Received: 25.10.2008 **Accepted: 31.12.2008**

Original Article

Epidemiology of drowning in Isfahan province, center of Iran

Ardeshir Sheikhazadi [*a], *Mohammad Hasan Ghadyani* [b]

Abstract

BACKGROUND: Drowning is a preventable cause of morbidity and mortality. We studied drowning deaths in Isfahan province, focusing on the activity victims were involved in and the setting of the incident.

METHODS: Retrospective analysis was done on all drowning deaths referred to Legal Medicine Organization of Isfahan province over a period of 5 years from 1 January 2002 to 31 December 2006.

RESULTS: During these 5 years, 355 persons suffered fatal drowning in Isfahan province. The annual incidence rate was 1.6 per 100000 population (2.6 & 0.4 for males and females, respectively). Mean age was 21.99 ± 14.86 and M/F ratio was 6.5:1. Most victims were 15-24 and 5-14 years of age (172 and 62 decedents, 3.0 and 1.8 per 100000 population/year, respectively). Most incidents occurred in natural settings, of which rivers, canals, lakes and ponds were the most common sites, respectively. The most frequently connected activity was swimming and wading, followed by accidental fall into water. The manner of death was found as following: 85.1% accidental, 1.7% suicidal, 0.3% homicidal and 12.9% undetermined.

CONCLUSIONS: Although the drowning related mortality in Isfahan province is comparable to developed countries, effective prevention of drowning with better programming and policies might reduce its rate.

KEYWORDS: Drowning, epidemiology, public health, Isfahan province, Iran.

JRMS 2009; 14(2): 79-87

Drowning is a preventable cause of morbidity and mortality. The World Health Organization (WHO) appraises the annual global incidence of death by drowning to be about 400,000.[1] This counting is apparently a gross underestimate because of underreporting.[2] The calamity of drowning often is mixed by the premature nature of death. In the developed countries, the highest incidence of drowning is seen in children under 5 years of age and young adults between 15 to 24 years old.[3,4] In some countries, drowning is the first or second leading cause of death in children.[5] About 1,200 drowning deaths occur each year in Iran.[6] Accidental immersing is a mainly preventable cause of death. Water safety unions, the general public and lawmakers need suitable data about the conditions of drowning to plan for effective preventive action. Effective avoidance measures require itemized understanding of the specific epidemiology of drowning incidents.

Despite the big number of deaths, relatively few epidemiologic studies have examined drowning in Iran. Isfahan attracts studies of drowning because it has many types of water settings from dikes, lakes and canals in the suburbs to rivers in the center. Data from 2002 through 2006 shows that only 3 other provinces of Iran have a higher drowning rate than Isfahan.[6] The aim of this study was to examine the incidence and characteristics of drowning in Isfahan province. We studied drowning deaths in Isfahan province, giving special con-

[a] M.D., Forensic Medicine Specialist, Associate professor, Department of Forensic Medicine, School of Medicine, Tehran University of Medical Sciences , Tehran, Iran.
[b] M.D., Internal Medicine Specialist, Assistant professor, Legal Medicine Organization of Iran, Tehran, Iran.
* Corresponding Author
E-mail: ardeshirsheikhazadi@yahoo.com; sheikhazadi@tums.ac.ir

sideration to the activity victims were involved in and the setting of the incident. The study benefited from the Legal Medicine Organization of Isfahan (LMO) that investigates all unnatural deaths in forensic medicine fields.[7]

Methods

Study Design. We used the model published by Patetta MJ and Biddinger PW.[8] Retrospective analysis was done on all drowning deaths that were happened in different cities of Isfahan province over a period of 5 years (from January 1 2002 to December 31 2006). The Data were obtained from Isfahan's LMO and judiciary reports to identify epidemiologic features associated with drownings.

