



Prevention of Drowning

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Drowning is a leading cause of injury-related death in children. In 2018, almost 900 US children younger than 20 years died of drowning. A number of strategies are available to prevent these tragedies. As educators and advocates, pediatricians can play an important role in prevention of drowning.

INTRODUCTION

Background

Drowning is the leading cause of unintentional injury-related death in US children 1 through 4 years of age and, as of 2018, has surpassed birth defects as the most common cause of death among this age group. Drowning is the third leading cause of unintentional injury-related death among US children and adolescents 5 through 19 years of age.¹ In 2018, almost 900 US children and youth under 20 years died of drowning and more than 7200 were seen at a hospital emergency department (ED) for a drowning event, with 35% of those children either hospitalized or transferred for further care.¹ Rates of drowning death vary with age, sex, and race; those at greatest risk are toddlers and male adolescents. Underlying medical conditions, such as seizures and autism, also increase risk. Fortunately, childhood unintentional drowning fatality rates have decreased steadily from 2.68 per 100 000 in 1985 to 1.09 per 100 000 in 2018. Most victims of nonfatal drowning do well, but severe long-term neurologic deficits are seen with extended submersion times, prolonged resuscitation efforts, and lack of early bystander-initiated cardiopulmonary resuscitation (CPR).^{2–4}

The American Academy of Pediatrics (AAP) has revised this technical report because of new information and research regarding (1) populations at increased risk; (2) racial and sociodemographic disparities in drowning rates; (3) water competency (water safety knowledge and attitudes, basic swim skills, and response to a swimmer in trouble)^{5,6}; (4) the need for close, constant, attentive, and capable adult supervision when children are in and around water as well as life

abstract

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jacket use among children and adults; (5) the importance of physical barriers to prevent access to water when children are not expected to be around water; and (6) the Drowning Chain of Survival and importance of bystander CPR (Table 1).

In 2002, the World Congress on Drowning and the World Health Organization revised the definition of drowning to be “the process of experiencing respiratory impairment from submersion/immersion in liquid.” Drowning outcomes are classified as death, no morbidity, or morbidity (further divided into moderately disabled, severely disabled, vegetative state/coma, and brain death). Terms such as wet, dry, near, secondary, active, passive, and silent drowning should not be used. The 2002 revised definition and classification is more consistent with other medical conditions and injuries and should help in drowning surveillance and collection of more reliable and comprehensive epidemiological information.⁷

Sociodemographic Factors

Rates of drowning vary by sociodemographic factors, such as age, sex, race and ethnicity, and the presence of neurodevelopmental disorders such as epilepsy, autism spectrum disorder (ASD), and intellectual disability. Drowning rates are reported on the basis of the population under examination, not on the basis of the group’s exposure; exposure-based rates might increase disparities among groups.⁸ The highest rate of drowning is in the 0- to 4-year age

group (2.26 per 100 000 population), with children aged 12 to 36 months being at highest risk (3.38 per 100 000). There is a second peak incidence in adolescence (1.90 per 100 000 among boys aged 15 to 19 years), attributable largely to a high number of male drowning deaths. Approximately 75% of childhood drowning victims are boys,¹ and, after the first year of life (during which risks are often similar), boys are at greater risk of drowning than are girls at each age. Among children and preteens, drowning death is roughly twice as common in boys as in girls, but among adolescents, the rate is almost 10 times higher among boys (Table 2).¹ The higher drowning rate for boys has been explained by greater exposure to aquatic environments, overestimation of swimming ability, higher risk taking, and greater alcohol use.^{9,10}

