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Factors associated with pediatric drowning admissions and outcomes at a trauma center, 2010–2017

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ABSTRACT

Background: Drowning is a leading cause of preventable mortality and morbidity in children. Its high fatality rate and frequent severe sequelae (e.g. brain damage and permanent loss of functioning) place a premium on preventive efforts.
Methods: A retrospective analysis of patients ≤21 years of age admitted between 2010 and 2017 to a pediatric trauma center was conducted to identify factors associated with drowning admissions, fatal drowning, and severe outcome (ventilator use, ICU admission, or death). Outcomes were modeled and estimated by use of logistic regression and Poisson regression.
Results: Drowning accounted for 153/4931 (3.1%) trauma admissions between 2010 and 2017. The risk of death (13.1% vs. 1.5%, $p < .01$), and severe outcome (24.8% vs. 7.8%, $p < .01$) was significantly higher for drownings vs. other causes. All 20 drowning deaths occurred among children left unattended. In Poisson regression analysis, weekends, summer breaks, and hotter days were independently associated with a higher probability of drowning admissions. Additionally, in analyses excluding indicators of severity, the odds of severe outcome were higher for children age ≤ 2 years [adjusted odds ratio (AOR) = 3.88 95% CI (1.58, 9.53)], and injury downtime of >5 min or unknown length [AOR = 6.66 95% CI (2.74–16.15)]. Immediate intervention after the discovery was associated with ~70% lower odds of a severe outcome.
Conclusions: Drowning admissions were both more severe and more often fatal compared to other pediatric injury causes of admission. Enhanced and targeted educational messages for parents of young children, focused on prevention behaviors on high-risk days and immediate bystander intervention, may reduce the occurrence and severity of these tragic accidents.
Table of contents summary: A retrospective multi-year cohort study to identify modifiable factors associated with drowning admissions, severe complications, and death from a large trauma registry database.
What's known on this subject: Drowning is a leading cause of unintentional injury that results in severe morbidity and a high rate of mortality. Children are disproportionately affected by drowning and have a higher risk of long term sequelae and death.
What this study adds: This study identified high-risk populations and periods for drowning, the importance of supervision, and the effectiveness of immediate intervention in reducing unfavorable outcomes after drowning. It also highlights a need for heightened local intervention for drowning prevention.

1. Introduction

Drowning is a leading cause of preventable mortality and morbidity with disproportionately higher rates in children [1]. In the United States, every year an average of 3880 drowning deaths take place, while >5500 emergency department visits occur for non-fatal drowning [2]. About 60% of drowning incidents presenting at the emergency department are subsequently admitted to the hospital, which is significantly higher than admissions for other injuries [2-4]. Many survivors of drowning episodes may remain severely neurologically compromised, and this tragic type of injury occurs even after remarkably short submersion times [5]. Adult supervision, early swimming lessons, pool fencing, and pool covers are known to deter drowning incidents [6].

Because drownings continue to occur and can occur in small amounts of water and in very brief unattended periods of time, it is

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important to identify factors that are potentially modifiable, and similarly, factors and circumstances that may serve as the basis for additional targeted strategies and education about water safety. This includes not only factors related to individual children and their families, but also those at an environmental level which, heretofore, have received limited investigation.

The purpose of this study conducted at a large pediatric trauma center in Florida was two-fold: (1) To identify factors independently associated with drowning admissions when compared to all other cause of admissions; (2) To identify factors independently associated with fatal and severe outcomes following a drowning, including those measured at the individual/family level as well as the broader environmental level. Such information can then serve as a basis for a person and time-specific targeted training programs and education campaigns.