Setting and Population. The province of Isfahan is one of the historical and industrial regions of Iran; with many types of water settings including dikes, lakes and canals and rivers. The population of the province is about 4,559,256 (2,335,399 male and 2,223,857 female); nearly 3.80 million (83.3%) reside in urban areas and the rest (n = 0.76 million; 16.7%) are residents of rural areas.[9]

Data Collection. Drowning deaths were identified by reviewing death certificates and autopsy reports that listed drowning as a possible primary or contributing cause of death in accordance with the International Classification of Disease (ICD-10). Additional data were obtained from the Isfahan's LMO records and county judiciary reports.

Demographic data included age, sex, date and place of death, place of residence and nationality of the victims, site of the drowning, correctness of ICD-10 classification, autopsy results, toxicology findings, manner of death and narrative summaries of the circumstances. Various sites of drowning such as well/pond, canal, river, lake, swimming pool, tank etc. were also recorded.

To determine death rates and relative risks, we compared numbers and percentages of drowning to population using demographic data from the Isfahan province census (Table 1).[9] To examine variations in the different categories of drowning, drowning rates were computed for all drowned victims and were subdivided on the bases of age and sex. The computed rates are approximate because the report did not comprise Isfahan's citizens who drowned out of their province. Cross tabulations were produced to see how demographic properties varied by activity and environment, using data on native and nonnative decedents. There are great disagreements on associated activities and incident settings. The toxicology laboratory of the Isfahan office of the LMO considers blood alcohol results of 20 milligrams deciliter (mg per dl) or higher as positive.

Table 1. The population of Isfahan province according to the statistical report of Iranian Authority for General Department of Public Statistics and Statistical Center of Iran, 2006.

Age group (years)	Male	Female	All
0-4	160860	152768	313628
5-14	355207	338346	693553
15-24	577337	560208	1137545
25-34	435975	412649	848624
35-44	324091	302319	626410
45-54	224353	212211	436564
55-64	120485	118884	239369
≤ 65	137091	126472	263563
Total	2335399	2223857	4559256

Data analysis. Data were analyzed using SPSS 16. Associations between categorical variables within the sample were tested for statistical significance using Pearson correlation analysis. Fisher exact test was used when the subjects were less than five. P values < 0.05 were considered as statistically significant.

Results

During the period of 2002 through 2006, 355 persons drowned in Isfahan Province, 87% (309 cases) were male and 13% (46 cases) were female. The mean age of drowned victims was 21.99 ± 14.86. The annual rate of drowning incidence was 1.6 per 100000 population (2.6 & 0.4 for males and females, respectively).

Demographic data. The frequency of drowning deaths according to age and gender is presented in Table 2. The highest incidence rates were seen in the age groups of 15-24, 5-14 and children under 5 years of age (3.0, 1.8 and 1.8 per 100 000 population/year, respectively).
Table 3 presents the gender of the drowning victims and the male to female ratio according to the year of incident. The range of sex ratio is varied from 4.2:1 to 12.3:1, with a mean of 6.5:1.

Employment and educational status. The majority of male drowned victims were students, simple workers, unemployed people and farmers, whereas the majority of female victims were housekeepers and students ($p < 0.01$). Generally, male victims had higher levels of education, but there was no significant correlation. About 35 percent of female victims (16 of 46, 0.1 per 100 000 population/year) and 15 percent of male victims (47 of 309, 0.4 per 100 000 population/year) were illiterate.

The places of death. The places of death were as follows: place of accident (n = 334, 94.1%, 1.5 per 100000 population/year), while transporting to hospital (n = 5, 1.4%, 0.02 per 100000 population/year), shortly after being transferred to hospital (n = 16, 4.5%, 0.07 per 100000 population/year). Only 19 cases (5.4%) of all drowned victims had received primary help including cardiopulmonary resuscitation (CPR). One hundred thirty six cases (38.3.0%) of all victims (0.6 per 100000 population/year) drowned in weekends and most of them drowned in the afternoon.

The seasonal variation. There was an obvious seasonal variation in mortality by drowning during the study period. July, August, June, May, September and April, respectively, were the most common months when deaths due to drowning happened. More than 91% of all deaths (1.4 per 100000 population/year) occurred during these months ($p < 0.01$).

Table 2. The frequency and incidence of drowning deaths according to age and gender in Isfahan province (2002–2006).