Among children aged 0 to 19 years overall, drowning rates from 2014 to 2018 are highest among Black (1.79 per 100 000) and American Indian (AI) and Alaska native (AN) (1.49 per 100 000) individuals; drowning rates are lower among white (1.06 per 100 000), Asian American and Pacific Islander (0.85 per 100 000), and Hispanic (0.82 per 100 000) individuals.¹ One analysis of 11 years of fatal drowning data among people younger than 30 years reveals that AI and AN individuals have the highest rates of fatal drowning (2.57 per 100 000), higher than both Black (1.90 per 100 000) and white (1.32 per 100 000) individuals. AI and AN

individuals have the lowest drowning risk of all races and ethnicities in swimming pools but the highest in natural water settings (1.22 per 100 000 among AI and AN versus 0.63 per 100 000 among Black and 0.42 per 100 000 among white individuals). AI and AN individuals could not be included in additional analyses of race and ethnicity (eg, white, Black, Hispanic) by single year of age because of small numbers. When considering race and ethnicity as a risk factor, age dramatically influences drowning disparities. The highest rates were among children aged 1 year, with rates for white children (5.22 per 100 000) higher than those for Hispanic (4.14 per 100 000) and Black (2.98 per 100 000) children. Between the ages of 1 and 5 years, drowning rates decreased significantly for each racial and ethnic group but decreased less among Black children. However, the drowning rates for Black children were significantly higher than those for white and Hispanic children at every age from 5 years to 18 years, and this difference persisted when examining drowning in swimming pools and natural water settings. An analysis that was focused specifically on swimming pool drowning deaths in the 5- to 24-year age group demonstrated that Black males had higher drowning rates than either white or Hispanic males, even when adjustments were made for income. Although the majority of white children drowned in residential pools, Black children were more likely to die in a public pool, often at a motel or hotel.¹¹ In swimming pools, Black children aged 5 to 19 years were 5.5 times more likely to drown than white children of the same age.¹² With no physiologic differences to explain the difference in drowning risk, race and ethnicity are likely a proxy for social and cultural differences

TABLE 1 Key Evidence-Based Strategies

Assess all children for drowning risk on the basis of risk and age, and prioritize evidence-based strategies:
<ul style="list-style-type: none"> • Barriers • Supervision • Swim lessons • Life jackets • CPR

TABLE 2 Unintentional Drowning Deaths, United States, 2014–2018

Age Group, y	Average Annual (Crude Rate No. Deaths Per 100 000)		
	Boys	Girls	Total ^a
<1	19 (0.93)	17 (0.90)	36 (0.91)
1–2	175 (4.32)	93 (2.40)	269 (3.38)
3–4	104 (2.55)	41 (1.05)	145 (1.81)
0–4	298 (2.93)	152 (1.56)	450 (2.26)
5–9	95 (0.91)	36 (0.36)	131 (0.64)
10–14	71 (0.68)	27 (0.26)	98 (0.47)
15–19	205 (1.90)	21 (0.21)	226 (1.07)
0–19	670 (1.60)	236 (0.59)	906 (1.10)

Source: Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System.

^a Totals may not add up because of rounding.

between the groups. The reasons that Black children and teenagers are at higher risk of drowning have not been thoroughly studied, but poor swimming skills in both children and their parents, lack of early training, and lack of lifeguards at motel and hotel pools may be important factors.^{11,13–15}

Risks related to race and ethnicity are likely related to differences in exposure, behavior, knowledge, and skills. In Ontario, Canada, African, Hispanic, and Asian people have higher age-adjusted drowning rates compared with those of European descent.¹⁶ In a survey targeting poor children of color, approximately 57.5% of Black youth and 56.2% of Hispanic youth reported being unable to swim or being uncomfortable in the deep end of the pool.¹⁴ Black females report fear of drowning; this negatively affects seeking swimming instruction and swimming abilities.¹⁵ Certain religious beliefs may prevent children from taking swimming lessons because of lack of single-sex aquatic settings or type of clothing restrictions.¹⁷ Socioeconomic disparities account for some, but not all, of the disparities. Inadequate funding for pools, swimming programs, and lifeguards, as well as the cost associated with swimming lessons, may affect water competency and community resources for low-income populations. Differences

persist after controlling for socioeconomic status, cultural and historical factors, and access.¹¹ Finally, the role of race and ethnicity as a risk factor may vary at the local level, necessitating examination of risk at the level of individual communities.¹⁸

Further research is imperative to learn more about racial and ethnic disparities in drowning and guide effective prevention interventions. A study performed in Alaska to decrease injury in AN territories successfully increased the use of float coats (summer-weight coats that doubled as personal flotation devices) by using an aggressive education campaign, increased enforcement, and increased availability of float coats. This project was successful because of partnership with tribal elders in developing culturally appropriate messaging.¹⁹ In addition, understanding the historical relationships that affect risk perception around water safety helps inform aquatic risk communication to different cultural and ethnic groups.²⁰ The drowning research agenda should include understanding the disparities affecting immigrants, refugees, and various ethnic and racial populations and establish evidence-based interventions to improving water competency and decreasing drowning rates in these disproportionately affected groups.