2. Methods

2.1. Data source and population

This study was an 8-year retrospective pediatric trauma registry review of all admissions (drowning and other injuries) conducted at the St. Joseph's Children's Hospital– Steinbrenner Emergency/Trauma Center in Tampa, FL, a Level II Trauma Center and a state-approved Pediatric Trauma *Referral* Center that has an annual ED census of nearly 45,000 patients. St. Joseph's Children's Hospital receives approximately 8231 patients each year by a specialized transport team, trained in neonatal and pediatric medicine, that travels 24/7 by dedicated ambulance, medical helicopter or fixed wing jet, to pick up newborns, infants and children under the age of 18 from sites of injury occurrence as well as from other hospitals in West-Central Florida. The study period included January 1, 2010, through December 31, 2017. This study was approved by Institutional Review Boards at BayCare Health System and University of South Florida. The pediatric trauma registrars abstracted patient data from the ED 24-hour report. This included identifying all admissions that were declared a trauma alert, anyone that went from the ED to the OR for a traumatic injury, and anyone admitted to the hospital with a traumatic injury. This record system also identified patients who were transferred in or out of the St. Joseph's facility for traumatic injuries. We included all patients aged 0 to 21 years, as this is the age range that is served by St. Joseph's Children's Hospital. We searched the pediatric trauma registry database for potential subjects whose primary cause of admission listed on the electronic medical record was drowning, or separately, all other causes.

In addition, for this analysis, aggregate level supplemental data for socioeconomic indicators were derived from the American Community Survey (ACS, 2012–2016 ACS 5 year data profile) which were available at the zip code level for patient residence and merged into the primary trauma registry database [7]. To facilitate identification of environmental factors (e.g. temperature changes) potentially associated with drowning admissions, daily climate data (2010–2017) for the Tampa Bay region were obtained from the Global Histological Climatology Network (GHCN) database maintained by National Oceanic and Atmospheric Administration (NOAA). These data were merged into the registry database by date of patient admission [8].

The pediatric trauma registry database was reviewed abstracted by trauma registry personnel and verified by the registry personnel and the lead investigator. The following elements were exported from the database onto a structured data collection forum: socio-demographic variables, information on type and circumstances of patient transport, details on nature and severity of injury, presence or absence of interventions prior to transport to the hospital, procedures performed while in the hospital, complications, and discharge status. The registry was also reviewed by two other investigators to ensure consistency and completeness in data abstraction.

Once exported, we sought to identify factors independently associated with: (i) drowning admission versus admissions for other types of injuries, and among drowning admissions only, (ii) fatal versus non-fatal or severe versus non-severe outcomes. Detailed text descriptions of all drowning admissions were manually reviewed and interpreted from the trauma registry electronic medical record system by two independent reviewers to identify presence of adult supervision, submersion time (drowning downtime) and immediate intervention following drowning. Injury Severity Score was calculated for patients using their Abbreviated Injury Scales (AIS) values at the time of admission [9,10].

An admission was determined to be due to drowning if drowning was the primary cause of admission listed on the electronic medical record. Fatal outcome was defined as death following the trauma admission. A severe outcome was defined as a composite endpoint of death, Intensive Care Unit (ICU) stay of 2 or more days, or ventilator assistance.

2.2. Statistical methods

Descriptive statistics for demographics, socioeconomic variables, indicators of clinical severity, and patient outcomes are presented as mean (SD) for continuous variables and counts (percentages) for categorical variables. To initially evaluate factors associated with admission for drowning versus all other causes, continuous variables were compared between the two groups by use of Student's *t*-tests or Wilcoxon tests (depending on distributional properties); categorical variables were compared by use of chi-squared tests or Fisher's exact test, as applicable. Forward stepwise logistic regression modeling was used to identify factors (demographic, socioeconomic, clinical severity and patient outcomes) independently associated with admission for drowning versus all other causes of trauma admission. Results are presented as adjusted odds ratios (AOR) and corresponding 95% confidence intervals (95% CI). A separate analysis conducted by use of Poisson regression was restricted to only days in which there was at least one hospital admission, with calendar and meteorological factors examined in relation to the number of admissions on a given day for drowning versus the number of admissions for all causes. Results of this model are presented as adjusted prevalence ratios (APR) and corresponding 95% confidence intervals. The univariate and logistic regression methods described above were also used for the analysis of fatal versus non-fatal or severe versus non-severe outcomes. Key to all analyses was the aim of identifying potentially modifiable factors for future prevention of morbid and fatal outcomes. Statistical significance was defined as a *p*-value of $<.05$. All analyses were conducted using the SAS System (Version 9.4, SAS Institute Inc., Cary, NC).