Age group	Males			Females			All		
	n	%	Rates per 100000 population/ year	n	%	Rates per 100000 population/ year	n	%	Rates per 100000 population/ year
0-4	17	4.8	2.1	11	3.1	1.4	28	7.9	1.8
5-14	52	14.7	2.9	10	2.8	0.6	62	17.5	1.8
15-24	161	43.3	5.6	11	3.1	0.4	172	48.4	3.0
25-34	40	11.3	1.8	7	1.9	0.3	47	13.2	1.1
35-44	13	3.6	0.8	2	0.6	0.1	15	4.2	0.5
45-54	10	2.8	0.9	2	0.6	0.2	12	3.4	0.5
55-64	8	2.2	1.3	1	0.3	0.2	9	2.5	0.8
> = 65	8	2.3	1.2	2	0.6	0.3	10	2.9	0.8
Total	309	87.0	2.6	46	13.0	0.4	355	100.0	1.6

N: Numbers of decedents
%: Percent of decedents

Table 3. The frequency, incidence and male/female ratio of drowning victims in Isfahan province per year (2002–2006).

Year	Frequency			M/F Ratio
	Male [Rate per 100000 population/year]	Female [Rate per 100000 population/year]	All [Rate per 100000 population/year]	
2002	59 [2.5]	8 [0.4]	67 [1.5]	6.3:1
2003	87 [3.7]	6 [0.3]	93 [2.0]	12.3:1
2004	59 [2.5]	14 [0.6]	73 [1.6]	4.2:1
2005	48 [2.1]	10 [0.5]	58 [1.3]	4.2:1
2006	56 [2.4]	8 [0.4]	64 [1.4]	6.0:1
Total	309 [2.6]	46 [0.4]	355 [1.6]	6.5:1

M/F Ratio: Male to female ratio

Activity. Generally, the most frequently connected activity was swimming and wading, followed by accidental falls into water (45.1% and 30.1%, 0.7 and 0.5 per 100000 population/year, respectively) (figure 1). Swimming and wading, accidental falls into water, motor boating, and motor vehicle accidents were activities implicated with drowning and there was a gender difference related to this variable ($p < 0.05$). Females had relatively high percentage of death due to unintentional fall into water. In other words, accidental fall into water was the most common cause of females' drowning, followed by swimming and wading (52.2% and 26.1%, 0.2 and 0.1 per 100000 population/year, respectively). There was only one case that a female was a passenger of a motor vehicle and drowned in an accident, and there was no female victim drowned due to motor boating accidents.

Setting. Most accidents occurred in natural settings, of which rivers, canals, lakes and ponds were the most common sites, respectively (figure 2). Children under 5 years of age accounted for 23.1 percent of pond drownings (6 of 26), but pond drowning was only the setting for 7.9 percent of total victims (28 of 355). Swimming and wading deaths accounted for

