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Barriers: Location, Functionality, and Method of Access in Childhood Pool/Spa Submersion Incidents, United States, 2000-2017

Alison Miller
Indiana University - Bloomington, almomill@indiana.edu

Kristina R. Anderson
Indiana University - Bloomington, anderskr@indiana.edu

William D. Ramos
Indiana University - Bloomington, wramos@indiana.edu

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Abstract

Drowning is a leading cause of fatality among children in the United States. In children younger than 15 years of age there were, on average, an estimated 371 pool- or spa-related fatal drownings reported per year for 2018 through 2020. This study reviewed narrative case reports obtained from the United States Consumer Product Safety Commission (CPSC) to understand pool barrier location, type, and functionality as methods of pool/spa access for childhood submersion incidents. Retroactive analysis of 1,523 fatal and non-fatal submersion incidents among children aged 13 years old and younger was conducted using the CPSC in depth investigation dataset from 2000-2017. Narrative descriptions were coded according to the attributes of barrier location, functionality, and method of access. To our knowledge, these characteristics of barriers have not been previously investigated to this depth. Outcomes indicate that consumer education campaigns should target households with swimming pools/spas and reiterate key findings that (1) submersion incidents occur even when barriers are present and (2) multiple layers of protection against unauthorized pool/spa access are critically important for residential pools/spas. Additionally, improved documentation of barriers is imperative to better understand and prevent drowning among children.

Keywords: drowning prevention, injury prevention, children, water safety

Background

Each year approximately 236,000 fatal drownings occur globally (World Health Organization [WHO], 2019). In the United States (U.S.), drowning is the second-leading cause of fatal injuries among children ages 0-14 years old and the number one leading cause of fatal injuries for children ages 1-4 (Centers for Disease Control and Prevention [CDC], 2020). In the United States, approximately 30% of drownings for children ages 5-14 occur in home pools and spas (CDC, 2020; Consumer Product Safety Commission [CPSC], n.d.). According to the World Health Organization [WHO], drowning is defined as "the process of experiencing respiratory impairment from submersion/immersion in liquid" with outcomes classified as death, morbidity, and no morbidity. Fatal drowning occurs when the drowning results in death whereas nonfatal drowning victims' survival results in a range of outcomes from no injuries to very serious injuries or permanent disability. In the United States there are, on average, 11 fatal and 22 nonfatal drowning deaths per day (CDC, 2020). However, the circumstances surrounding each drowning event, while unique, indicate patterns in factors that are associated with drowning events (Anderson et al., 2021; Fisher & Balanda, 1997).

One of these under-explored factors is the role of barriers in preventing unauthorized access to residential pools/spas (Morgenstern et al., 2000; Quan & Gomez, 1990). The CPSC defines a *successful* pool barrier as one that "prevents a

child from getting over, under, or through and keeps the child from gaining access to the pool except for when supervising adults are present" (2012, p. 5). Barriers located at home pools and spas can vary based on location, type, and functionality.

Previous research efforts related to submersion incidents typically categorize reports by demographic factors such as age and gender. For example, children of toddler years and male gender are generally considered risk factors related to drowning fatality (Ryan et al., 2020). Little evidence-based knowledge exists about the effectiveness of a wider variety of attributes related to barriers. Home pools/spas in private and residential settings are frequent sites of unintentional drowning and submersion incidents, mainly due to a lack of layers of protective barriers such as pool covers, fencing, or pool alarms, especially among young children less than five years old (Shields et al., 2011). Extant literature suggests that between 66-96% of youth drowning incidents occur when the pool or spa space is not fully enclosed (Stevenson et al, 2003; Blum & Shield, 2000). Many communities have safety regulations requiring barriers at home swimming pools/spas, however, these regulations vary by state and can be challenging to enforce (Morgenstern et al., 2000). Even when a barrier exists, it is possible for it to be ineffective at preventing access to a body of water, resulting in a child having unauthorized access. Few studies have retrospectively studied the role of barriers in submersion incidents.