3. Results

3.1. Drowning admissions

A total of 4931 trauma admissions occurred between the years 2010–2017, of which, 153 (3.1%) were for drowning as the primary cause. Of the 153 drownings, 85.6% occurred in pools, 6.5% in oceans, 4.6% in lakes or rivers, and 3.3% occurred in bathtubs. Most drownings (77.8%) occurred among children left unattended, even if for just a brief period. Of the 153 patients admitted for drowning, 65.4% were male and 35.6% were female. The majority of children were white (63.1%) and non-Hispanic (97.0%). (Table 1).

3.2. Factors associated with drowning as primary cause of admission

Patients admitted for drowning were younger (4.0 vs. 9.0, $P < .001$) and had a higher mean injury severity score (12.1 vs. 5.9, $P < .001$), compared to trauma registry admissions for other causes. For this large trauma center, the proportion of all admissions attributed to drowning increased over the 8-year time period representing 1.6% of admissions in 2010–11, 2.7% of admissions in 2012–2013, 4.1% of admissions in 2014–2015, and 3.6% of admissions in 2016–2017 ($P = .001$, test of

Table 1
Factors univariately associated with admission for drowning vs. other admission causes.

Factor	Drowning (n = 153, 3.1%)	Other cause (n = 4778, 97.9%)	P
Age in years, mean (SD)	4.0 (3.2)	9.0 (5.8)	<0.001
Gender, n (%)			0.61
Male	100 (65.4)	3025 (63.3)	
Female	53 (34.6)	1753 (36.7)	
Race, n (%)[a]			0.90
Non-white	57 (37.3)	1754 (36.8)	
White	96 (62.7)	3015 (63.2)	
Ethnicity, n (%)[a]			0.001
Non-Hispanic	148 (96.7)	4191 (88.0)	
Hispanic	5 (3.3)	570 (12.0)	
City of residence, n (%)[a]			0.42
Tampa	53 (34.9)	1815 (38.1)	
Other	99 (65.1)	2953 (61.9)	
County of residence, n (%)			0.09
Hillsborough and adjacent counties	130 (85.0)	3899 (81.6)	
Counties not adjacent to Hillsborough	15 (9.8)	364 (7.6)	
Not reported	8 (5.2)	515 (10.8)	
Zip-median household income (past 12 mo.), mean (SD)	49,057 (20146)	49,658 (17677)	0.72
Zip-Pct. with income to poverty ratio < 1, mean (SD)	12.6 (7.4)	13.1 (7.7)	0.42
Zip-unemployment rate (age ≥ 16), mean (SD)	9.2 (3.5)	8.9 (3.3)	0.31
Year of admission, n (%)[b]			0.001
2010–2011	18 (11.8)	1074 (22.5)	
2012–2013	31 (20.3)	1103 (23.1)	
2014–2015	53 (34.6)	1237 (25.9)	
2016–2017	51 (33.3)	1364 (28.5)	
Hour of hospital admission, n (%)			0.001
Midnight to 5:59 AM	10 (6.5)	742 (15.5)	
6:00 AM to 11:59 AM	7 (4.6)	458 (9.6)	
12:00 PM to 5:59 PM	55 (36.0)	1448 (30.3)	
6:00 PM to 11:59 PM	81 (52.9)	2130 (44.6)	
Health insurance, n (%)			<0.001
Medicaid	95 (62.1)	2266 (47.4)	
Self-pay	20 (13.1)	253 (5.3)	
Private	31 (20.2)	1377 (28.8)	
Other insurance	7 (4.6)	882 (18.5)	
Injury severity score (ISS), mean (SD)	12.1 (8.5)	5.9 (6.0)	<0.001
Service patient admitted to, n (%)[a]			
Pediatric	88 (58.3)	2236 (49.4)	<0.001
Pediatric intensivist	57 (37.7)	330 (7.3)	
Pediatric trauma	4 (2.7)	630 (13.9)	
Others	2 (1.3)	1328 (29.4)	
Mode of transport to hospital, n (%)[a]			<0.001
Ambulance	90 (58.8)	3270 (68.4)	
Privately owned vehicle	13 (8.5)	1026 (21.5)	
Helicopter	50 (32.7)	473 (9.9)	
Police	0 (0)	8 (0.2)	
Documented complication, n (%)[c]			0.004
No	142 (92.8)	4650 (97.3)	
Yes	11 (7.2)	128 (2.7)	
Death, n (%)			<0.001
No	133 (86.9)	4706 (98.5)	
Yes	20 (13.1)	72 (1.5)	
Severe outcome (ICU ≥ 2 days, ventilator, death), n (%)			<0.001
No	115 (75.2)	4407 (92.2)	
Yes	38 (24.8)	371 (7.8)	

