

Descriptive Epidemiology of Pediatric Drowning Patients Presenting to a Large Southern US Children's Hospital

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Objectives: Drowning is the leading cause of death for children ages 1 to 4, and it is among the leading causes of death for children of all ages. National data show disparities in drowning risk for certain racial groups. This study aimed to describe characteristics of patients presenting after a drowning event to guide focused drowning prevention outreach efforts.

Methods: This was a retrospective chart review study designed to analyze the epidemiologic and demographic characteristics of drowning-related injuries and deaths that presented to a large, urban, southern US pediatric hospital from 2016 to 2019. All patients aged 0 to 19 years were identified using *International Classification of Diseases, Ninth Revision* and *Tenth Revision* codes for drowning or submersion injuries.

Results: One hundred sixty-two patients met the inclusion criteria for the study. Submersion injuries were most common in the 1- to 5-year-old age group. Fifty-eight percent of patients were male. The analysis of race showed that 65% of patients were White and 33% of patients were Black. Pools were the setting for 78% of drowning events. Fifty-four percent of patients received cardiopulmonary resuscitation. Sixty-four percent of patients required hospitalization after the injury.

Conclusions: Characteristics of drowning victims may vary significantly from national data, depending on the area involved. This finding highlights the need for assessing local data to better inform local outreach. Further research is necessary to understand why such variance exists. Drowning prevention education, tailored toward pool safety and preschool-age children, should be a focus of injury prevention efforts.

Key Words: demographic, drowning, pediatric

In the United States, drowning causes almost 4000 deaths annually.¹ Drowning, which is defined as “the process of experiencing respiratory impairment from submersion/immersion in liquid” by the World Health Organization, is an important cause of preventable injury and mortality.² Furthermore, drowning is among the top 5 causes of death in children in the United States and is the number 1 cause of injury-related death in children aged 1 to 4 years.^{2,3} The pediatric population is at higher risk for drowning than adults, given their curiosity and desire to explore their environment, which is developmentally not yet matched with caution or water-safety knowledge.⁴ Although drowning mortality rates in the United States have declined by 36% from 2000–2013 for patients younger than age 20 years, the drowning mortality rate is still higher than other high-income countries, including France, Germany, and Japan.⁴

The epidemiology of drowning events has historically shown certain groups being at higher risk for submersion injuries. As such, it is crucial that pediatric providers in all settings from primary care to the emergency department (ED) to the intensive care unit (ICU) recognize the patterns of drowning in their community and target interventions appropriately. Many previous studies have analyzed national data and describe substantial racial and ethnic disparities among drowning victims.^{2,5} This study aimed to describe the characteristics of patients presenting with submersion injuries to a large, urban, southern US children's hospital to compare local data with published national data. We hypothesized that our data would show similar trends seen in nationally representative samples. Given that prevention continues to be the mainstay of treatment, we hoped to detect

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Key Points

- Ages 1 to 5 and being male were associated with an increased risk of drowning.
- Characteristics of local drowning victims may vary significantly from national data.
- Drowning prevention efforts should be tailored to at-risk populations based on local and national information.

patterns in our data to identify high-risk groups that may benefit from focused interventions to reduce drowning rates.

Methods

This is a retrospective chart review study designed to analyze the epidemiology and demographic characteristics of drowning-related injuries that presented to Children's of Alabama in Birmingham, AL, from January 2016 to December 2019. Children's of Alabama is the only freestanding pediatric hospital in the state, the only pediatric extracorporeal membrane oxygenation center in the state, and is a Level 1 trauma center, caring for 70,000 patients in the ED annually. The study was reviewed and deemed exempt by the institutional review board of the University of Alabama at Birmingham. The medical records of all patients between the ages of 0 and 19 years presenting to the hospital with the diagnosis of drowning were reviewed. Patients were identified from hospital records using the *International Classification of Diseases, Ninth Revision* and *Tenth Revision* coding system. The dataset included patients who presented to the ED and patients who bypassed the ED as direct admissions to any location within the hospital, either as a transfer from another hospital or directly from the scene. Patients who died while in the ED or while admitted to the hospital were included.