Peden, Franklin, and Pearn (2020) indicated in their study that of pool drowning deaths that occurred in a depth of >300mm (approximately 12"), 91% of were known to have no fencing barriers. According to Thompson and Rivara (2010), pool fences are a passive environmental intervention, designed to reduce unintended access to swimming pools and to prevent drowning. Pool fences should also have a dynamic and secure gate and isolate (i.e., four-sided fencing) the pool from the house; this can reduce the risk of drowning by 83% when compared with three-sided fencing (Thompson & Rivara, 2010). The American Red Cross (2020) Circle of Drowning Prevention references four-sided fencing as a crucial component of drowning prevention in addition to swimming skills, lifejackets, lifeguards, and supervision. These studies reflect that pool barriers can be effective in drowning prevention and should be more widely utilized; however few studies have comprehensively analyzed multiple barriers through a comprehensive lens.

The CPSC has collected incident-related data for nearly five decades as part of its In-Depth Investigations (INDP) dataset investigation process; however, the incident narratives deriving from these investigations have not been analyzed at scale for key information related to barrier location, functionality, and method of access [CPSC, n.d.]. To our knowledge, no systematic analysis of variables related to pool and spa barriers has ever occurred. In the present study, we sought to

identify and understand drowning data related to barriers specific to location, functionality, and method of circumvention associated with youth submersion incidents.

Method

Sample

The dataset we used was retrieved through a Freedom of Information Act (FOIA) request from the CPSC INDP. The INDP dataset includes cases identified through Child Death Review files of all 50 U.S. states, media reports, and the CPSC's National Electronic Injury Surveillance System (NEISS) dataset. The NEISS encompasses emergency room data from approximately 100 representative hospitals across the U.S. (CPSC, n.d.). Once a case is detected, a CPSC investigator administers an inquiry, resulting in a comprehensive report.

Through the FOIA, all case records of victims 14 years old or younger from 2000-2017 were requested. Other FOIA measures included those cases involving pool product categories (e.g., above ground, portable, wading, unspecified) as well as classifications for hot tubs/home spas, swimming pool equipment, inflatable toys, water slides, and other swimming-related events.

The data set included the following attributes: Report date, incident city and state, gender and age of patient (in years, or years/months if younger than 2 years old), primary injury category and body part, severity (i.e., fatal or non-fatal), product category, and a narrative (utilized for analysis in this study). Narratives varied in length with an average of 73 words.

Inclusion Criteria

The original dataset included 1,723 incidents. Due to duplicates in the record (e.g., two cases were recorded if the submersion incident involved two aquatic products), 196 cases were removed. Furthermore, narratives that referenced multiple victims were replicated, so that one case would represent one child (resulting in 24 additional cases). Other exclusions included all incidents that occurred prior to 2000 (n = 3), but had been recorded months or years later, those that occurred outside the 50 U.S. states (n = 2), and incidents that occurred in natural water bodies such as rivers and lakes (n = 8). Additionally, obvious errors in the dataset (e.g., a case documenting an adult fatality and another citing a fireworks accident) were excluded (n = 2). The final number of cases after these exclusions and inclusions were applied was 1,537.

Attribute Development

An inductive process was used to develop attributes from narrative content. The first 200 narratives were independently reviewed by a member of the research team to identify and define emergent codes. All three research team members met after the first review to examine the initial proposed codes, deliberate definitions, and evaluate whether any new or combined codes were pertinent. Finally, several attributes related to *Barrier Characteristics* including *Barrier Location (indoor, outdoor, multiple), Barrier Functionality (secure/locked, fenced/closed access, unfenced/open), and Breached Barrier (type of barrier including door, ladder, gate or other)* were classified and documented. Table 1 outlines the attribute definitions and categorial options for each.

The initial researcher then returned to the dataset with the refined list of codes, re-examined the first 200 narratives, and resumed coding narratives in 200-case increments. Meanwhile, a 2nd researcher, also using 200-case batches, assessed the coding of each narrative to validate accuracy and consistency in the application of attribute definitions. Monthly meetings were held with all three researchers to review cases in which deviations in coding were identified. The number of cases flagged for potential inconsistency improved monthly, suggesting enhanced inter-rater reliability. Initial batches of 200 cases occasionally had 20+ cases with one or more attributes recognized as potentially inconsistent; however, the last three batches had 9, 5, and 2 inconsistencies identified, respectively.

