Demographic Factors and Their Association with Outcomes in Pediatric Submersion Injury

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Abstract

Objectives: To describe the epidemiology and outcomes of serious pediatric submersion injuries and to identify factors associated with an increased risk of death or chronic disability.

Methods: A retrospective database review of 1994–2000 Massachusetts death and hospital discharge data characterized demographic factors; International Classification of Diseases, Ninth Revision (ICD-9), Clinical Modification (ICD-9-CM), or ICD-10 injury codes; and outcomes for state residents 0–19 years of age identified with unintentional submersion injuries. The authors performed logistic regression analysis to correlate outcomes with risk and demographic factors.

Results: The database included 267 cases of serious submersion injury, defined as those requiring hospitalization or leading to death. Of these 267 patients, 125 (47%) drowned, 118 (44%) were discharged home, 13 (5%) were discharged home with intravenous therapy or with availability of a home health aide, and 11 (4%) were discharged to an intermediate care/chronic care facility. The authors observed a trend of improved outcome in successively younger age groups ($p < 0.0001$). The multivariable logistic regression analysis showed an increased likelihood of poor outcome for males compared with females (odds ratio [OR]: 2.52; 95% confidence interval [95% CI] = 1.31 to 4.84) and for African Americans compared with whites (OR: 3.47; 95% CI = 1.24 to 9.75), and a decreased likelihood of poor outcome for Hispanics compared with whites (OR: 0.056; 95% CI = 0.013 to 0.24).

Conclusions: After serious pediatric submersion injuries, the overall outcome appears largely bimodal, with children primarily discharged home or dying. The observations that better outcomes occurred among younger age groups, females, and Hispanic children, with worse outcomes in African American children, suggest that injury prevention for submersion injuries should consider differences in age, gender, and race/ethnicity.

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Submersion injury remains a significant cause of mortality and morbidity in the pediatric population. Drowning or death within 24 hours of submersion injury represents the second leading cause of death due to unintentional injury in children aged 0–19 years in the United States, with 1,158 pediatric deaths reported due to drowning in 2002.[1] In Massachusetts, drowning was the leading cause of injury mortality in children 1–4 years of age for the period from 1995 to 1999, accounting for 23.2% of injury deaths in that age group.[2]

Remarkably little is known about the true incidence of near-drowning or survival after submersion, because of limitations in data sources reporting on children who may be evaluated after a submersion incident but not admitted to a hospital. A study by Wintemute reported 2,122 childhood drownings in the United States in 1986 and estimated an additional 7,745 hospitalizations and 30,980 emergency department (ED) visits for submersion

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injuries.[3] Reported ratios of drowning to near-drowning vary, with different definitions and age groups used in the various calculations making comparisons a challenge.[4]

The outcome after submersion generally appears bimodal, with the majority of children surviving with good neurologic outcomes; however, those requiring aggressive resuscitation often have a poor prognosis, such as death or permanent neurologic damage.[3,5] These children may be left in a permanent vegetative state from the anoxic brain injury, achieving cardiorespiratory stability without the return of higher-level brain function. They may require institutional care or home nursing care.[3] An estimated 11% of those who have a submersion injury survive with severe neurologic damage.[6] Previous studies on outcome in submersion injury have focused on predictive factors determined in the field, in the ED, or in the intensive care unit.[7–13] In addition, many regional studies and a few national studies have focused on the epidemiology of either drowning or near-drowning.[4,14–16] However, since limited data sources exist, to the best of our knowledge, no studies to date have reviewed the epidemiology and disposition combining both populations on a statewide or nationwide level.

This study sought to use statewide data to describe the epidemiology and outcomes of serious submersion injury, including both drowning and near-drowning. Our objective was to identify factors associated with an increased risk of chronic disability or death. Determining demographic characteristics of those at increased risk for chronic disability or death after submersion may aid in focusing future prevention efforts.

