



ORIGINAL RESEARCH

# Temporal and Environmental Trends in Pediatric Submersion: A Year-round Phenomenon

*James F. Buscher, MD<sup>1</sup>, Jennifer N. Fishe, MD<sup>2</sup>, Phyllis L. Hendry, MD<sup>3</sup>, Andrew M. Bertrand, BSH, CPT<sup>4</sup>, Andrew C. Schmidt, DO, MPH<sup>5</sup>, Haytham Helmi, MD, MPH<sup>6</sup>*

*<sup>1</sup>Pediatric Emergency Medicine Fellow, Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

*<sup>2</sup>Assistant Professor of Emergency Medicine, Associate Medical Director, Pediatric Emergency Department, Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

*<sup>3</sup>Professor of Emergency Medicine and Pediatrics, Associate Chair of Research, Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

*<sup>4</sup>Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

*<sup>5</sup>Assistant Professor of Emergency Medicine, Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

*<sup>6</sup>Assistant Director of Clinical Research, Department of Emergency Medicine, University of Florida College of Medicine-Jacksonville, Jacksonville, FL*

## ABSTRACT

Submersion is a leading cause of death for those age 14 years and younger in the United States. Our objective was to describe the trends and patient characteristics surrounding pediatric submersions in North Central and Northeast Florida. This study is a sub-analysis of data submitted as part of a multicenter Pediatric Submersion Score Study. We conducted a retrospective chart review of children 0-18 years of age with unintentional submersion injuries. Demographic, prehospital, hospital, and environmental data were abstracted. A total of 183 children were included, with data being analyzed using descriptive statistics. A significant proportion of submersions (19%) occurred during the fall and winter months, accounting for 46% of total deaths. One out of four submersions occurred in an open body of water. Emergency medicine and pediatric providers should be prepared to treat, educate, and advocate regarding pediatric submersion year-round, especially in warmer climates with open bodies of water.

## INTRODUCTION

Submersion is the leading cause of death for children age 1-4 years and the second leading cause of death for children age 14 years and younger in the United States (US).<sup>1</sup> Worldwide, it is the third leading cause of unintentional death.<sup>2</sup> Children younger than 5 years of age, especially males, are at greatest risk for submersion injury<sup>3,4</sup> which also has a higher incidence in African Americans and Hispanics.<sup>5</sup> It is estimated that for every submersion death in the US, five additional patients are treated in the Emergency Department (ED) for non-fatal submersion injuries.<sup>6</sup> While the fatality rate has decreased<sup>7</sup>, more than 50 percent of submersion injuries seen in the ED require hospitalization.<sup>8</sup>

Although submersions in the US occur year-round, most occur during the summer months.<sup>9</sup> Additionally, submersions occur in a variety of locations. For children 0-4 years old, 50% of fatal and 65% of non-fatal submersions occur in swimming pools.<sup>3</sup> Infant submersions tend to occur in bathtubs or buckets and toddlers in pools<sup>7,10</sup>, while those 5 years and older tend to drown in open water areas.<sup>11</sup>

Significant prevention efforts have focused on submersion events, yet it remains a leading cause of morbidity and mortality for the pediatric population. In 2017, the World Health Organization (WHO) published recommendations to decrease submersions worldwide.<sup>12</sup> Those recommendations focus on barriers, safe places away from water to play, teaching children over six years old to swim, bystander intervention, managing flood risks, and safe boating/shipping/ferry regulations. In May 2019, the American Academy of Pediatrics (AAP) updated its policy statement regarding the prevention of submersion injury based on new information and research.<sup>7</sup> The interventions emphasized are 4-sided pool fencing, life jackets, swim lessons, supervision, lifeguards, and other interventions discussed, including bystander CPR.

Despite those efforts, Florida leads the country in submersion deaths of children ages 1-4 years.<sup>13</sup> In addition to the warm climate, Florida is a peninsula and has easy accessibility to water with a total area of 18.5% water within the state.<sup>14</sup> Therefore, we sought to describe submersion injury patterns in Florida to discern if further enhancements to injury prevention efforts should be made to prevent more fatal and non-fatal submersion injuries.

