman-population.
11. Reporter SR. Drowning cases spike in Oman. Times of Oman. [cited 2020 January 1]. Available from: https://timesofoman.com/article/108495/Oman/Drowning-cases-spike-in-Oman-says-PACDA.
12. Hossain M, Mani KK, Sidik SM, Hayati KS, Rahman AK. Socio-demographic, environmental and caring risk factors for childhood drowning deaths in Bangladesh. BMC Pediatr 2015 Sep;15(10):114-117.
13. Al-Qurashi FO, Yousef AA, Aljoudi A, Alzahrani SM, Al-Jawder NY, Al-Ahmar AK, et al. A Review of nonfatal drowning in the pediatric-age group: a 10-year experience at a university hospital in Saudi Arabia. Pediatr Emerg Care 2019 Nov;35(11):782-786.
14. Al Rumhi A, Al Awisi H, Al Buwaiqi M, Al Rabaani S. Home accidents among children: a retrospective study at a tertiary care center in Oman. Oman Med J 2020 Jan;35(1):e85.
15. Al-Fifi SH, Shabana MA, Zayed M, Al-Binali AM, Al-Shehri MA. Drowning in children: Aseer Central Hospital experience, Southwestern Saudi Arabia. J Family Community Med 2011 Jan;18(1):13-16.
16. Bamber AR, Pryce JW, Ashworth MT, Sebire NJ. Immersion-related deaths in infants and children: autopsy experience from a specialist center. Forensic Sci Med Pathol 2014 Sep;10(3):363-370.
17. Fang Y, Dai L, Jaung MS, Chen X, Yu S, Xiang H. Child drowning deaths in Xiamen city and suburbs, People's Republic of China, 2001 5. Inj Prev 2007 Oct;13(5):339-343.
18. Kyriacou DN, Arcinue EL, Peek C, Kraus JF. Effect of immediate resuscitation on children with submersion injury. Pediatrics 1994 Aug;94(2 Pt 1):137-142.
19. Al-Shaqsi S, Al-Risi A, Al-Kashmiri A. Do lay people in Oman know how to perform cardiopulmonary resuscitation? Oman Med J 2018 Mar;33(2):178-179.
20. Quan L, Wentz KR, Gore EJ, Copass MK. Outcome and predictors of outcome in pediatric submersion victims receiving prehospital care in King County, Washington. Pediatrics 1990 Oct;86(4):586-593.
21. Lavelle JM, Shaw KN. Near drowning: is emergency department cardiopulmonary resuscitation or intensive care unit cerebral resuscitation indicated? Crit Care Med 1993 Mar;21(3):368-373.
22. Quan L, Kinder D. Pediatric submersions: prehospital

predictors of outcome. Pediatrics 1992 Dec;90(6):909-913.

23. Kawati R, Covaciu L, Rubertsson S. Hypothermia after drowning in paediatric patients. Resuscitation 2009 Nov;80(11):1325-1326.
24. Horisberger T, Fischer E, Fanconi S. One-year survival and neurological outcome after pediatric cardiopulmonary resuscitation. Intensive Care Med 2002 Mar;28(3):365-368.
25. Forler J, Carsin A, Arlaud K, Bosdure E, Viard L, Paut O, et al. [Respiratory complications of accidental drownings in children]. Arch Pediatr 2010 Jan;17(1):14-18.
26. Tyler MD, Richards DB, Reske-Nielsen C, Saghafi O, Morse EA, Carey R, et al. The epidemiology of drowning in low- and middle-income countries: a systematic review. BMC Public Health 2017 May;17(1):413.
27. Szpilman D, Bierens JJ, Handley AJ, Orlowski JP. Drowning. N Engl J Med 2012 May;366(22):2102-2110.