Data were extracted from patients' electronic medical records. Demographic information including age, sex, race, ZIP code of residence, and type of insurance was included. Information also was collected to characterize the incident, including the date of incident, ZIP code of incident (if available), setting of the incident, and whether cardiopulmonary resuscitation (CPR) was administered at the scene and by whom. As the quality (and true necessity) of bystander CPR could vary based on level of training, patients who received CPR were further classified by whether the CPR was given at the scene by a professional, such as an emergency medical technician or healthcare worker, or a nonprofessional, such as a family member. Severity of the drowning incident was assessed by noting the patients' length of stay, whether they were admitted or discharged, the assigned Emergency Severity Index level of acuity upon arrival to the ED, need for intubation, medical interventions, and any relevant medical history. Descriptive analysis was performed, including means, frequencies, and proportions. We analyzed the frequency of drowning and relative risk related to age, sex, race, and ZIP code of residence. All of the analyses were conducted using SPSS software version 24.0 (IBM SPSS Statistics, Armonk, NY).

Results

A total of 167 charts were identified and reviewed. Five of these charts were excluded on chart review to result in a total of 162 patients who met the inclusion criteria for the study. The exclusions included one visit in which a child had a seizure while standing up in the water but was never submerged, two charts that were miscoded, one chart that was included twice with the same visit identification, and one visit in which a child was presenting for a reevaluation of the same complaint after a submersion event

(the original evaluation after the submersion event was included). The age distribution of the 162 patients who were analyzed is shown in Figure 1. Submersion injuries were most common in the 1- to 5-year-old age group (59%, $n = 95$, 95% confidence interval 51%–66%). Ninety-four (58%) patients were male and 68 (42%) were female. Race statistics reported at patient registration showed that 105 (65%) patients were White, 54 (33%) were Black, 2 (1%) were Asian, and 1 was of unknown race. When further analyzed, 60 (37%) patients were White males, 45 (28%) were White females, 32 (20%) were Black males, 22 (14%) were Black females, 1 (0.6%) was an Asian male, and 1 (0.6%) was an Asian female.

Of the 119 patients who were seen initially in the ED, the median (interquartile range) acuity using the Emergency Severity Index was 3 (interquartile range 1). Fifty-eight (49%) of the ED patients were discharged home and 1 (0.8%) died in the ED before admission. Including patients seen in the ED and 43 additional direct admissions who bypassed the ED, 103 (64%) patients were admitted to the hospital. Of these admissions, 24 (23%) were admitted to an acute care floor, 42 (41%) were admitted to the step-down unit, and 37 (36%) were admitted to the ICU. After admission, 94 (91%) were eventually discharged home and 9 (9%) died while admitted to the hospital. The average length of stay in either the ED alone, the ED and admission time, or time after direct admission was 45.6 hours.

Patients were further characterized by whether or not they received CPR: 87 (54%, 95% confidence interval 46%–62%) patients received CPR either at the scene or in the ED. Of those who received CPR, 64 (74%) received CPR by a nonprofessional bystander and 18 (21%) received CPR from a professional. (Five of the patients who received CPR did not have the CPR provider documented in sufficient detail to determine their CPR certification status.) Figure 2 shows the proportion of each disposition type in those cases in which CPR provider was known ($n = 82$). Of those who received CPR by a nonprofessional bystander, 5 (6%) died after admission. Of those who received CPR from a professional, 1 (1%) died in the ED and 2 (2%) died after admission.

Demographic data, including insurance type, were collected on each patient. Patient insurance providers included Medicaid,

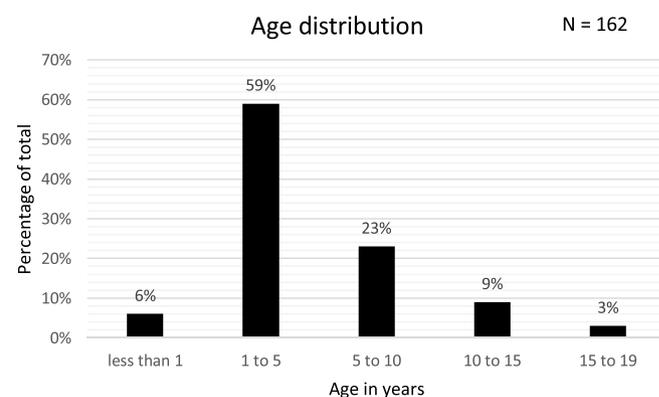


Fig. 1. Number of submersion injury patients by age group.