Analysis

Narrative codes were analyzed using quantitative descriptive data which included counts and frequencies. Chi-square (χ^2) tests of association were calculated using SPSS 27.0. This study was approved by the Institutional Review Board of Indiana University (2009998119, September 29, 2020). Due to the lack of clearly identifiable or contact information for cases within the INDP database, subject consent was waived. Quotes of the submersion descriptions were included to help depict barrier attributes; in these quotes, details that would identify the victim have been removed or edited to prevent identification of those cases. The narrative quotes have also been edited for spelling and grammar.

Table 1

Barrier Attributes

Variable	Definition	Categories
Barrier characteristics		
Barrier location	Location of the most-implicated barrier/ barrier relied upon by supervisor/homeowner	Indoor/House Outdoor Multiple Other None Unspecified N/A-Authorized access
Barrier functionality	Efficacy characteristic of the barrier	Secured/locked Fenced/closed access Unsecured/unlocked Unfenced/open access Broken/dysfunctional Multiple Other None Unspecified N/A-Authorized access
Breached barrier	Type of most-implicated barrier breached	Door Ladder Gate Fence Deck Stairs Pool cover Other Multiple barriers: Door & ladder Multiple barriers: Other combination Unspecified N/A-Authorized access

Results

Demographic Data

The age of victims largely included younger children; 30.3% (n = 465) were 12-23 months, 38.0% (n = 583) were 2 years old, and 19.7% (n = 303) were 3 years old, 8.2% (n = 126) were 4 years old, 3.1% (n = 47) were between ages 5-9 years old, and 0.8% (n = 13) were 10-12 years old. Male victims accounted for 62.7% (n = 963) of incidents and sex was significantly associated with fatality: $\chi 2$ (1, N = 1536) = 9.11, p = 0.003. Incidents were reported across the U.S. including the South (46.4%, n = 713), Midwest (22.4%, n = 344), West (17.6%, n = 271), Mid-Atlantic (10.8%, n = 166), and New England (2.7%, n = 42) regions. Most incidents occurred in either a temporary or permanent pool (89.9%, n=1382).

By submersion incident outcome, 1375 (89.5%) resulted in fatal outcomes and 162 (10.5%) resulted in non-fatal outcomes. Among non-fatal outcome incidents, 29.8% (n = 48) of victims were 12–23 months, 35.4% (n = 57) were 2 years old, 17.4% (n = 28) were 3 years old, 8.1% (n = 13) were 4 years old, 5.0% (n = 8) were 5–9 years old, and 4.3% (n = 7) were 10–12 years old. By fatal outcome incidents, 30.3% (n = 416) were 12–23 months old, 38.8% (n = 526) were 2 years old, 20.0% (n = 275) were 3 years old, 8.2% (n = 113) were 4 years old, 2.8% (n = 39) were 5–9 years old, and 0.4% (n = 6) were 10–12 years old.

Barrier Location

Barrier location is defined as the site of the most implicated barrier (i.e., the barrier most relied upon by the caregiver or supervisor to prevent access, according to the case narrative) (Table 1). Of cases indicating a barrier location, fatal incidents were most frequently cited as having a barrier location *outdoors* (47%, n=310, Table 2). *Barrier Location* was not significantly associated with fatality $\chi 2$ (4, N = 694) = 4.020, p = .403. The following exemplative narrative illustrates the *Barrier Location* as being *outdoors* during a submersion incident.

> A 20-month-old female died of drowning in an inflatable above-ground swimming pool. The pool was located in an area enclosed by a fence, but the gate was not closed. The victim wandered into the pool while her mother was using the bathroom. She was found floating face down unconscious. Efforts to revive her were unsuccessful.

The excerpt above indicated a fatal submersion incident with an *Outside Barrier Location* that was left *Unsecured/Unlocked*. The following exemplative narrative illustrated the *Barrier Location* as being inside during a submersion incident.

> An 18-month-old male entered the backyard of the family home via a sliding glass door or through a pet door. Her 4-year-old brother was also in

> the backyard. An unfenced above-ground pool was about 9 feet from the sliding glass door. The victim was able to get up into the above ground pool that was about 34-36 inches high. The child drowned in the pool water, which was about 33-inches deep.