METHODS

Study Design

This study was a retrospective case series using the 1994–2000 Massachusetts electronic death database from the Department of Public Health Registry of Vital Records and Statistics and the Massachusetts Hospital Discharge Database administered by the Massachusetts Division of Health Care Finance and Policy (DHCFP). All nonfederal acute care hospitals in Massachusetts are mandated to submit discharge data to the DHCFP. The Committee on Clinical Investigations approved the study protocol.

Study Setting and Population

We ascertained cases of unintentional submersion injuries from the 1994–1998 Massachusetts death data and all years of the DHCFP hospital discharge data using the International Classification of Diseases, 9th Revision (ICD-9) and the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes, respectively. Specific cases were classified as unintentional submersion injuries using the ICD-9/ICD-9-CM diagnosis code 994.1 (drowning and nonfatal submersion) or E-codes. For the 1999–2000 death data, we used the International Classification of Diseases, 10th Revision (ICD-10) E-codes for case ascertainment of unintentional submersion injury. We further identified Massachusetts residents between the ages of 0 and 19 years from their residential zip code and age information.

Study Protocol

We initiated a process of de-duplication between cases from the hospital discharge database and the death database. First, the cases were matched by age and discharge date/date of death, and then they were matched by at least two of the following three criteria: date of birth, gender, and zip code of residence. In the process of de-duplication, we identified 27 cases in the hospital discharge database that matched cases in the death database. We also identified three deaths in the hospital discharge database that did not appear in the death database, and these cases were included as deaths in the study. One child in the hospital discharge database had three separate admissions; only the first admission was included for this study.

Measures

The E-codes were grouped by nature of the submersion for data analysis. The following codes were used for classification of the 1994–2000 hospital discharge data (ICD-9-CM codes) and the 1994–1998 death data (ICD-9 codes): bathtub (E910.4), pool/other (E910.8), water sports (E830, E832, E910.0–910.2, and E910.3), and unspecified (E910.9). For the 1999–2000 death data, the following ICD-10 codes were used: bathtub (W65 and W66), pool/other (W67, W68, W69, W70, and W73), water sports (V90 and V92), and unspecified (W74).[17–19] Disposition outcomes of the hospitalized submersion cases were obtained from the DHCFP hospital discharge data. From this information, together with the death data, the outcomes of the submersion cases were characterized into four categories: 1) discharged home from the hospital without further care, 2) discharged home with intravenous (IV) therapy or with availability of a home health aide, 3) discharged to intermediate care/skilled nursing/rehabilitation facility, and 4) death.

Data Analysis

We calculated univariate statistics for age group, gender, race/ethnicity, season, and cause or type of submersion injury, and the proportional distributions of the outcome by the above variables. We performed chi-square analysis to examine the unadjusted associations between outcome and the above variables and to evaluate the trend effect of age group on outcome. Multivariable logistic regression was used to analyze the independent effects of age group, gender, race/ethnicity, submersion type, and season on poor outcome, which was defined as death or chronic disability. We performed all of the data analysis using SAS, version 8.02 (SAS Institute, Cary, NC).

RESULTS

Characteristics of the Study Subjects

From 1994 to 2000, a total of 267 serious submersion injuries requiring hospital admission or resulting in death occurred in Massachusetts residents aged 0–19 years (Figure 1). There were 125 (47%) children who drowned and 142 (53%) who were admitted and survived to discharge. Children aged 1–4 years composed the largest age group of submersion cases (35%). As shown in Table 1, the data included similar numbers among the 5–10-year-old age group (22%) and the 15–19-year-old