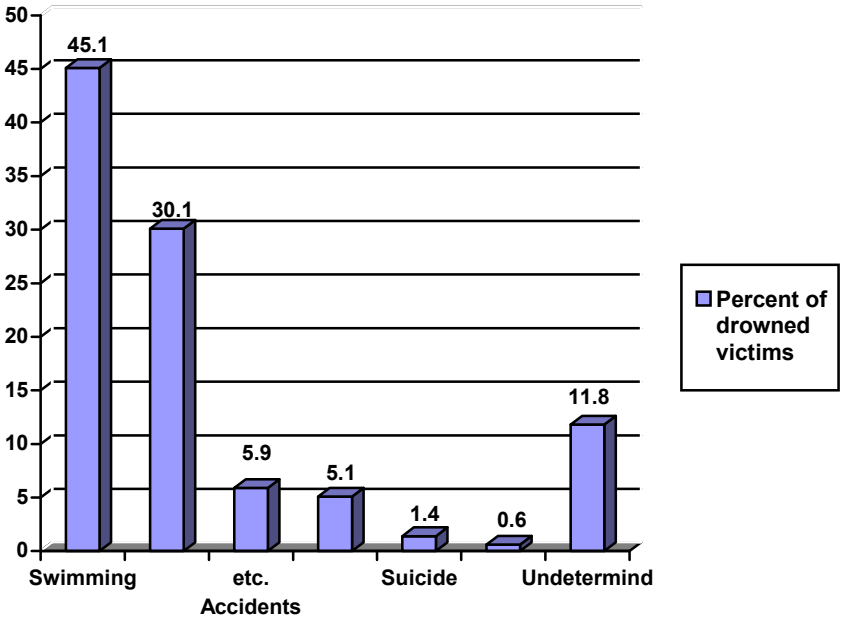

Figure 1. Frequency of drownings according to victims' activities or motives in Isfahan province, center of Iran (2002-2006).

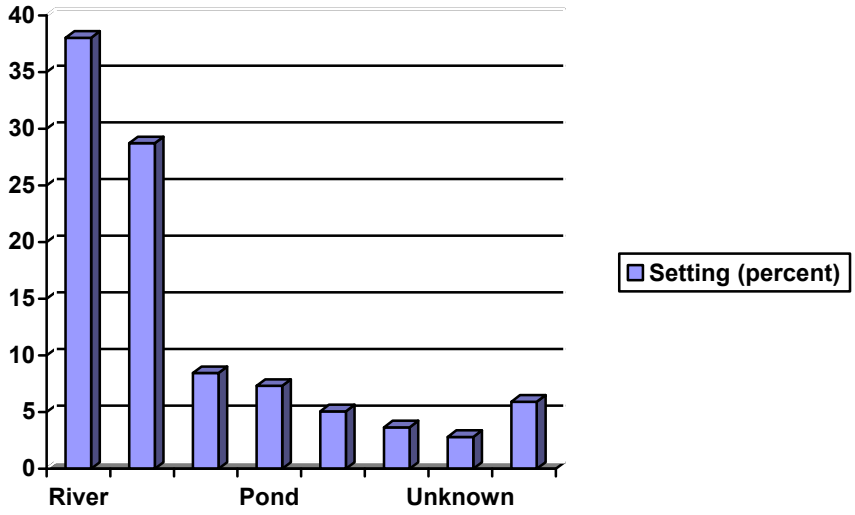

Figure 2. Setting of drownings in Isfahan province, center of Iran (2002-2006).

92.3 percent of drownings in public in-door pools (12 of 13), but they were associated activities of only 16.7 percent of the private pools drownings (3 of 18). The difference is due to the large number of children who fell into private pools. Children younger than 10 years of age accounted for 44.4 percent of private pool deaths (8 of 18), a relatively high percentage, and all of them were due to accidental falls into water.

Alcohol consuming. Out of 265 victims of drowning in Isfahan aging 15 and older, only 65 (24.5 percent) were tested for ethyl alcohol in their blood. Not being examined was typically due to absence of evidence for history of alcohol consumption, advanced decomposition or protracted survival following recovery from the water. Ethanol was detected in the blood of 13 examined victims and only 4 cases showed a blood alcohol concentration (BAC) of 100 mg per dl or greater.

Involvement of other individuals. Seventy-four percent of all victims (263 of 355, 1.2 per 100000 population/year) were testified. The witnessed percentage varied noticeably according to the collaborated activity and ranged from 94 percent for group swimming to 12 percent for private swimming pools. Resuscitation attempts were reported in 19 persons of the testified drownings. In 6 instances, rescue attempts resulted in the death of the would-be rescuer. Out of 28 drowned children under 5 years of age, 21 cases (75%) were unattended. Out of the 21, 19 fell into a body of water, such as a swimming pool or a lake and 2 were swimming or wading in a swimming pool.

Preexisting illness. A history of a seizure disorder was reported for 8.5 percent and considerable cardiovascular disease was reported for 6 percent of the victims. However, the prevalence of cardiovascular disease may actually have been higher; because autopsies were done only for 40 percent of the total decedents.