The role of socioeconomic status and income on drowning rates, independent of race, is not well known. Worldwide, drowning rates are much higher in low-income, resource-limited countries, possibly because of the increased exposure to natural bodies of water.^{21,22} In contrast, a study of pool drowning conducted in California found that among children younger than 10 years, drowning rates were actually associated with higher family income and parental education. This association was attributed to increased exposure to residential swimming pools in more affluent communities.²³ In the Netherlands, individuals of ethnic minorities were more likely to drown than those of Dutch heritage, even after adjusting for age, sex, income, and urbanization.²⁴ Among Black males in the United States, swimming pool drowning risk remained higher even after controlling for income,¹¹ and among urban youth, Black children reported lower swimming ability after controlling for income.¹³ Underlying reasons are not well understood but may include cultural, historical (such as segregation and lack of access), and environmental influences.

Temporal and Geographic Variation

Among all causes of unintentional injury death in the United States, drowning shows the greatest seasonal variation.²⁵ For drowning victims younger than 15 years, 70% of deaths occurred from May to August; the risk of drowning significantly increased (up to 69%) when the outside temperature exceeded 30°C (86°F).²⁶ Drowning also occurred disproportionately on Saturdays and Sundays. In 2016, in Maricopa County, Arizona, 47% of the 131 life-threatening pool-related incidents among children aged 0 to 4 years occurred on the weekend. The peak time of day was 6 PM to 8 PM, with 75% of all incidents

occurring between noon and 9 PM.²⁷ In another report, approximately one-half of drownings occurred between 4 PM and 6 PM, coinciding with the busiest swim times as well as distractions secondary to meal preparation.²⁸

For the period 2014–2018, the 3 US states with the highest number of drowning deaths in the 0- to 19-year age group were California (419 per 100 000), Florida (489 per 100 000), and Texas (516 per 100 000). For the same age group, the states with the highest rates of drowning deaths per 100 000 population aged 0 to 19 years were Louisiana (2.3), Florida (2.1), and Mississippi (2.0). The lowest drowning death rates were reported in some of the New England and mid-Atlantic states.²⁵

Setting

Age is an important determinant of drowning location. Most infants drown in bathtubs and buckets, whereas the majority of preschool-aged children drown in swimming pools. Older children and adolescents are more likely to drown in natural bodies of water. In a large national study of 1420 drowning deaths in children younger than 20 years, 47% of drownings in all age groups occurred in fresh water, 32% in artificial pools, 9% in the home (bathtubs, buckets), and 4% in salt water.²⁹ In a study from Washington state, natural bodies of water were the setting in 35% of drownings in the 0- to 4-year age group, 69% of the drownings in the 5- to 14-year age group, and 95% of the drownings of adolescents.³⁰ Similar findings were found in another study conducted in Massachusetts.³¹ In contrast, for nonfatal drowning involving children and adults, 57% occurred in pools, 25% occurred in natural bodies of water, 9%

occurred in bathtubs, and 8% were unspecified.³²

Most infant drowning deaths occur in bathtubs (62%–71%) and large buckets (16%).^{25,29} Almost all parents report believing a child should be at least 6 years old before being allowed to bathe alone.³³ However, approximately 15% to 30% of caregivers have reported leaving their children younger than 2 years unsupervised in the bath for a period ranging from 1 minute to slightly over 5 minutes.^{34,35} In fact, in this study, 33% of parents reported leaving children younger than 2 years for a little over 1 minute and 24% for more than 2 minutes but less than 5 minutes.³⁴ The caregivers were distracted by a phone, getting diapers or clothes for the child, or completing household chores.³⁴ Of note, first-time parents were less likely to leave children in the bathtub when compared with parents with an older child.³⁶ The association of unsupervised bathtub drowning deaths with the use of bathtub seats and rings was recognized more than 2 decades ago.³⁷ The bath seat and ring are designed to position the infant in a sitting position with 3 to 4 legs and suction cups at their base. Three hazard scenarios have been described with these devices: (1) the seat tipping over from suction cup failure, (2) the child becoming entrapped in leg openings that are too big, and (3) the child climbing out of the seat.³⁷ Additionally, infant tubs pose another risk contributing to bathtub drownings. Between January 2004 and December 2015, a total of 247 incidents were reported to the Consumer Product Safety Commission (CPSC) involving infant tubs, 31 fatal and 216 nonfatal.³⁸