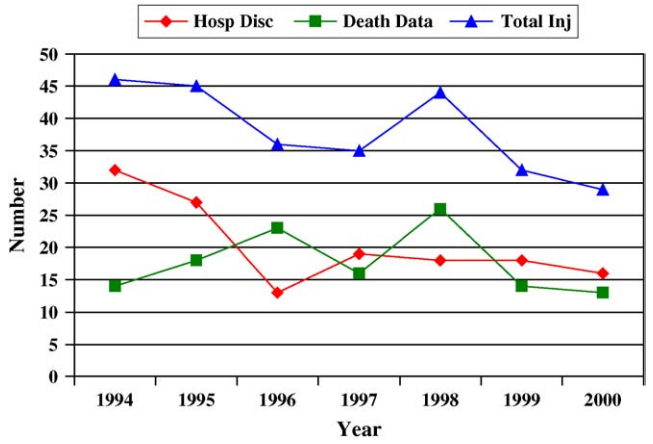

Figure 1. Massachusetts submersion injuries among children 0 to 19 years of age, from 1994 to 2000. Disc = discharge; Inj = injuries. Based on data obtained from the Registry of Vital Records and Statistics, Massachusetts Department of Public Health; and the Massachusetts Hospital Discharge Database, Massachusetts Division of Health Care Finance and Policy.

age group (21%). Twice as many males (67%) as females (33%) experienced serious submersion injuries. Consistent with the racial/ethnic distribution in Massachusetts where the African American and Hispanic populations compose approximately 7% and 8.1% of the population, respectively, white children accounted for the majority of cases (60%), with about equal numbers of African American (12%) and Hispanic (10%) children (Table 1).[20]

Overall, we found that 50% of the injuries were classified as submersion occurring in a swimming pool or other non-bathtub site, 16% were related to water sports, and 13% involved the bathtub. Twenty-one percent were coded as unspecified or unknown. Water sports accounted for 4.5% with poor outcomes, bathtub incidents accounted for 3%, and swimming pool/other incidents accounted for 26.6%.

We observed the bimodal distribution previously reported,[3,21] with 118 (44%) being discharged home and 125 (47%) dying. Those discharged home with IV therapy or with availability of a home health aide, or discharged to a facility for continuing care, constituted much smaller numbers (Figure 2). The subjects discharged to chronic care facilities primarily suffered neurologic and pulmonary complications, including aspiration pneumonia and acute respiratory distress syndrome (ARDS), based on ICD codes. Eight had diagnoses of coma, encephalopathy, persistent vegetative state, or anoxic brain damage.

We used the chi-square test for trend to examine the impact of age group on outcome. Given the small number of patients discharged home with further care or to chronic care facilities, we dichotomized the outcomes into "good" (i.e., discharge home with or without IV

Table 1
Multivariable Analysis for Increased Odds of Poor Outcome* vs. Good Outcome, Massachusetts Residents, 0–19 Years of Age, 1994–2000

Variable	Number (%)	Univariate Test % Poor Outcome	Univariate Test p-value	Adjusted OR (95% CI)
Age group		(% within age group)		
<1 year	25 (9)	32	<0.0001	0.30 (0.069–1.34)
1–4 years	93 (35)	40		0.16 (0.061–0.43)
5–10 years	60 (22)	43		0.12 (0.045–0.34)
11–14 years	32 (12)	56		0.35 (0.11–1.1)
15–19 years†	57 (21)	82		(1.0)
Gender				
Female†	89 (33)	12.7	<0.003	(1.0)
Male	178 (67)	38.2		2.52 (1.31–4.84)
Race/ethnicity				
White†	159 (60)	34.5	<0.0001	(1.0)
African American	32 (12)	9.4		3.47 (1.24–9.75)
Hispanic	28 (10)	1.1		0.056 (0.013–0.24)
Other/unknown	48 (18)	6.0		0.39 (0.18–0.84)
Season				
Winter (Jan–Mar)	27 (10)	5.2	0.57	3.19 (1.0—10.11)
Spring (Apr–Jun)	39 (15)	7.1		1.41 (0.6–3.32)
Summer (Jul–Sept)†	174 (65)	32.6		(1.0)
Fall (Oct–Dec)	27 (10)	6.0		2.45 (0.79–7.57)
Nature of submersion				
Water sport	42 (16)	4.5	<0.009	0.21 (0.082–0.54)
Bathtub	35 (13)	3		0.16 (0.046–0.53)
Pool/other†	133 (50)	26.6		(1.0)
Unspecified	57 (21)	12.7		1.46 (0.54–3.99)

OR = odds ratio.
Based on data obtained from: Registry of Vital Records and Statistics, Massachusetts Department of Public Health; and Massachusetts Hospital Discharge Database, Massachusetts Division of Health Care Finance and Policy.
* "Poor outcome": discharged to a chronic care facility, or death. "Good outcome": discharged home, with or without intravenous therapy or access to a home health aide.
† Referent category.