[a] Missing values: Race: 9 (<0.1%), Ethnicity: 11 (<0.1%), City of Residence: 11 (<0.1%), Mode of Transport: 1 (<0.1%), Service Patient Admitted to: 256 (5.2%). p-Values are derived using χ^2 test and Fisher's exact test for categorical variable and t-test or Wilcoxon test for continuous variables.
[b] p-Value derived using χ^2 test of trend.
[c] Documented complications include - respiratory trauma, extubation, pneumonia, pressure ulcer, cardiac arrest etc.

trend). Children admitted for drowning as compared to admissions for all other causes were significantly more likely to have a fatal outcome (13.1% vs. 1.5%, $P < .001$) or severe outcome defined as death, ICU stay ≥2 days, or ventilator assistance (24.8% vs. 7.8%, $P < .001$, Table 1).

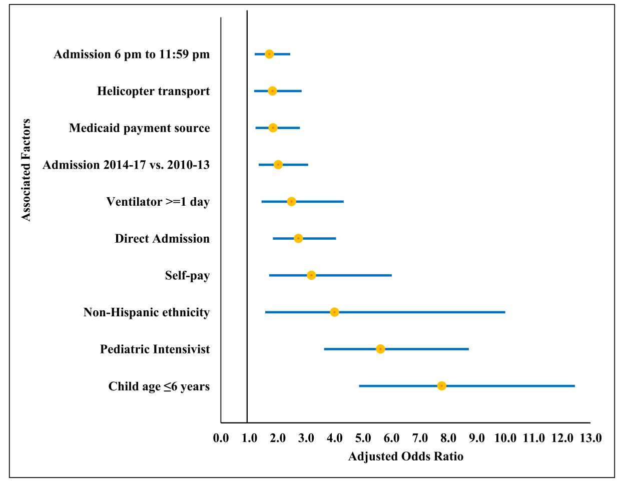

Fig. 1. Multivariable logistic regression model of factors associated with drowning vs. other admission causes (n = 4651). The filled circles represent adjusted odds ratios; the left and right ends of the horizontal lines depict the lower and upper limits of 95% confidence intervals, respectively.

In logistic regression analysis (Fig. 1), demographic factors independently associated with admission for drowning included child age ≤ 6 years (AOR = 7.77, 95% CI: 4.85, 12.45), Medicaid payment (AOR = 1.84, 95% CI: 1.22, 2.78), self-pay (AOR = 3.19, 95% CI: 1.70, 6.01) and Non-Hispanic ethnicity (AOR = 4.0, 95% CI: 1.56, 10.0). Indicators of clinical severity independently associated with admission for drowning included helicopter transport (AOR = 1.82, 95% CI: 1.17, 2.84), admission service to a pediatric intensivist (AOR = 5.62, 95% CI: 3.63, 8.72) and ventilator use for more than one day (AOR = 2.49, 95% CI: 1.43, 4.32). Drowning admissions to the trauma center occurred mostly during the months of May (19.7%) to August (8.8%) and showed significantly different monthly percentage of admissions as compared to admissions from other causes ($p < .001$) (Fig. 2). In Poisson regression analysis (Table 2), drowning admissions were more prevalent on the weekends (APR = 1.91 95% CI: 1.39–2.62), during summer breaks (APR = 2.16, 95% CI: 1.41–3.52), and on days with substantially higher average daily temperatures compared to the previous day (10 °F increase in average daily temperature: APR = 1.34 95% CI: 1.01–1.78).