In a national study, 56% of drownings in children aged 0 to 4 years occurred in swimming pools, but a sizable portion (26%) occurred in fresh bodies of water

(rivers, creeks, lakes, ponds, canals, and quarries).²⁹ In children younger than 5 years, the largest numbers of natural water drownings occur in ponds, whereas older children more commonly drown in lakes.³⁹

Although children aged 5 to 14 years are slightly more likely to drown in a natural body of water than in a swimming pool, a high proportion (69%) of adolescents aged 15 to 19 years drowned in natural bodies of water.²⁹ More than one-half of natural water drownings occur in children younger than 14 years, and a greater proportion of these occur in urban settings with populations of more than 1 million.³⁹

In-ground Pools

As opposed to open bodies of water, swimming pools have fewer drowning hazards, such as unknown depths, undefined areas, and presence of currents and waves.¹² However, swimming pools can pose a serious risk to toddlers and young children and older children who do not know how to swim. There are an estimated 6700 pool- or spa-related, hospital ED-treated, nonfatal drowning injuries and 379 pool- or spa-related fatal drownings each year involving US children younger than 15 years.⁴⁰ Of these, 75% involve children younger than 5 years. The recurring drowning scenario in pools and spas for young children includes unexpected, unsupervised access to the water. Only 17% had been last seen in or near the pool or spa before the incident and 10% had compromised or circumvented a pool or spa barrier.⁴⁰

Pediatric swimming pool drownings occur in single-family and multifamily residences or public pools. Pediatric swimming pool drownings in single-family and multifamily residences are best predicted by the number of pools by

housing type and the number of children aged 0 to 17 years by housing type.⁴¹ The risk of a submersion is 2.7 times higher for a child at a multifamily than a single-family residence and 28 times more likely in a swimming pool at a multifamily property than a pool at a single-family residence.⁴¹

Fixed and Portable Aboveground Pools

Aboveground pools can be fixed or portable. Aboveground pools can vary in size and height from small inflatable pools to larger versions that can hold thousands of gallons of water.⁴² A portable pool is any movable structure intended for swimming or other water recreation, including wading pools, inflatable pools, and “soft-sided, self-rising” pools. Portable pools are increasingly popular compared with fixed aboveground pools because they can be set up and taken down or moved to another location with relative ease. Portable pools in residential settings also pose a risk of submersion-related morbidity and mortality to children.

From 2014 to 2016, there were, on average, 363 fatalities each year associated with pool or spa drownings involving children younger than 15 years. Aboveground pools accounted for 19% and portable pools accounted for 5% of these fatalities.⁴³

The CPSC recommends that all pools, in-ground and aboveground, have a barrier, optimally 4-sided isolation fencing. The pool structure can serve as a barrier if the walls of the pool are high enough to meet the recommended 4-foot height for barrier fencing. Alternatively, a barrier can be mounted onto the top of the pool structure. The CPSC also recommends that, if the pool walls are not high enough, the steps or ladder leading to the pool be secured, locked, or removed or

surrounded by a barrier to prevent access when the pool is not in use.⁴² The American Society for Testing and Materials (ASTM) has published a standard (F 2666-16) for aboveground pools for residential use that addresses structural integrity, sanitation, electrical safety, and safety message labeling.⁴⁴