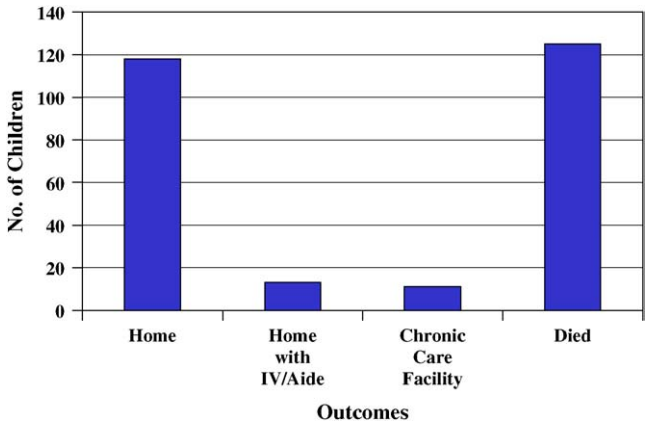

Figure 2. Distribution by outcomes, Massachusetts submersion injuries among children 0 to 19 years of age, from 1994 to 2000. IV/Aide = intravenous therapy/access to a home health aide. Based on data obtained from the Registry of Vital Records and Statistics, Massachusetts Department of Public Health; and the Massachusetts Hospital Discharge Database, Massachusetts Division of Health Care Finance and Policy.

therapy or availability of a home health aide) and "poor" (i.e., discharge to a chronic care facility or death). Figure 3 summarizes the outcomes we observed by age group. The trend analysis shows the increasing proportions of those with good outcomes as a function of decreasing age group ($p < 0.0001$) (Figure 3). In addition, chi-square analysis was performed for univariate analysis of the predictive factors of gender, race/ethnicity, season of the year, and nature of the submersion (Table 1).

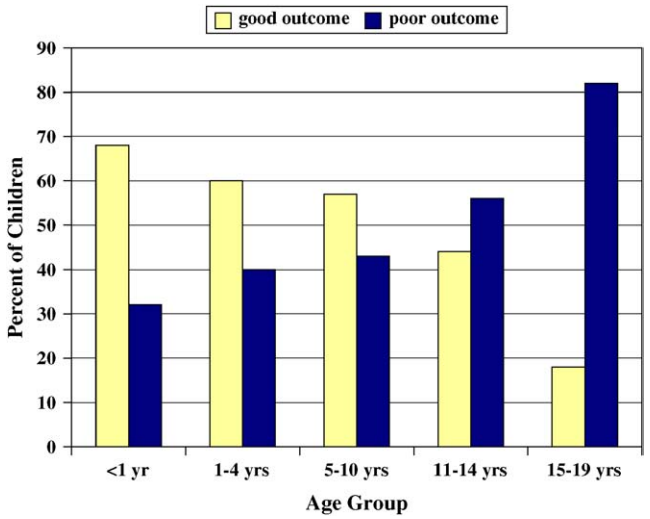

Figure 3. Age group and outcome (by percentage), Massachusetts submersion injuries among children 0 to 19 years of age, 1994 to 2000. Good outcome = discharged home, with or without intravenous therapy or access to a home health aide; poor outcome = discharged to a chronic care facility or death. Based on data obtained from the Registry of Vital Records and Statistics, Massachusetts Department of Public Health; and the Massachusetts Hospital Discharge Database, Massachusetts Division of Health Care Finance and Policy.