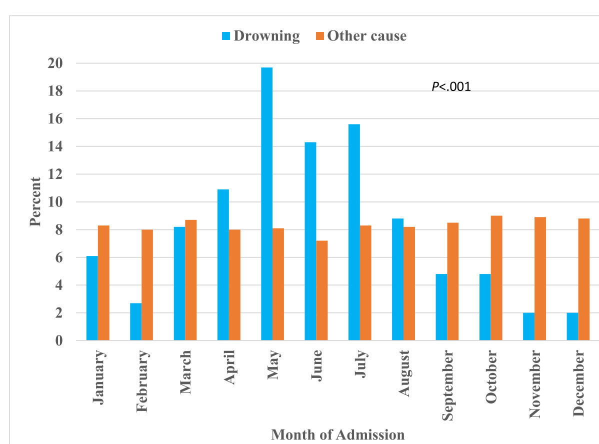

Fig. 2. Drowning admissions (blue columns) compared to admissions from all other causes (orange columns) by the month of admission to the pediatric trauma center. Monthly results are presented as percentage of all admissions during the year. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Multivariable Poisson regression model of selected environmental and calendar factors associated with daily drowning admissions ($n = 2305$).

Factors	Prevalence Ratio	95% Confidence interval	P
Summer break (yes vs. no)	2.16	1.41, 3.32	<0.001
Weekend (yes vs. no)	1.91	1.39, 2.62	<0.001
10 F increase in average temperature	1.34	1.01, 1.78	0.041

3.3. Fatal and severe drowning outcomes

Twenty children died from drowning, representing a case fatality rate of 13.1%. All 20 deaths occurred among children left unattended (Table 3). As seen in Fig. 3, among pool drownings ($n = 131$), 86 (65.6%) occurred in private pools and the remaining 45 (34.4%) occurred in non-private pools (public, community, or apartment complex pool). Compared to non-private pools, drownings that occurred in private pools were more likely to be unattended at the time of drowning (87.2% vs. 60.0%, $P = .004$), have injury downtime of >5 min or unknown length (51.2% vs. 24.4%, $P = .003$), yet have immediate intervention after discovery (69.8% vs. 51.1%, $P = .04$). Of the 20 fatal drownings, 6 (30.0%) ultimately resulted in organ donations.

Table 3 provides the comparison of demographic factors, socioeconomic factors, indicators of clinical severity and other factors by fatal drowning versus non-fatal drownings. Comparing indicators of clinical severity, children with fatal drownings (vs. non-fatal) were more likely transferred from another hospital (50.0% vs 25.6%, $P = .02$), transported by helicopter (70.0% vs. 27.1%, $P = .001$) and had higher mean injury severity score (31.2 vs. 9.4, $P < .001$). Immediate intervention by a parent or bystander (e.g. CPR, rescue breaths, back compressions etc.) occurred in 58.2% of all drowning admissions. Injury downtime of either >5 min or unknown length was associated with a higher rate of fatality (80.0% vs. 35.3%, $P < .001$) as well as severe outcome (71.1% vs. 31.3%, $P < .001$).

3.4. Multivariate analysis and models: factors associated with fatal and severe drowning outcomes

Multivariate analysis including and excluding indicators of severity of injury were performed (Table 4). Injury downtime of >5 min or unknown length was strongly associated with fatality (AOR = 3.52 95% CI: 1.10–12.35), along with helicopter transport, and admission to a pediatric intensivist. After excluding indicators of injury severity (e.g. helicopter transport, Table 4, Model 2), the odds of fatal drowning were higher for children ≤2 years (AOR = 3.72, 95% CI: 1.32–10.47) and those with injury downtime of >5 min or unknown length (AOR = 7.28 95% CI: 2.25–23.58). Parallel analyses (Table 4, Model 3) for factors independently associated with higher adjusted odds of severe outcome included age ≤ 2 years (AOR = 3.88, 95% CI: 1.58–9.53), and injury downtime of >5 min or unknown length (AOR = 6.66, 95% CI: 2.74–16.15). Immediate intervention after discovery (e.g. CPR, rescue breaths, back compressions) was associated with ~70% lower odds of severe outcome (AOR = 0.31 95% CI: 0.13–0.74).