The following exemplative narrative illustrated the *Barrier Location* as having multiple barriers during a submersion incident.

> During the few minutes the victim was left alone, he went out a back sliding patio door that was left open. Without anyone in the house knowing, he went outside. The victim exited the patio door that leads to the backyard, went over to the above ground swimming pool in the backyard, and climbed up a ladder that was inadvertently left on the above ground swimming pool. The victim climbed the ladder and fell into the pool, which resulted in his drowning. The victim was in the pool for an unknown period until he was removed; CPR was given but victim succumbed to drowning.

Barrier Functionality

Where there was open access with no fencing 19% (n=96), 9% (n=46) of fatal drownings occurred where the barrier was secured/locked and 1% (n=3) of fatal drownings occurred where fencing existed and access to the pool was closed (Table 4). Of those cases with barriers that were described as unsecured/unlocked (n=308), unfenced/open access (n=98), broken/dysfunctional (n=29), 94.5% resulted in fatality (n=411). *Barrier Functionality* was not significantly associated with fatality $\chi 2$ (6, N = 539) = 5.262, p = 0.511 for this dataset. The following exemplative narratives indicate a failure of barrier functionality resulting in fatality.

> A 30-month-old female drowned in an above-ground swimming pool in an apparently unwitnessed incident. The victim was found in a neighbor's pool beneath the pool cover. It is thought that she gained entrance to the fenced pool area through a displaced vertical fence slat.

> A two-year-old male was able to pull open an access gate to an above-ground pool and get inside. The child climbed up five stairs, opened the gate as it did not latch securely, and jumped into the pool. The pool had a soft solar cover floating on top. When the child was found ten minutes later, he was partially under the solar cover and not breathing. He was transported to an area hospital and later air lifted to a regional children's hospital, where he died ten days later.

Barrier Type

Barrier Type (Table 1) indicated a door as the most cited barrier breached in 27% (n=150) of fatal cases; in 22% (n=127) of fatal drownings, a ladder was implicated

(Table 3). *Barrier Type* was not significantly associated with fatality $\chi 2$ (8, N = 618) = 4.583, p = 0.801.

The following exemplative narrative illustrates the *Barrier Type* being a ladder.

> A 19-month-old male was found floating face down in the family's above-ground 3.5-foot pool after being unattended for approximately five minutes. The mother and father attempted CPR while neighbors called 911. The victim was transported to the hospital where he was pronounced dead. The ladder was usually removed from the pool; however, on the particular day, it had been left in the pool allowing access to the victim who climbed the ladder into the pool without his life preserver. The cause of death was drowning.

The following exemplative narrative illustrates the *Barrier Type* as being a door.

> The 2-year-old male was at a babysitter's house. He walked out a patio door, which lead to an above-ground swimming pool. He fell into the swimming pool and was discovered beneath the plastic pool cover. He was pronounced dead at the hospital from accidental drowning.

The following exemplative narrative illustrates a gate *Barrier Type*.

> A toddler drowned after she wandered away alone and accessed a neighbor's backyard through an unlocked gate. She was later discovered submerged underwater in a permanent in-ground pool.

Table 2

Barrier locations of fatal and non-fatal drowning incidents

Description	All incidents		Non-fatal		Fatal	
	N	%	n	%	n	%
Barrier location						
Indoor/House	179	26%	12	34%	167	25%
Outdoor	327	47%	17	49%	310	47%
Multiple	115	17%	5	14%	110	17%
Other	3	0%	0	0%	3	0%
None	70	10%	1	3%	69	10%
Total	**694**	**100%**	**35**	**100%**	**659**	**100%**
Unspecified	843	-	127	-	716	-

Table 3

Barrier types in fatal and non-fatal drowning incidents

Description	All incidents		Non-fatal		Fatal	
	n	%	n	%	n	%
Barrier type						
Ladder	133	22%	6	18%	127	22%
Door	162	26%	12	35%	150	26%
Gate	85	14%	4	12%	81	14%
Fence	29	5%	2	6%	27	5%
Stairs	18	3%	2	6%	16	3%
Deck	21	3%	1	3%	20	3%
Pool cover	12	2%	0	0%	12	2%
Other	24	4%	2	6%	22	4%
Door & ladder	59	10%	2	6%	57	10%
Mult. Barriers: Other	75	12%	3	9%	72	12%
Total	**618**	**100%**	**34**	**100%**	**584**	**100%**
Unknown	919	-	128	-	791	-