Unfortunately, many parents do not consider fencing for an inflatable or portable pool, and such pools often fall outside of local building codes that require pool fencing. Because they contain such large amounts of water, these pools are often left filled for weeks at a time, presenting a continuous danger. The soft sides of some models allow children to lean over and easily fall into the pool headfirst. Ladders supplied with inexpensive aboveground pools generally cannot be locked to block access and are cumbersome to remove from the pools. Whether portable or fixed, children may be able to gain access to the water more easily than parents and caregivers intend. Children can enter the pool using the pool ladder (68%) or by climbing on a nearby object (20%).⁴⁵ In a study of aboveground pools, children between 42 and 54 months of age were shown to be able to climb into a pool with a 48-inch wall, even if the ladder was removed.⁴⁶

It is important to stress that no single intervention is fully protective. Rather, multiple layers of protection are recommended. Industry is advised to develop affordable and effective products that include isolation fencing, safety covers, and alarms for portable pools. Extensive public education should stress that children can drown in portable pools. These efforts should be combined with strategies that reduce drowning risk, such as close supervision, CPR education, and methods to prevent unsupervised children from gaining access to these pools.⁴⁷

Drain Entrapment

Entrapment and hair entanglement remain causes of injury and drowning in the pediatric population. The CPSC reported 11 victims of circulation entrapment from 2014 to 2018 (4 pool and 7 spa), including 2 fatalities, all in children aged 0 to 14 years, with the peak in the 5- to 9-year age group.⁴⁸ A circulation entrapment is defined as an entrapment involving the water circulation system of the product. Hair entanglement typically involves girls with long hair who are underwater near a suction outlet. The water flow into the drain sweeps the hair into and around the drain cover, where it becomes entangled in the holes and protrusions of the cover. Other types of entrapment involve a limb or body part. This scenario often involves a child playing with an open drain, inserting a hand or foot into the pipe, and then becoming trapped by increasing suction and resulting tissue swelling. Deaths occur from drowning.

Entrapment and entanglement can be prevented by the use of special drain covers, safety vacuum release systems (SVRSs), filter pumps with multiple drains, and a variety of other pressure-venting filter construction techniques.⁴⁹ Unfortunately, many parents and pool and spa owners are not aware of the risk of entrapment and entanglement; only 15% have installed antivortex drain covers, only 14% have multiple drain systems, and only 12% have SVRSs in their pools or spas.⁵⁰ In 2007, Congress passed the Virginia Graeme Baker Pool and Spa Safety Act, which requires drain covers, unblockable drains, and SVRSs for all public pools and spas in the United States.⁵¹ The act markedly reduced the number of injuries and deaths attributable to drain entrapment.⁵² Although the act does

not apply to private pools, residential pool owners can protect against entrapment by implementing the recommendations reflected in the legislation.

Lapses in Adult Supervision

Although poor supervision is often cited as a contributing factor for childhood drowning, especially for younger children,^{18,53,54} an accepted definition for adequate supervision is lacking.⁵⁵ Supervisory behavior has been described as being composed of 3 components: proximity, attention, and continuity.⁵⁶ Attention and continuity are related to awareness, and proximity is related to the ability to intervene if needed. Proximity might be particularly important for young children and/or nonswimmers. For beginning swimmers, adequate supervision should include “touch supervision” in which the supervising adult is within arm’s reach of the child so they can pull the child from the water if the child’s head becomes submerged. High levels of all 3 components are likely necessary to keep children safe when around water. When children are not intended to be in or around the water, differing levels of the components may be appropriate, but the inevitable decreases in attention and proximity and lapses in continuity highlight the need for barriers to prevent water entry. It is important to note that supervision cannot replace barriers, and barriers cannot eliminate the need for supervision; they should work in conjunction with each other.