4. Discussion

Although drownings represented just 3% of all admissions during the eight-year study period, they were associated with significantly higher rates of severe outcomes and mortality compared to other trauma registry admissions. The higher rates of transport by helicopter and admission to pediatric intensivist unit are an indication of the severity of drowning admissions compared to other types of injury. Even with optimal medical care, patients admitted for drowning are at higher risk of

Table 3
Factors univariately associated with fatal vs. non-fatal drowning admissions ($n = 153$).

Factor	Fatal ($n = 20$, 13.1%)	Non-fatal ($n = 133$, 87.7%)	P
Age in years, mean (SD)	2.7 (2.0)	4.1 (3.3)	0.009
Gender, n (%)			0.33
Male	15 (75.0)	85 (63.9)	
Female	5 (25.0)	48 (36.1)	
Race, n (%)			0.44
Non-white	9 (45.0)	48 (36.1)	
White	11 (55.0)	85 (63.9)	
Ethnicity, n (%)			1.0
Non-Hispanic	20 (100.0)	128 (96.2)	
Hispanic	0 (0.0)	5 (3.8)	
City of residence, n (%)[a]			0.32
Tampa	5 (25.0)	48 (36.4)	
Other	15 (75.0)	84 (63.6)	
County of residence, n (%)			0.38
Hillsborough and adjacent counties	17 (85.0)	113 (85.0)	
Counties not adjacent to Hillsborough	1 (5.0)	14 (10.5)	
Not reported	2 (10.0)	6 (4.5)	
Zip-median household income (past 12 mo.), mean (SD)	43,419 (11768)	49,951 (21068)	0.05
Zip-pct. with income to poverty ratio < 1, mean (SD)	14.3 (5.7)	12.3 (7.6)	0.28
Zip-unemployment rate (age ≥ 16), mean (SD)	10.4 (3.4)	9.0 (3.4)	0.10
Year of admission, n (%)[b]			0.98
2010–2011	2 (10.0)	16 (12.1)	
2012–2013	4 (20.0)	27 (20.3)	
2014–2015	8 (40.0)	45 (33.8)	
2016–2017	6 (30.0)	45 (33.8)	
Health insurance, n (%)			0.08
Medicaid	14 (70.0)	81 (60.9)	
Self-pay	5 (25.0)	15 (11.3)	
Private	1 (5.0)	30 (22.6)	
Other insurance	0 (0.0)	7 (5.2)	
Location of drowning, n (%)			0.01
Private pool	12 (60.0)	74 (56.6)	
Public, community or apartment complex pool	3 (15.0)	42 (31.6)	
Bath tub	3 (15.0)	2 (1.5)	
Lake or river	2 (10.0)	5 (3.8)	
Ocean	0 (0.0)	10 (7.5)	
Immediate intervention after discovery (CPR, rescue breaths, back compression etc.), n (%)			0.20
No	11 (55.0)	53 (39.8)	
Yes	9 (45.0)	80 (60.2)	
Injury downtime >5 min or not known, n (%)			<0.001
No	4 (20.0)	86 (64.7)	
Yes	16 (80.0)	47 (35.3)	
Unattended at the time of drowning, n (%)			0.008
No	0 (0.0)	34 (25.6)	
Yes	20 (100.0)	99 (74.4)	
Injury severity score (ISS), mean (SD)	31.2 (10.8)	9.4 (2.9)	<0.001
Mode of transport to hospital, n (%)			0.001
Ambulance	6 (30.0)	84 (63.2)	
Privately owned vehicle	0 (0.0)	13 (9.8)	
Helicopter	14 (70.0)	36 (27.1)	
Transferred from another hospital, n (%)			0.02
No	10 (50.0)	99 (74.4)	
Yes	10 (50.0)	34 (25.6)	
Service patient admitted to, N (%)[a]			<0.001
Pediatric	0 (0)	88 (66.2)	
Pediatric intensivist	15 (83.3)	42 (31.6)	
Pediatric trauma	2 (11.1)	2 (1.5)	
Others	1 (5.6)	1 (0.8)	
Documented complication, n (%)			<0.001
No	12 (60.0)	130 (97.7)	
Yes	8 (40.0)	3 (2.3)	

[a] Missing values: City of Residence: 1 (<0.1%). p-Values are derived using χ^2 test or Fisher's exact test for categorical variable and t-test or Wilcoxon test for continuous variables as applicable.
[b] p-Value derived using χ^2 test of trend.