## METHODS

### Study Design

This study is a sub-analysis of a retrospective multicenter study from the Pediatric Emergency Medicine Collaborative Research Committee (PEM CRC). Permission for the sub-analysis was granted by the principle investigator of the PEM CRC multicenter study. Children aged 0-18 years who presented to the pediatric EDs of two hospitals in North Central and North Eastern Florida following an unintentional submersion event between the years 2010 to 2017 were included.

### Study Setting

Jacksonville has a population of approximately 900,000 persons, with 31% being African American and 15.9% of the population living in poverty.<sup>15</sup> The national poverty level<sup>16</sup> is 10.5%. The academic hospital ED treats 15,000 pediatric patients annually and patients requiring critical care are transferred to a local children's hospital. Gainesville has a population of 133,857 persons, with 21.4% African Americans and 31.4% living in poverty.<sup>17</sup> The academic hospital ED treats 25,000 pediatric patients annually and has a 24-bed pediatric ICU with advanced care capabilities, including ECMO.

### Data Abstraction and Statistical Analysis

Pediatric victims of unintentional submersions were identified from hospital medical records using ICD-9 and ICD-10 codes. Patients were excluded if the submersion was intentional or was secondary to an act that led to submersion (e.g., motor vehicle crash). Prehospital, scene submersion characteristics, and hospital data were abstracted through manual chart review. Both the multicenter study and sub-analysis were approved by the University of Florida Institutional Review Board.

Study data were collected and managed using REDCap™ (Research Electronic Data Capture) electronic data capture tools hosted at University of Florida. REDCap™ is a secure, web-based application designed to support data capture for research studies. Descriptive statistics were used to describe data that was normally and non-normally distributed, respectively.

### Patient and Public Involvement

It was not appropriate or possible to involve patients or the public in the design, conduct, reporting, or dissemination plans of our research

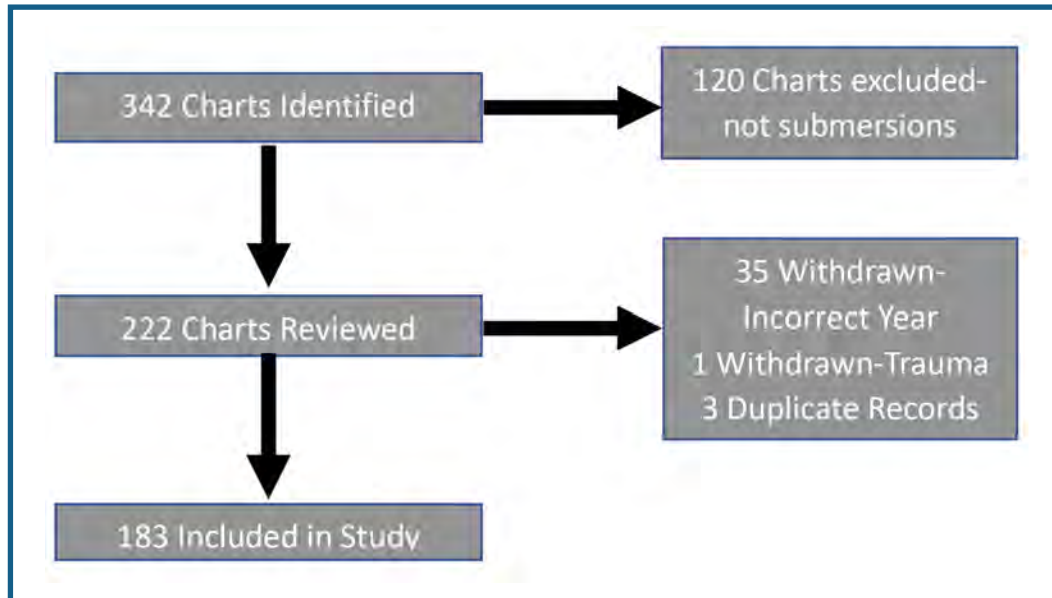
## RESULTS

A total of 342 charts were obtained. After review, 35 were the incorrect year, 120 were not submersions, 1 was trauma, 3 were duplicate records; 183 encounters were included (Figure 1).