Drowning most often occurs quickly and quietly during periods of inadequate supervision. In Bangladesh, a case-control study of unintentional injury deaths among children younger than 5 years found that fatalities were 3 times more likely to occur in unsupervised

children compared with matched, alive children.²² Among 127 drowning deaths in children examined by a state’s child death review teams, 38 (30%) were not in the care of an adult (4% unsupervised entirely, 25% with other children or friends, 4% at a location with lifeguards present). In deaths occurring among children younger than 5 years, teams identified inadequate supervision and isolated neglect as a factor in 68% (21 of 31) of cases.¹⁸ When responding to an online questionnaire, parents admitted that they talked to others (38%), read (18%), ate (17%), and talked on the phone (11%) while supervising their child near water.⁵⁷ In a study of 496 drowning deaths in children younger than 14 years that were reviewed by state child death review teams, only 10% were completely unsupervised at the time of the drowning.⁵⁷ A more recent examination of national child death review data found that supervision was assessed to be lacking in 49% of incidents involving children drowning in pools. Caregivers often provided inadequate supervision because of drug or alcohol impairment, injury or illness, or distraction. Necessary supervision was noted to be lacking more often among drowning deaths involving younger children compared with older children.⁵⁴ Similarly, in an Australian study of 339 unintentional drowning deaths among children aged 0 to 14 years, coroners identified lack of supervision as a contributory factor in 72% of cases.⁵³

Parental perceptions regarding necessary levels of supervision change as children progress through swim training, potentially to the detriment of the child’s safety.^{58,59} In a survey of parents of children aged 2 to 5 years enrolled in community swim lessons 4 times

over 8 months, as parents’ perceptions of their child’s swim skill increased, their belief in the child’s ability to keep themselves safe in the water increased and their perception regarding the need for parental supervision decreased.⁵⁹ The sociocultural norms and environment of a community can also influence parental perceptions and resultant supervisory behavior that is deemed appropriate.⁶⁰

Alcohol

Alcohol plays a significant role in drowning risk related to boating, swimming, and supervision. A meta-analysis found that 30% to 70% of swimming and boating fatal drowning victims had a measurable blood alcohol concentration (BAC) and that 10% to 30% of these deaths could be attributed specifically to alcohol use.⁶¹ In boating, there is evidence that the relative risk of drowning death is directly related to BAC, with a 16-fold greater risk when BAC was greater than 0.10 (100 mg/dL).⁶² Boat passengers are at risk for alcohol-related drowning regardless of the alcohol use of the boat operator.⁶³ Most drownings associated with alcohol occur during recreational periods, over weekends, and in the afternoon. A longitudinal study showed that a decrease in regional unintentional drowning rates was associated with a decrease in deaths attributable to alcohol use.^{64,65}

Alcohol may increase the risk of drowning not only by impairing judgment and performance but also through physiologic effects (eg, poor balance, impaired orientation, hypothermia) that affect survival once submersion occurs.⁶² Alcohol use while boating is also significantly associated with low or no life jacket use.⁶⁶ Little information is available regarding the association of drug use and

drowning. In a 10-year retrospective study from Ohio, researchers found that only 3% of 141 accidental drowning deaths were associated with illicit drugs.⁶⁷

Studies examining the relationship of caregiver alcohol use and unintentional childhood injury indicate that caregiver-reported number of drinks predicted decreased caregiver supervision and a higher likelihood of children sustaining injury.^{68,69} Avoidance of alcohol and drug intake positively affects caregivers' prevention of and recognition and response to a child struggling to swim in water, resulting in better drowning surveillance. Alcohol and other drug use should be avoided when swimming, boating, or supervising children in and around the water. Boaters should be educated about the dangers of consuming alcohol when operating or riding in a watercraft, and authorities should enforce local Boating Under the Influence legislation.

At-Risk Populations

Certain populations are at increased risk of drowning because of behavioral, skill, or environmental factors as well as underlying medical conditions.

Toddlers

For the period 2014–2018, the highest rate of drowning occurred in the 0- to 4-year age group (2.26 per 100 000 population), with children aged 12 to 36 months being at highest risk (3.38 per 100 000). Most infants drown in bathtubs and buckets, whereas the majority of preschool-aged children drown in swimming pools.²⁹ These children are developmentally curious and drawn to water but lack the awareness of its dangers. For instance, as many as 35% of typically developing children aged

10 to 18 months can climb into a bathtub.⁷⁰

Therefore, the primary problem for this young age group is lack of barriers to prevent unanticipated, unsupervised access to water, including swimming pools, hot tubs and spas, bathtubs, natural bodies of water, and standing water in homes (buckets, tubs, and toilets). The CPSC found that 69% of children younger than 5 years were not expected to be at or in the pool at the time of a drowning incident.⁷¹