The manner of death. The distribution of deaths according to different manners of drownings during the studied period was evaluated. Accidental drowning (n = 302, 85.1%) was the most common manner of death, followed by undetermined (n = 46, 12.9%), suicidal drowning (n = 6, 1.7%) and homicidal drowning (n = 1, 0.3%).

Nonresidents' victims. A total number of 44 (12.4%) of all drowned victims were travelers from other parts of Iran, especially from prov-

inces of Charmahal-Bakhtiari, Tehran, Khuzestan and Kerman. The mean age of the travelers was 18.86 ± 11.00, and M/F ratio was equal to 7.8:1. June, August, September, and July, respectively, were the most common months when travelers died due to drowning and 36.4% of these deaths occurred in 2003. Eleven cases (25.0%) drowned in weekends and 77.3% drowned in the afternoon. Most travelers drowned in river of Zayandeh-rood (38.6%) and canals (34.1%). The most common cities where travelers drowned were Isfahan and Falavarjan (79.5% and 11.4%, respectively) and the most common activities implicated with drowning were swimming and unintentional falls into water (45.5% and 27.3%, respectively).

Discussion

Isfahan drowning deaths were studied in order to identify victims' population groups, accident settings, and implicated activities. Age and sex groups of victims were comparable to those reported nationally and for most other provinces of Iran.[6,10] In this study, we found significant differences between drowning rates by age and sex. With regard to age, the young adult group (15 to 24 years of age) had proportionately high rates. Males were drowned 6.5 times more than females. The overall rate of drowning in Isfahan from 2002 to 2006 was 1.6 per 100,000 population, which is lower than the rate reported in Mazandaran, Khuzestan and Gilan provinces during the same period.[6,10] The Isfahan rate, however, is very close to the national rate of 1.8 per 100,000 in 2002 through 2006.[6]

Natural freshwater settings were the sites of about 83 percent of all drownings, which highlights the risk of going in such water whether deliberately or not. The low proportion of saltwater drowning in Isfahan is not surprising, because of geography of the region.

The ratio of implicated activities with drowning are similar to the results of studies performed nationally or in other provinces.[6,10] Despite the fact that swimming and wading was the most common implicated activity, about one third of the drownings occurred following involuntary entry into the water. Many of these drownings could be prevented by using personal flotation devices and proper fencing around dangerous sites.

Although only about one fourth of adult victims were examined for blood alcohol, positive blood alcohol tests were few and only 4 persons showed a BAC of 100 mg per dl or greater. Drinking alcohol before going in the water has multiple potentially adverse effects, including dysfunction of judgment, orientation, reflexes, and motor activity. Ethyl alcohol can raise the probability of hypothermia, and there is evidence that alcohol can influence hypoglycemia in an activating human being who has not eaten recently.[8] The relation between drowning and alcohol consumption has been documented in different countries and various settings. The findings of our study is in opposition to the results of many studies conducted in other countries.[8,11-22] The reason might be religious and cultural differences and that alcohol consumption is prohibited in Iran.

Many authors indicate that the increase or decrease of drowning death in a year is closely related to seasons, climatic factors and geographic zone.[23-26] Our study showed that the majority of deaths took place during the summer followed by the end of the spring, when the weather is warm. This correlates to the results of studies in other provinces of Iran and also in western countries.[6,10,23-28]

With regard to the forensic etiology, three possibilities are usually considered: accidental, suicidal and homicidal submersion, but murderous form of drowning is of less statistical importance. Accidental submersion is the most common cause of deaths by drowning. In this respect, some authors such as Giersten,[29] Copeland [30] and Wintemute et al [31] have reported a range of 80% to 90% of the total number of deaths caused by submersion. Our study confirms these results, and more than 85% of all submersions were accidental with the male to female proportion key being 7.9:1. This finding is similar to the studies mentioned above, but the rate is lower than that of some other areas

of Iran.[10] However, there may be variations depending on the geographic zone where the study is conducted.