Table 1 describes patient characteristics and demographics. Patients were mostly male (62%) and children younger than four years of age comprised 69% of the total encounters. Most injuries, (77%) occurred in pools or bathtubs. A total of 71% of the patients were admitted. Surprisingly, 41.5% of patients received CPR prior to hospital arrival, with 58% reported to have received some bystander resuscitative support (e.g., abdominal thrusts, back blows, rescue breaths, chest compressions). A total of 13 deaths were recorded, with ten occurring in children age four years and younger.

In all children, more than 60% were ages 1-2 years, and 71% were admitted to the hospital. Sixty-seven percent of those admitted were injured in a pool with 20% occurring in open bodies of water. Only one death occurred in an open body of water. Interestingly, more than 85% reported being supervised, but less than 35% witnessed the submersion. For the children age five years and older, 65% occurred in pools and 13% in bathtub.

Table 2 describes the patient characteristics for events occurring in open bodies of water and shows a total of 39 submersions occurred in open bodies of water (free-flowing water, river, stream, ocean, lake, etc.), of those, 82% of these children were admitted to the hospital, and almost 64% occurred in children four years and younger.



*Figure 1: Submersion data flowsheet*

## DISCUSSION

This study provides a regional description regarding pediatric submersion injuries in Florida. We observed similarities and differences compared with previously published national data regarding pediatric submersion injury. As with prior studies, our data demonstrates a male predominance and children aged four years and younger continue to have the highest incidence. Of that age group, pools/hot tubs remain the most likely location for the submersion to occur. However, we did not further subdivide the data to assess for event locations for those younger than 4 years of age. Based on our findings, one out of every five submersions occurred in an open body of water. Unlike previous research, we found a high rate of open bodies of water submersions in children aged four and younger.

Even with submersion injuries decreasing across the United States, the number of children hospitalized remains highest in the West and South.<sup>18</sup> While some studies report that more than half of submersion injuries evaluated in the emergency department (ED) require hospitalization<sup>19</sup>, our patient population had a higher rate of admission at 71% as well as a high rate of CPR before arrival (41.5%). When compared to other states, the death rate per 100,000 people for pediatric submersions in Florida is above the national average. In addition, many other coastal states have higher than average rates such as North Carolina and South Carolina, while many midwestern states, such as Nebraska and Minnesota are below the average.<sup>20</sup>

Although severity is a cause for hospitalization, factors related to poverty have been previously noted by organizations such as the AAP.<sup>7</sup> In addition, 90% of worldwide submersions occur in middle to low-income countries.<sup>9</sup> That increased rate of admission for our patients may have been based on the severity of illness or patient demographics. Other factors may have played a role such as lack of a medical home, decreased knowledge regarding water safety, decreased supervision (access to lifeguards), or even bystander knowledge of CPR. Another factor that may have led to a higher proportion of admission is the need to transfer children evaluated in community emergency departments to UF Gainesville tertiary care center for a higher level of care.

Public vigilance for submersion prevention is usually highest during spring and summer months, as are prevention campaigns. However, we found that one out of every five submersions occurred during the fall and winter seasons. Additionally, parents report that submersion injury information is useful and are able to recall the information.<sup>21</sup> Recent literature has emphasized the