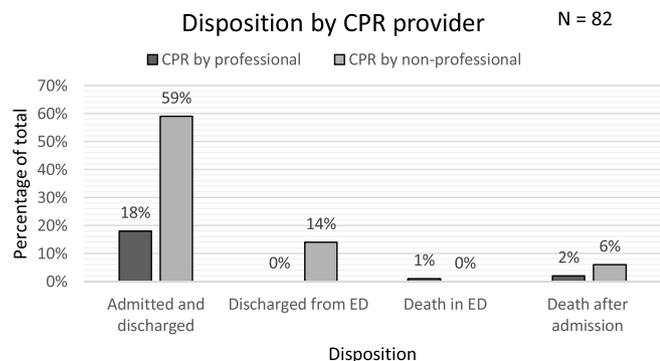


Fig. 2. Comparison of disposition of submersion injury patients who received cardiopulmonary resuscitation by a professional bystander versus a nonprofessional bystander. CPR, cardiopulmonary resuscitation; ED, emergency department.

BlueCross BlueShield, Viva Health, United, GEHA, Humana TRICARE, Patient First, Blue Cross/United, Medicaid/BlueCross, Cigna, Aetna, and self-pay. Insurance type was grouped into public insurance, private insurance, and self-pay categories for ease of analysis. Seventy-eight (48%) patients had publicly funded insurance, 77 (48%) patients had private insurance, and 7 (4%) patients were listed as self-pay.

The largest number of submersion injuries occurred during the month of June, with 42 patients (26%). July had 32 cases (20%) and May had 30 cases (19%). There were fewer cases during the cooler months of the year (Fig. 3).

Settings of the submersion injuries were grouped into pools, bathtubs, natural water sources, septic tanks, and unknown. Pools included private pools (in-ground and above-ground), public pools (hotels, apartment complexes, and city pools), and waterparks. Natural water sources included creeks, lakes, rivers, ponds, and springs. There were 126 (78%) drownings that occurred in pools, 21 (13%) that occurred in natural water sources, and 13 (8%) that occurred in bathtubs. There was 1 (1%) submersion injury that occurred in a septic tank and 1 (1%) case had an unknown or undocumented location.

Of the 126 submersion injuries that occurred in pools, 1 (1%) patient was younger than 1 year of age, 81 (64%) patients were 1 to 5 years of age, 32 (26%) patients were 5 to 10 years of age, 9 (7%) patients were 10 to 15 years of age, and 3 (2%) patients were 15 to 19 years of age. Of the 13 submersion injuries that occurred in bathtubs, 8 (61%) patients were younger than 1 year old, 3 (23%) patients were 1 to 5 years of age, 1 (8%) patient was 5 to 10 years of age, 1 (8%) patient was 10 to 15 years of age, and 0 patients were 15 to 19 years of age. Of the 21 submersion injuries that occurred in natural water sources, 0 patients were younger than 1 year of age, 9 (43%) patients were 1 to 5 years of age, 5 (24%) patients were 5 to 10 years of age, 5 (24%) patients were 10 to 15 years of age, and 2 (9%) patients were 15 to 19 years of age (Fig. 4).

The 10 patients who died, either in the ED or while admitted to the hospital, were further stratified by sex, race, setting, and age. Of those who died, 6 (60%) were male and 4 (40%) were female. Seven (70%) were White and 3 (30%) were Black. Seven (70%) were in a pool, 2 (20%) were in a bathtub, and 1 (10%) was in a natural water source. One (10%) was younger than 1 year of age, 7 (70%) were 1 to 5 years of age, 1 (10%) was 5 to 10 years of age, 1 (10%) was 10 to 15 years of age, and 0 were 15 to 19 years of age.