Logistic Regression Analysis

A multivariable logistic regression model was used to calculate adjusted odds ratios (ORs) for the association of poor outcome and the factors of age group, gender, race/ethnicity, season, and nature of the submersion. We found that the males experienced 2.52 (95% confidence interval [95% CI] = 1.31 to 4.84) times worse outcomes than the females. In considering race/ethnicity, the African American children ($n = 32$) experienced significantly worse outcomes than the white children ($n = 159$) (OR: 3.47; 95% CI = 1.24 to 9.75), while the Hispanic children ($n = 28$) experienced significantly better outcomes than the white children (OR: 0.056; 95% CI = 0.013 to 0.24). In comparing ICD-9/ICD-9-CM codes, we found that submersions related to water sports (OR: 0.21; 95% CI = 0.082 to 0.54) or bathtubs (OR: 0.16; 95% CI = 0.046 to 0.53) were associated with decreased odds of poor outcome compared with drownings in pools and other locations, but this could not be further specified because of the limitations of ICD coding. We did not find any significant seasonal differences in risk of death or chronic disability, using summer as the reference category (Table 1).

DISCUSSION

Submersion injury generally results in the outcomes of either normal survival or death, with a smaller number of children surviving with chronic conditions, including in a persistent vegetative state. Previous studies on outcome have primarily focused on investigating predictive factors. Quan and Kinder found that submersion duration and resuscitation duration (<10 minutes) were the best field predictors of outcome in a study of submersion victims in King County, Washington, treated by emergency medical services (EMS).[12] Demographic (age and gender), incident-related, clinical, and treatment variables were analyzed for predictors of outcome in a study by Graf et al.; they developed a prediction rule including comatose state, lack of pupillary light reflex, gender, and initial blood glucose level.[8] More recently, a study by Christensen et al. evaluating the utility of potential predictive factors and scoring systems to determine outcome concluded that individual outcome cannot be accurately predicted in the acute setting.[22]

To the best of our knowledge, this is the first statewide study about the distribution of outcomes and their association with demographic factors for pediatric submersion injuries requiring hospitalization and/or leading to death. Statewide data about outcomes can help to inform locally directed injury prevention efforts. From our study, the average annual death rate of pediatric submersion injury was 2.3 per 100,000. This compares with the pediatric death rates of 4.6 per 100,000 for motor vehicle injuries, 0.4 per 100,000 for fires/burns, and 0.16 per 100,000 for falls.[2] When considering injuries requiring hospitalization, we calculated an average annual rate of 1 per 100,000 for submersion injuries, compared with the rates of 50.6 per 100,000 for motor vehicle injuries and 84.7 per 100,000 for falls.[2]

Quan et al. studied ten years of pediatric drownings and near-drownings in King County, Washington, and found that preschool-aged children and males were at

greatest risk for submersion injuries.[21] We have built on these observations by analyzing race/ethnicity as well as gender and age and their association with outcomes in pediatric submersion injury.

We observed the same bimodal distribution of outcomes reported by others with nearly equal numbers of children discharged home or dying. Only 11 (4.1%) children were discharged to a chronic care facility with neurologic or pulmonary complications. We found a significant trend of increasing proportions of children with worse outcome with advancing age group. This may reflect less supervision of the older children, which in turn may lead to longer submersion times and delayed resuscitation. Inadequate supervision has been identified as an important factor associated with submersion incidents, and higher case fatality rates have been observed when victims were with their peers.[21] Longer submersion time, especially greater than 10 to 25 minutes, represents a well-recognized risk factor for poor outcome (death or severe neurologic impairment).[11] One study has also demonstrated that immediate resuscitation is associated with good outcome, defined by others as neurologically normal or mild anoxic encephalopathy.[23] For example, a toddler may suffer a submersion event when he wanders into the swimming pool when there is a lapse in adult supervision; however, caregivers probably notice his absence sooner and subsequent resuscitation is provided more quickly than for a teenager who submerges at a lake with her friends. Risk-taking behavior in adolescents may further contribute to their higher rates of poor outcome. This includes exposure to water or water sports while under the influence of alcohol or illicit drugs, which increases the risk of sustaining a submersion injury.[16,24]