Data analyses showed that 1.7% of all cases were suicidal submersion, i.e. 6 out of 355 cases with equal male-female ratio. This is much lower than what has been studied in another part of Iran, i.e. 3.6% and also the rates reported by Shetty, i.e. 42.3%, Avis, i.e. 8.9%, and Auer, 18.6%.[10,26,32,33] Comparing victims' sex, a clear difference is observed. Drowned females include 50% of all suicidal submersions. These percentages are higher than the 32.5%, 26.4%, 36.4% and 20% obtained by Sheikhazadi,[10] Shetty,[26] Copeland [30] and Avis[32] respectively. With regard to males, suicidal submersion is 50% of all submersions of this etiology. Higher observations were obtained in Mazandaran Province (north of Iran),[10] and Newfoundland.[32]

On the other hand, it is stated that homicidal submersion is really rare because of difficulties it involves when the victim is adult, unless the victim is first weakened by something like alcohol or drugs. Only one case of murder was found in this study, a 2 month aged baby who was tossed into the well by the mother's suicide. Typically this type of death has a dyadic nature. This case represented 0.3% of all deaths due to submersion, a similar percentage to Mazandaran's victims of drowning,[10] but a smaller percentage compared with the 1% and 2.3% obtained by Wintemute et al.[31] and Copeland [33] in Sacramento and Florida, respectively.

When the manner of death could not be recognized, the case is considered undetermined, which comprised 12.9%, i.e. 46 cases of total deaths caused due to drowning in our study.

Only about 5 percent of all drowned victims had received primary help including CPR. It means that some cases could be prevented if victims or witnesses were familiar with water safety and techniques of rescue and resuscitation.

High proportion of children and adolescents victims of drowning is especially disastrous. Drowning in swimming pools or other sites prone to accidental falls into water appear preventable by appropriate supervision or adequate fencing.

There were at least two obvious limitations in this study. First, it was a retrospective study and thus some data were unavailable. There was no sufficient information about swimming abilities of victims and the underlying medical conditions such as ischemic heart disease, cardiac arrhythmias, autism and specially seizure disorder which is a known risk factor for drowning. Second limitation was relatively low proportion of victims who were examined for BAC and drug consumption.

Acknowledgments

The authors thank the Deputy of Research of Legal Medicine Organization of Iran for funding the study, LMO and Judicial office of Isfahan province for providing access to the records, Dr. Sepideh Emshasahand for assistance with archival searches, and Mr. Saman Sheikh Azadi for editing the manuscript.

Conflict of Interest

This study was supported by a grant from Legal Medicine Organization of Iran, Vice Chancellor for Research Affairs (grant number: 1.2.77907).

Authors' Contributions

ASh carried out the design and coordinated the study, participated in most of the experiments and prepared the manuscript.

MHGh provided assistance in the design of the study, coordinated and carried out all the experiments and participated in manuscript preparation. All authors have read and approved the content of the manuscript.