Discussion

Drowning is among the leading causes of injury death for children of all ages.⁶ Previous studies have looked at national trends in drowning events. We hypothesized that our data would show similar trends, but we found several key differences as well. This highlights the need for accurately assessing local data to effectively target at-risk populations. Nationally, submersion injury has the highest death rate in children aged 1 to 4 years old and is more common in males.^{7,8} The dataset in this study follows the national pattern for affected ages, with the majority of drowning deaths presenting to this hospital occurring in patients ages 1 to 5 (70%); however, children in this age group make up a disproportionate percentage of the deaths, as young children

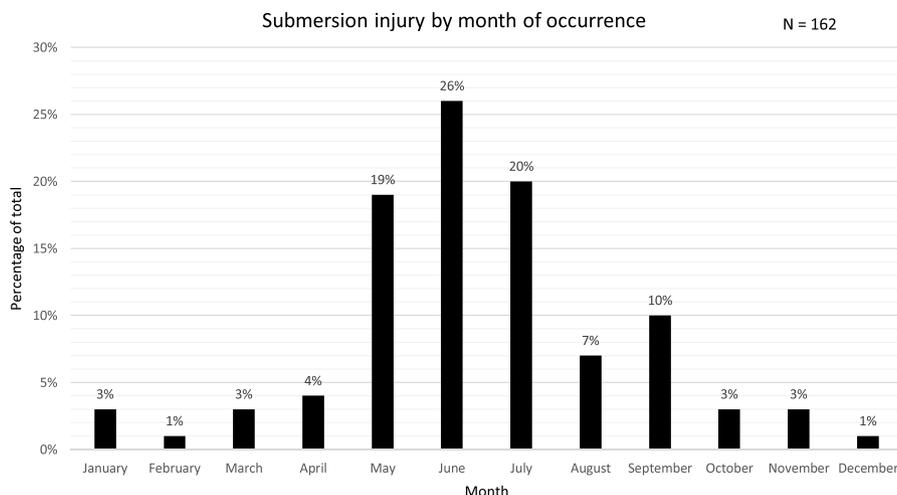


Fig. 3. Submersion injury cases by month of occurrence.

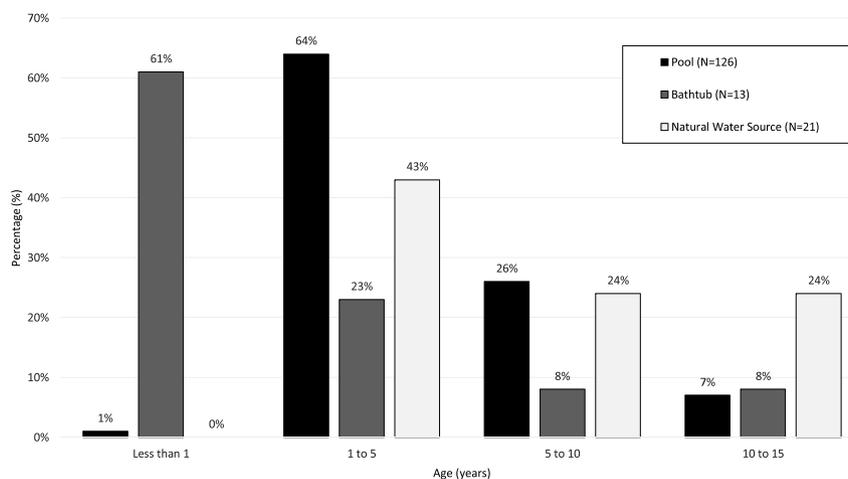


Fig. 4. Location of submersion injury cases by age group.

represented only 59% of the total number of recorded drowning cases. Again, agreeing with national data, the majority of the drowning victims in this study were male.