The observation that Hispanic children are less likely to experience a poor outcome may reflect supervision, since 16 of 28 (57%) of Hispanic children were less than 5 years of age compared with four of 32 (13%) of African American children who were less than 5 years of age. When considering drowning alone, Warneke and Cooper found higher rates of drowning in Hispanic children compared with white children in Texas.[15] A California near-drowning study by Ellis and Trent did not find a statistically significant difference in near-drowning rates by race or ethnicity, including Hispanics.[4] These differences need to be further explored by considering age, gender, and site of submersion in conjunction with race/ethnicity. Studies are needed to determine whether factors such as differences in swimming ability, access to health care, or the safety of specific settings such as public pools play a role in the racial disparities noted.[25] Future studies should also explore any interactions between key demographic variables and any cultural influences that may impact the risk of submersion injuries and their outcomes.

Consistent with prior studies on drowning[15,25,26] and near-drowning and hospitalization,[4,21] males and African American children had increased odds of a poor outcome. Greater prevention efforts, including swimming lessons, should continue to be focused on these at-risk children and teenagers. Additional injury prevention efforts for children in the older age groups include increasing teen awareness of the risk of drowning and the consequences of near-drowning. High-school students should be encouraged to learn swimming and cardiopulmonary resuscitation. Parents must further remain vigilant about drowning prevention and the greater risk of poor outcome in adolescents.

LIMITATIONS

Several limitations have an impact on this study. First, our results depend on the quality of the information contained in the databases, and some possibility exists that cases were not identified or that duplicate cases remained despite our efforts to eliminate them. As a retrospective review, we were limited to the data contained in the database and were unable to gather further situational or clinical information about the cases. In addition, this analysis included only submersion injuries severe enough to lead to hospitalization, and it excluded any cases of near-drowning in children seen in an outpatient clinic or in an ED and discharged home, or those not referred to a health care facility. Statewide ED data were not available at the time of this study; however, these data are now being collected. Future analysis of ED and outpatient data will provide insight and more reliable estimates about the incidence of those submersion events with no significant sequelae. Only then can the true distribution of submersion injury outcomes be determined. This study also assumed that the injury severity levels among the age groups of the hospitalized population were similar; however, clinical practice could be influenced by the child's age. For example, a younger child may be more likely to be hospitalized after submersion injury than an older child. Statewide ED data could also be used to examine this.

Another limitation is that ICD-9 and ICD-9-CM E-coding often lacks specific information about the type of body of water associated with the submersion and limits our ability to fully explore the relative risks associated with different injury sites that might lead to better site-related injury prevention efforts. As a result, comparison with other studies about sites of submersion and outcomes at these sites cannot be accurately evaluated. Specifically, the code E910.8 is for "other accidental drowning or submersion"; this represents a broad category including drowning in a quenching tank or swimming pool in addition to any submersion not specified as bathtub, water sport, or nonrecreational swimming and diving. Since 1999, ICD-10 codes, which provide more specific information for site of submersion injury, have been used in the Massachusetts electronic death database and were included in this study. Although ICD-10 codes are more specific for sites of submersion injury than ICD-9 E-codes, there are still some categories that could be further characterized. For example, the code W69 is for "drowning and submersion while in natural water, includes: lake, open sea, river, stream," which does not differentiate between coastline beaches and inland bodies of water. The ability to differentiate these events could aid in future studies evaluating submersion injury outcomes based on site of submersion, which may help in counseling clinicians and parents to site-specific dangers as well as focusing interventions.

CONCLUSIONS

In this study, younger children with serious submersion injuries demonstrated an improved trend for better outcome compared with adolescents, while Hispanic children demonstrated increased likelihood of better outcome compared with white children. Given the various risks associated with different demographic groups, prevention efforts for submersion injuries should consider strategies as a function of age, gender, and race/ethnicity.

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