Table 4

Functionality of barriers in fatal and non-fatal drownings

Description	All incidents		Non-fatal		Fatal	
	n	%	n	%	n	%
Barrier Functionality						
Secured/locked	47	9%	1	4%	46	9%
Fenced/closed access	3	1%	0	0%	3	1%
Unsecured/unlocked	308	57%	21	78%	287	56%
Unfenced/open access	98	18%	2	7%	96	19%
Broken/dysfunctional	29	5%	1	4%	28	5%
Multiple	29	5%	1	4%	28	5%
Other	25	5%	1	4%	24	5%
Total	**539**	**100%**	**27**	**100%**	**512**	**100%**
Unknown	998	-	135	-	863	-

Discussion

Regarding *Barrier Location* in fatal submersion incidents, outside barriers were implicated most frequently (47%). This is likely due to pool barriers generally being located outside. As a result, this finding may not represent a repeated failure but an indicator of volume/frequency. For example, the *Barrier Types* that were coded as outside include ladders, gates, fences, stairs, decks, and pool covers, whereas those that were inside included mainly doors. Nonetheless, outside pool barriers may need to be reexamined for effectiveness, as this *Barrier Location* failed to prevent submersion incidents. In contrast, having *multiple Barrier Locations (indoor and outdoor)* was one of the lowest frequencies of fatal drowning (17%) suggesting a protective effect.

Barrier Type can vary widely, and different types can have different locations. For example, having a door as the indicated *Barrier Type* had the highest percentage of fatal drowning (26%). It can be assumed that the location of this *Barrier Type* has a *Barrier Location* of being indoors. Because all houses have doors of entry and exit with locks that may or may not function, it makes sense that this would be the most frequently cited *Barrier Type.* A ladder was indicated as the second highest percentage related to fatal drowning (22%). Ladders may be perceived as a barrier by homeowners because they believe a child will not be able to scale the ladder; however, this "barrier" may facilitate access.

There are additional barrier designs that can be added to ladders to help in preventing a child from climbing pool ladders. A passive safety system added to a ladder has the potential to reduce submersion-related incidents by adding an additional barrier to unauthorized swimming pool access (Pierce & Ziernicki, 2018); however, the data did not indicate if these were utilized. A study by Ridenour (1997) found that even when a pool ladder is removed, 30% of children in the study were still able to climb the pool wall of an above-ground pool. This indicates that removal of a pool ladder alone should not be used as the only method of prevention. Notably, when narratives indicated the most frequently-cited types of individual barriers, ladders and doors, were both present, the percentage of fatal drownings accounted for 10% of cases. This could indicate that having multiple barrier types has the potential for the prevention of fatal submersion incidents, providing further guidance for drowning prevention. A pool cover was cited as a *Barrier Type* in 2% (n=12) of fatal cases and 0% of non-fatal cases; however, no studies supported pool covers as an effective barrier; instead, they may provide a false sense of security and could entrap and conceal drowning victims as mentioned in several of our narrative exemplars (Denny et al., 2021).

Barrier functionality indicates that a barrier is in place and is working as intended. The efficacy of a barrier is important for it to function properly in

preventing submersion incidents. In 56% of fatal cases, a barrier was identified as being unsecured/unlocked. If the existing barriers had been functioning as intended, it may be assumed that the fatal case number would be lower. Door and window locks are unlikely to be effective because of how often they are left unlocked accidentally; having a secure and locked barrier does not eliminate the risk of unauthorized access to water (Blum & Shield, 2000). Being secured or locked was indicated in 9% of fatal incidents; further exploration into how secured or locked barriers are being breached could help to improve overall barrier efficacy.