One key and unexpected difference between this study and national data was in relation to the racial distribution of submersion injuries. National data consistently show that Black children are at higher risk of drowning than their White peers, with drowning rates 5 to 10 times higher for Black children than for White children.^{9–12} Only 33% of drowning victims at this institution were Black, and Black children made up 30% of the drowning deaths. This difference is not explained by the racial makeup of the local population. According to US Census data, the city of Birmingham, Alabama, is 70% Black and 25% White.¹³ The data in this study more closely resemble the statewide racial makeup, which is 69% White and 27% Black¹³; however, even taking these demographics into account, the numbers still do not match national trends. The overall racial breakdown of the US population is 76% White and 13% Black, and drowning rates are still disproportionately higher in Black children.¹³ It is unlikely that Black children in this hospital's patient population would have lower exposure to water sources, as drowning can occur in any body of water, including household water sources such as bathtubs. Further research into parental attitudes surrounding drowning risk or participation in water activities may be beneficial to better understand the observed difference in drowning rates.

Early and effective bystander CPR has been shown to improve outcomes in drowning victims.^{8,14} In our study, more patients who received CPR from a professional died compared with those who received CPR from a nonprofessional (22% vs 8%). This likely speaks to the higher level of illness of those receiving professional CPR rather than to the quality of the CPR being performed. There was no way to determine through chart review how long a child may have been hypoxic, but a case could be made that the delay in receiving effective CPR while waiting for emergency medical services to arrive also may contribute to the increased mortality rate seen in those who received professional CPR.

The limitations of the study were primarily the result of the nature of a retrospective chart review. We initially set out to stratify the severity of drowning events by assessing Glasgow Coma Score both at the scene and on arrival to the hospital. This was abandoned, however, because of incomplete records and difficulty extrapolating from limited documentation. Also, because of inconsistent documentation, the ZIP code in which the incident occurred could not be obtained in the majority of cases. The ZIP code of residence listed in the chart was obtained instead as a proxy measure to be used when analyzing the data for drowning hot spots. In addition, patients were placed into groups by admission status (admitted, discharged, or expired) and admission location (ICU, step-down, or acute care floor) as a way to assess the severity of the event, but our study did not have a follow-up component or any review of charts other than the visit attached to the drowning incident to assess morbidity associated with submersion injury. Even in instances in which drowning does not result in death, there can be significant morbidity associated with severe drowning events.^{15–17} An additional limitation of the study was that although this hospital is the only pediatric Level 1 trauma center in Alabama and would be expected to take in the majority of local drownings and the majority of severe drownings within the hospital's catchment area, pediatric patients may have presented to other hospitals within the region. If the patients were not transferred to our hospital, then they would not have been included in our study, and therefore they may skew the data unintentionally.

Drowning prevention is of paramount importance and is the ultimate motivation for understanding drowning injury data. The use of barriers such as proper pool fencing and education about the importance of close supervision can improve safety behaviors.^{14,18,19} Swim lessons can improve swimming ability and water safety skills, and although ensuring equitable access to swim lessons is an important goal for improving public health, swim lesson participation is not a guaranteed way to prevent drowning.²⁰ Previous data on swim lessons are mixed. A

case-control study published in 2009 showed an 88% risk reduction in 1- to 4-year-old children who participated in formal swim lessons but no statistically significant risk reduction in children ages 5 to 19 years.²¹ Swim lesson participation also did not correlate with observed ability in a study that compared child and parental survey responses with in-water swimming performance.²⁰ There have been studies that link positive parental attitudes toward swimming and self-reported parental swimming ability to increased child swimming ability.²² As such, targeting parents with information on water safety skills and adult swim lessons may have a downstream benefit of preventing pediatric drowning events. Even elite athletes are at risk for drowning, particularly with intentional hyperventilation, breath holding drills, and hypoxic training styles.²³ National data show significantly higher rates of drowning in Black children, and there is an inverse relationship between rates of fatal drowning and participation in competitive swimming.^{17,23,24} In areas that have increased rates of competitive swimming, particularly among Black males, there are decreased drowning rates.²³

Conclusions

Drowning is an important cause of morbidity and mortality in pediatrics. The variance from national trends in demographic characteristics highlights the need for assessing local data to better inform local outreach. Advocacy and policy efforts at the state and national levels require an understanding of national trends to ensure that all children are included, however. Future directions include using data collected on ZIP code of residence to identify high-risk geographic areas within the local metropolitan area and within the state that could benefit from focused drowning prevention outreach.

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