		TIME OF YEAR			
	Total N=183	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
	N (%)	N (%)	N (%)	N (%)	N (%)
<b>DEMOGRAPHICS</b>					
<b>GENDER</b>					
Male	113 (62%)	17 (9%)	48 (26%)	40 (22%)	8 (4%)
Female	70 (38%)	5 (3%)	31 (17%)	30 (16%)	4 (2%)
<b>Age</b>					
< 1 year	11 (6%)	3 (2%)	5 (3%)	3 (2%)	0 (0%)
1-4 years	116 (63%)	14 (8%)	49 (27%)	43 (23%)	10 (5%)
5-12 years	42 (23%)	3 (2%)	21 (11%)	17 (9%)	1 (1%)
13 – 17 years	14 (8%)	2 (1%)	4 (2%)	7 (4%)	1 (1%)
<b>RACE</b>					
White	110 (59%)	15 (8%)	43 (23%)	42 (23%)	10 (5%)
Black	53 (28%)	4 (2%)	29 (16%)	18 (9%)	2 (1%)
Asian	3 (2%)	0 (0%)	1 (1%)	2 (1%)	0 (0%)
Other	7 (4%)	0 (0%)	2 (1%)	5 (3%)	0 (0%)
Unknown	10 (7%)	3 (2%)	4 (2%)	3 (2%)	0 (0%)
<b>DISPOSITION</b>					
<b>ADMIT</b>					
Yes	130 (71%)	16 (9%)	56 (31%)	48 (26%)	10 (5%)
No	53 (29%)	6 (3%)	23 (13%)	22 (12%)	2 (1%)
<b>Deaths</b>					
< 1 year	1 (1%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)
1-4 years	9 (5%)	2 (1%)	2 (1%)	5 (3%)	0 (0%)
5-12 years	1 (1%)	0 (0%)	1 (1%)	0 (0%)	0 (0%)
13 – 17 years	2 (1%)	1 (1%)	1 (1%)	0 (0%)	0 (0%)
<b>WATER TYPE</b>					
Swimming Pool	123 (67%)	10 (5%)	57 (31%)	51 (28%)	5 (3%)
Bathtub	18 (10%)	6 (3%)	2 (1%)	6 (3%)	4 (2%)
Hot tub/Jacuzzi	1 (1%)	0 (0%)	1 (1%)	0 (0%)	0 (0%)
Open body of water	36 (20%)	6 (3%)	17 (9%)	10 (5%)	3 (2%)
Free flowing/river/stream/bayou	3 (2%)	0 (0%)	1 (1%)	2 (1%)	0 (0%)
Other/Blank	2 (1%)	0 (0%)	1 (1%)	1 (1%)	0 (0%)

*Table 1: Patient demographic and epidemiological characteristics*

OPEN WATER SUBMERSIONS					
	N (%)	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
<b>GENDER</b>					
Male	27 (69%)	4	11	9	3
Female	12 (31%)	2	7	3	0
<b>Age</b>					
< 1 year	0 (0%)	0	0	0	0
1-4 years	25 (64%)	5	10	8	2
5-12 years	6 (15%)	0	4	2	0
13 – 17 years	8 (21%)	1	4	2	1
<b>RACE</b>					
White	27 (69%)	6	11	7	3
Black	8 (20%)	0	3	5	0
Asian	0 (0%)	0	0	0	0
Other	1 (1%)	0	1	0	0
Unknown	3 (1%)	0	3	0	0
<b>Admit</b>					
Yes	32 (82%)	5	14	10	3
No	7 (18%)	1	4	1	1
<b>DEATHS</b>					
< 1 year	0 (0%)	0	0	0	0
1-4 years	1 (1%)	1	0	0	0
5-12 years	1 (1%)	0	1	0	0
13 – 17 years	2 (1%)	1	1	0	0
<b>WATER TYPE</b>					
Open body of water	36 (92%)	6	17	11	2
Free flowing/river/stream/bayou	3 (8%)	0	1	2	0

*Table 2: Patient characteristics for open bodies of water submersions*

regional nature of open water submersions as well as the associated decrease in submersions with an increase in regulations.<sup>6,11</sup> Given the high number of our occurrences in open bodies of water, further regulations could be encouraged.

### Limitations

This study has limitations that merit consideration. First, this was a retrospective chart review of patients admitted to two health care systems in Florida, and results may not be generalizable to all regions. Information provided by emergency medical services and the electronic medical record may be limited or have variability in recorded history. Finally, the data do not account for patients that were pronounced deceased in the field did not obtain medical care at our institutions.

### CONCLUSION

Submersion prevention is emphasized during summer, yet this study found nearly one-quarter of submersions occurred in fall and winter. We also found a significant number of submersions in open bodies of water. Submersion injury prevention legislation and advocacy should adapt to year-round guidance and more specific preventative measures regarding open bodies of water, while medical providers should also be prepared to educate and treat patients for these injuries year-round. In addition, further research should be performed looking into pediatric submersions including the socioeconomic factors related to the rates of submersions and need for admission.

### Acknowledgements

The authors acknowledge the University of Florida College of Medicine –Jacksonville, Department of Emergency Medicine,

Division of Research's research assistants for their assistance in data extraction and study completion. We would also like to thank Dr. Rohit Shenoj and Texas Children's Hospital for the use of their data.