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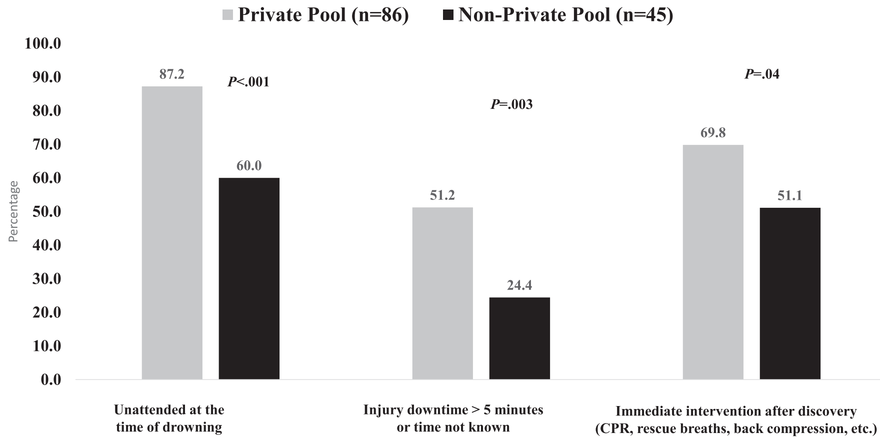

Fig. 3. Selected characteristic of drownings in private pools (gray shading) versus pools classified as non-private (public, community, or apartment complex pool) (black shading).

worse outcomes due to the nature of the injury and high rates of long-term complications due to cardiac arrest and brain injury [11-13].

The results of this study highlight the importance of primary and secondary prevention in reducing fatalities and severe outcomes associated with drowning injuries. In particular, all of the fatal drownings in our cohort were among unattended children. Our data are consistent with previous findings indicating that injury downtime of >5 min or unknown length is associated with higher risk of mortality [14]. Young children are at higher risk of drowning and fatality, and thus, should never be left unattended near water, including bath tubs for any period of time [1,2,15-18]. The American Academy of Pediatrics' report on drowning prevention emphasized the importance of continuous adult supervision in prevention of drowning incidents [19]. Not surprisingly, immediate intervention following discovery was shown to significantly reduce the risk of having a severe outcome. This is consistent with recommendations by CDC and findings from studies examining the impact of bystander CPR on drowning outcomes [20-22].

During the period 2010–2017, Florida was noted to be the one of the leading states for under age 19 drowning deaths with over 750 drowning deaths and death rate of 2.15 per 100,000 [23,24]. A small rise in the number of drowning deaths in the state over the past decade corresponds, at least indirectly, with overall population increase, as drowning deaths have remained stable over that period of time [25]. Although recent Florida Department of Health data reveals non-fatal drowning admission rates for ages 0–19 have decreased over the last few years, our trauma center saw an apparent increase in drowning admissions over the eight-year study period. [26] The reasons for this apparent increase are not clear, and may relate to referral patterns. In addition, the trauma center switched to use of ICD10 codes (vs. ICD-9 codes) in 2015–2016. While in theory, this change in diagnostic criteria could have explained, at least in part, the apparent increased admission rates over time, on manual review of the diagnosis codes and text descriptions of the drowning events, we found no evidence of any type of ascertainment bias that might be related to the switch from use of ICD9 to 1CD10 codes. Thus, the apparent increase in drowning admissions over time could reflect a true increase in drowning incidence in the trauma center's geographic catchment area, or alternatively, higher and perhaps more geographically disperse referral pattern for drowning accidents, or a combination of both. Given that the drowning case fatality rate has remained relatively stable over the time period, this argues against a selection bias over time on case referrals. Notwithstanding the above uncertainties, the increase in drowning admissions to our trauma center further reinforces the need for continued robust public policy and prevention strategies. Furthermore, our findings provide support to strategies offered by WatersmartFL-a FDOH drowning prevention program, which include promotion of supervision, barriers, and emergency preparedness [27]. These data can also be leveraged to increase awareness of drowning risk and prevention in local and regional communities. Consistent with other studies, the most common site of drowning in our study was pools (public and private pools) [2,3], and these amenities are particularly prevalent in Florida. In our study, fatal drownings were more likely to occur among children in bathtubs, in private pools, and among unattended children. These results emphasize the need for uninterrupted supervision of children at all times, even around small volumes of water.