References

1. Brundtland GH. From the World Health Organization. Reducing risks to health, promoting healthy life. JAMA 2002; 288(16):1974.
2. DeNicola LK, Falk JL, Swanson ME, Gayle MO, Kissoon N. Submersion injuries in children and adults. Crit Care Clin 1997; 13(3):477-502.
3. World Health Organization. Injury: a leading cause of the global burden of disease. Geneva: World Health Organization; 2002.
4. World Health Organization. Fact sheets about injuries: drowning [Online]. 2003. Available from: URL: http://www.who.int/violence_injury_prevention/publications/other_injury/en/drowning_factsheet.pdf.
5. Smith G. Global burden of drowning. Proceedings of the World Congress on Drowning, Amsterdam; 2002.
6. Death registration, statistics published by Legal Medicine Organization of Iran. Tehran, Iran. LMO Press Annual report. 2002; 206.
7. Kiani M, Sheikhazadi A. A five-year survey for dental malpractice claims in Tehran, Iran. J Forensic Leg Med 2009; 16(2):76-82.
8. Patetta MJ, Biddinger PW. Characteristics of drowning deaths in North Carolina. Public Health Rep 1988; 103(4):406-11.
9. The Statistical Report of the Islamic Republic of Iran. The Iranian Authority for General Department of Public Statistics and Statistical Center of Iran, 2006. Available from URL: http://www.sci.org.ir/portal/faces/public/census85/census85.natayej (Accessed 9 November 2007).
10. Sheikhazadi A, Ghadyani MH. Epidemiology of drowning in Mazandaran province, north of Iran. Am J Forensic Med Pathol. 2009; in Press.
11. Lunetta P, Penttila A, Sarna S. Water traffic accidents, drowning and alcohol in Finland, 1969-1995. Int J Epidemiol 1998; 27(6):1038-43.
12. Canadian Red Cross Society. National drowning report. Mc Gill University, 34[3]. 2001.
13. Mackie IJ. Patterns of drowning in Australia, 1992-1997. Med J Aust 1999; 171(11-12):587-90.
14. Howland J, Hingson R, Mangione TW, Bell N, Bak S. Why are most drowning victims men? Sex differences in aquatic skills and behaviors. Am J Public Health 1996; 86(1):93-6.
15. Smith GS, Keyl PM, Hadley JA, Bartley CL, Foss RD, Tolbert WG, et al. Drinking and recreational boating fatalities: a population-based case-control study. JAMA 2001; 286(23):2974-80.
16. Logan P, Sacks JJ, Branche CM, Ryan GW, Bender P. Alcohol-influenced recreational boat operation in the United States, 1994. Am J Prev Med 1999; 16(4):278-82.
17. Warner M, Smith GS, Langley JD. Drowning and alcohol in New Zealand: what do the coroner's files tell us? Aust N Z J Public Health 2000; 24(4):387-90.
18. Howland J, Hingson R. Alcohol as a risk factor for drownings: a review of the literature (1950-1985). Accid Anal Prev 1988; 20(1):19-25.
19. Browne ML, Lewis-Michl EL, Stark AD. Unintentional drownings among New York State residents, 1988-1994. Public Health Rep 2003; 118(5):448-58.
20. Mengert PH. A study of the relationship between the risk of fatality and blood alcohol concentration of recreational boat operators. 1st ed. Springfield: Available through the National Technical Information Center; 1992.
21. Smith GS, Houser J. Risk factors for drowning: a case-control study. In: Abstracts of the 122nd Annual Meeting of the American Public Health Association, Washington, D.C., October 30–November 3, 1994:323. abstract.
22. Lunetta P, Smith GS, Penttila A, Sajantila A. Unintentional drowning in Finland 1970-2000: a population-based study. Int J Epidemiol 2004; 33(5):1053-63.
23. Hedberg K, Gunderson PD, Vargas C, Osterholm MT, MacDonald KL. Drownings in Minnesota, 1980-85: a population-based study. Am J Public Health 1990; 80(9):1071-4.
24. Davis S, Smith LS. The epidemiology of drowning in Cape Town--1980-1983. S Afr Med J 1985; 68(10):739-42.
25. Pearn J. Pathophysiology of drowning. Med J Aust 1985; 142(11):586-8.
26. Suresh Kumar SB, Shetty M. Epidemiology of drowning in Mangalore, a coastal Taluk of South India. J Forensic Leg Med 2007; 14(7):410-5.
27. Wong LL, McNamara JJ. Salt water drowning. Hawaii Med J 1984; 43(6):208-10.
28. Baker SP. The injury fact book. 2nd ed. New York: Oxford University Press; 1992.
29. Giersten JC. Drowning. In: Tedeschi CG, Eckert WG, editors. Forensic Medicine: a study in trauma and environmental hazards. philadelphia: Saunders; 1977. p: 1317-22.

30. Copeland AR. Suicide by drowning. Am J Forensic Med Pathol 1987; 8(1):18-22.
31. Wintemute GJ, Kraus JF, Teret SP, Wright MA. The epidemiology of drowning in adulthood: implications for prevention. Am J Prev Med 1988; 4(6):343-8.
32. Avis SP. Suicidal drowning. J Forensic Sci 1993; 38(6):1422-6.
33. Auer A. Suicide by drowning in Uusimaa province in southern Finland. Med Sci Law 1990; 30(2):175-9.