## REFERENCES

1. Shenoj RP, Allahabadi S, Rubalcava DM, Camp EA. The pediatric submersion score predicts children at low risk for injury following submersions. *Acad Emerg Med*. 2017;24(12):1491–1500.
2. World Health Organization. Drowning [Internet]. 2020 [cited 2020 May 10] <https://www.who.int/news-room/fact-sheets/detail/drowning>
3. Shenoj RP, Levine N, Jones JL, Frost MH, et al. Spatial analysis of paediatric swimming pool submersions by housing type. *Injury Prev*. 2015;21(4):245–253.
4. Shenoj RP, Koerner CE, Cruz AT, et al. Factors associated with poor outcome in childhood swimming pool submersions. *Pediatr Emerg Care*. 2016;32(10).
5. Frieden TR, Harold Jaffe DW, Kent CK, et al. Morbidity and Mortality Weekly Report Centers for Disease Control and Prevention MMWR Editorial and Production Staff. *MMWR*. 2014; <http://wonder.cdc.gov/ucd-icd10.html>.
6. Felton H, Myers J, Liu G, Winders Davis D. Unintentional, non-fatal drowning of children: US trends and racial/ethnic disparities. *BMJ*. 2015;5:8444.
7. Denny SA, Quan L, Gilchrist J, et al. Prevention of drowning. *Pediatrics*. 2019;143(5).
8. Center for Disease Control and Prevention. Unintentional drowning: get the facts. 2016 [cited 2019 Jun 9]. <http://www.cdc.gov/homeandrecreationalafety/water-safety/waterinjuries-factsheet.html>
9. el Sibai R, Bachir R, el Sayed M. Submersion injuries in the United States: Patient characteristics and predictors of mortality and morbidity. *Injury*. 2018;49(3):543–548.
10. Macintosh I, Austin S. Management of drowning in children. *Paediatr Child Health*. 2017;27(9):415–419.
11. Quan L, Mills B, Chau SS, Bennett E, et al. Association of designated open water swim area regulations and open water drowning rates. *Injury Prev*. 2019;27(1):10-16.
12. Geneva: World Health Organization. Preventing drowning: an implementation guide. 2017.
13. Florida Department of Health. Drowning Prevention [Internet]. 2019 [cited 2019 Jun 11]. <https://www.floridahealth.gov/programs-and-services/prevention/drowning-prevention/index.html>
14. USGS. How wet is your state? The water area of each state [Internet]. [cited 2020 Apr 9]. [https://www.usgs.gov/special-topic/water-science-school/science/how-wet-your-state-water-area-each-state?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/special-topic/water-science-school/science/how-wet-your-state-water-area-each-state?qt-science_center_objects=0#qt-science_center_objects)
15. United States Census Bureau. Quickfacts Jacksonville [Internet]. [cited 2020 Apr 6]. <https://www.census.gov/quickfacts/fact/table/jacksonvillecityflorida/PST045218>
16. Semega J, Kollar M, Ashton V, et al. U.S. Census Bureau, Current Population Reports, Income and poverty in the United States: 2019. U.S. Gov Pub Office 2020;60-270 (RV).
17. United States Census Bureau. Quickfacts Gainesville [Internet]. [cited 2020 Apr 6]. <https://www.census.gov/quickfacts/fact/table/gainesvillecityflorida/PST045218>
18. Bowman SM, Aitken ME, Robbins JM, Baker SP. Trends in US pediatric drowning hospitalizations, 1993-2008. *Pediatrics*. 2012;129(2):275–281.
19. Centers for disease Control and Prevention. Home and recreational safety [Internet]. 2016 [cited 2019 Jun 9]. <http://www.cdc.gov/homeandrecreationalafety/water-safety/waterinjuries-factsheet.html>
20. Borse NN, Julie Gilchrist M, Dellinger AM et al. CDC childhood injury report: Patterns of unintentional injuries among 0-19 year olds in the United States, 2000-2006. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2008.
21. Quan L, Bennett E, Cummings P, et al. Do parents value drowning prevention information at discharge from the emergency department? *Ann Emerg Med*. 2001;37(4):382–385.