Pool fencing was indicated as a *Barrier Type* in 5% (n=27) of fatal submersion incidents; however, when evaluated with *Barrier Functionality* as fenced/closed access, fatal accidents were 1% (n=3). In contrast, when *Barrier Functionality* was identified as unfenced/open access, fatal submersions accounted for 19% of cases. This highlights the importance not only of the presence of a barrier, but a fully functioning barrier (Pearn et al., 1997). Four-sided pool fencing, when functioning and installed correctly, has been identified by several states as a required ordinance; this ordinance can be challenging to enforce, and its effectiveness may need to be monitored (Morgenstern et al., 2000). A study in Australia found that government inspections of pool fencing raised compliance from 50% to 97% (vanWeerdenburg et al., 2006). In contrast to perimeter fencing (3-sided fencing, property and pool), pool fencing is most effective when it is isolation fencing (4-sided fencing, enclosing the pool only), has a secure and self-latching gate, and legislation is in place to enforce these protections (Kemp & Sibert, 1992; Thompson & Rivara, 2010). The risk of a child drowning in a pool with 3-sided fencing was twice that of a pool with 4-sided fencing (Stevenson et al., 2003). Barrier compliance may also be a socioeconomic issue as constructing a 4-sided fencing barrier could be costly and inaccessible for some families (Fisher et al, 1997). Compliance is more effective when combined with public education, legislation, and enforcement (Peden et al., 2021). As seen in the examples above, barriers are only effective when fully functioning as intended and alone are not the only solution to drowning prevention where multiple layers of protection are necessary (Brugeja & Franklin 2013). With this study we hope that the findings outlined here identify multiple opportunities for future drowning prevention research regarding barriers and their characteristics

Limitations

The data within this study were a convenience sample in an existing database for which parent/caregiver consent had been required to participate in the field investigator's work. Due to these circumstances, the results may not be representative of all submersion events, especially non-fatal cases, which are possibly underreported given that minor events may not prompt an INDP investigation. Additionally, factors may have been present that were not recorded

in the narrative. The volume of missing data was another limitation for this research study. Within each attribute category the following cases were categorized as "unknown": barrier location 55% (n=843), barrier type 60% (n=919), and barrier functionality 65% (n=998). These "unknown" attributes are not a representation of the occurrence, but a lack of the attribute being recorded in the narratives.

Conclusion

Submersion incidents happen quickly, typically in a supervision lapse of less than 5 minutes. Submersion times of 5 minutes or more are linked to poor outcomes. (Anderson et al., 2021; Shenoi et al., 2016). The outcome of submersion incidents can be fatal, leading to death, or nonfatal, which could result in brain damage or permanent disability. One study found that only 8.6% of drowning victims have favorable outcomes if they were found pulseless at the scene (Shenoi et al., 2016). Barriers are one layer of protection recognized in drowning prevention that can be effective when used appropriately and kept in working order; safety professionals have long advocated for their appropriate use and maintenance. Our results indicated that in submersion incidences where an unsecured, unlocked, unfenced, open access, broken, or dysfunctional barrier existed, 80% resulted in fatality (n=411). This contrasts with 10% (n=49) occurring where the barrier was secured, locked, or fenced and 10% (n=52) having an "other" or "multiple" designation. Having fencing and a secured/locked barrier does not eliminate the possibility of drowning, but as indicated in the existing data, the frequency is lower. There is no federal pool fencing standard; however, several states such as Arizona and Florida have adopted their own fencing legislation.

Current literature has indicated that barriers are an underutilized injury prevention strategy among pool owners (Peden et al., 2020). Most studies seeking to understand barriers to drowning in aquatic environments have focused on limited factors, such as victim age, victim gender, time between incident and victim death, description of the water body type, or focused on a specific barrier's effectiveness in contrast to a comprehensive and broader analysis. Through detailed review of descriptive incident narratives, this study identifies and categorizes multiple incident attributes associated with barriers in fatal and non-fatal submersion incidents, as reported to the US Consumer Product Safety Commission (CPSC) from 2000-2017. Through this study we sought to identify and understand the role of barriers implicated in child submersion incidents and the characteristics of those barriers to inform injury prevention efforts. We hope that the findings outlined aid in the design of educational campaigns and prevention efforts to reduce youth submersion incidents.

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