Table 4
Logistic regression analysis of factors associated with fatal and severe drowning outcomes.

Factor	Adjusted Odds Ratio	95% Confidence Interval	P
Model 1: fatal outcome (including severity indicators) ($n = 151$)			
Admission service - pediatric intensivist	6.29	1.63, 24.31	0.008
Helicopter transport	3.99	1.22, 12.99	0.02
Injury downtime not known or ≥5 min	3.52	1.01, 12.35	0.05
Model 2: fatal outcome (excluding severity indicators) ($n = 153$)			
Injury downtime not known or ≥5 min	7.28	2.25, 23.58	<0.001
Age <2 years	3.72	1.32, 10.47	0.01
Model 3: severe outcome (ICU ≥ 2 days, ventilator use, or death) ($n = 151$)			
Injury downtime not known or ≥5 min	6.66	2.74, 16.15	<0.001
Age <2 years	3.88	1.58, 9.53	0.003
Immediate intervention after discovery (CPR, rescue breaths, back compression etc.)	0.31	0.13, 0.74	0.008

Our study additionally revealed that drownings admissions were more prevalent from May to August indicating that the risk of drowning rises as soon as the temperature rises. The fact that the month of May, which coincides with the onset of summer vacation, showed the highest frequency of drownings provides a clear rationale for targeted educational prevention messages, ideally no later to occur than the month of April. We also determined that drowning admissions were more likely to occur on weekends, summer months, and on hotter days, and thus, vigilance is especially needed on these days. To aid in this effort, timely educational programs starting earlier in the year and media dissemination strategies may be effective in raising awareness during these particularly vulnerable periods for drownings.

Strengths of this study include analysis of a relatively large sample of trauma admissions, consistent data definitions used in the electronic medical record system over 8 years, inclusion of both quantitative and qualitative data (i.e. text fields) in the analysis, and inclusion of individual level (patient) and aggregate level (e.g. zip code) variables, including meteorological data. Limitations of this study include its retrospective nature, and the relatively low incidence of drowning which precluded the ability to perform detailed subset analyses by source of drowning. In addition, the study cohort represents admissions to the trauma center and does not account for all patients who were not

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admitted after initial consult. The potential impact of drowning patients being discharged from the emergency room is likely limited, as the majority of these patients are admitted to the hospital even if for a day for further observation [4,28,29]. Some lack of precision in determining drowning location, being attended versus unattended at the time of drowning, and amount of submersion time may have occurred, hence, these results should be considered as estimates at large. Similarly, residual confounding due to unmeasured factors cannot be ruled out for multivariable estimates of factors associated with admission for drowning and severity of outcomes from drowning. Finally, this a single center study and the results observed in our study may not be generalizable to other regions. Even though the generalizability of our study is limited, its findings are informative for local and regional decision making.

5. Conclusions

Despite limitations inherent in hospital administrative data systems and retrospective data analyses, the present study provides valuable information about specific risk factors for drowning admissions and fatal drownings and severe outcomes in a contemporary dataset. Drowning admissions were more severe than other causes of injury admission and more frequently fatal. This analysis reinforces that simple interventions such as immediate bystander intervention following drowning can reduce severe, unfavorable outcomes. It also showed that children, especially younger children, should never be left unattended even for a brief period, and that continuous adult supervision is critical in prevention of drowning. The information on risk factors identified can be used to plan and strategically implement local interventions such as media announcements and educational campaigns to reduce drowning injuries and mortality. This includes several timing-related factors that represent higher drowning vulnerability, including weekends, summer months, and on particularly hot days.

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Declaration of competing interest

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