Adolescents

Older adolescents (aged 15 to 19 years) have the second-highest fatal drowning rates. In this age group, approximately one-half of all drownings occur in natural water settings.⁷² In 2016, SafeKids Worldwide reported that the natural water fatal drowning rate for adolescents aged 15 to 17 years was more than 3 times higher than that for children aged 5 to 9 years and twice the rate for children younger than 5 years.⁵⁴ Adolescence is a formative period, often involving seeking high-intensity and exciting experiences and sensations.⁷³ During this time, adolescents are especially vulnerable to the presence of peers. The mere presence of peers promotes risk-taking activity, especially if the adolescent has experienced previous social isolation.⁷⁴ This behavioral psychology plays a role in vulnerable teenagers, especially adolescent boys of racial and ethnic minorities, in social aquatic activities. The increased risk for fatal drowning in adolescents can be attributed to several factors, including overestimation of skills, underestimation of dangerous situations, engagement in high-risk and impulsive behaviors, and substance use.⁷⁵ Alcohol remains a leading factor in drowning deaths among adolescents and adults,

contributing to 30% to 70% of recreational water deaths among US adolescents and adults.⁷⁶ Providing drowning prevention anticipatory guidance to adolescents and their caregivers, especially relating to alcohol use, can help address reported low rates of water safety knowledge in this age group.⁷⁷

Boaters

In 2019, the US Coast Guard reported 46 boating deaths in individuals aged 19 years and younger, with 59% attributed to drowning; the remainder were mostly attributable to trauma. The majority (78%) of the boating deaths in this age group occurred while riding in an open motorboat (39%) or canoe or kayak (39%). Analysis of all fatal boating incidents revealed that 70% of the operators had not had boating safety instruction, and 23% of the incidents cited alcohol as a leading factor.⁷⁸

Most boating-related drowning deaths (86%) occur among individuals who are not wearing a life jacket.⁷⁸ In children younger than 14 years, nearly 45% of those who died in a boating-related incident were not wearing a life jacket.⁵⁷ Federal law requires life jacket use for children younger than 13 years on recreational boats in the United States. In an observational study of small boats, researchers found that 90% of children younger than 5 years wore life vests, but only 13% among those aged 14 years or older wore life vests.⁷⁹ Trends in life jacket use from 1999 to 2010 showed an increase in life jacket use across all pediatric age groups in all boat types, but only an increase among adult boaters in sailboats.⁸⁰ Another observational study of swimmers and waders in designated swim areas revealed that life jacket and other flotation device use decreased with increasing age,

with 50% of children younger than 6 years using a life jacket compared with 3% of adults.⁸¹

Underlying Medical Conditions

Epilepsy

Epilepsy is a known risk factor in drowning, and drowning is the most common cause of death from unintentional injury for people with epilepsy, most commonly in bathtubs.⁸² Children with epilepsy have a relative risk for fatal and nonfatal drowning 7.5-fold to 10-fold higher than children without seizures.^{83,84} Drowning risk is dependent on such factors as age, severity of illness, degree of exposure to water, and level of supervision.^{83–85}

Despite this drowning risk, water-based activities such as swimming can be safe for children with epilepsy, especially for those with well-controlled seizures (as defined by the child's neurologist). Many children with epilepsy learn to swim (and can do so safely), and some children with epilepsy swim competitively. Children with poorly controlled seizures (as defined by the child's neurologist) might be safest with one-to-one direct supervision (ie, constantly attentive and ready to quickly intervene) during water-based activities. Bathtubs and shallow water can present a hazard for any child with epilepsy, and showers are preferred over baths when age appropriate.¹⁷

Parents of children with poorly controlled seizure disorders should have a discussion with their child's neurologist or pediatrician before any swim activity. Whenever possible, children with epilepsy should also consider swimming only at locations where there is a lifeguard to add a layer of protection to their one-to-one supervision.

Autism

Children with ASD are at increased risk of drowning. A 2017 study revealed that unintentional injury deaths were nearly 3 times as likely for all individuals with ASD compared with the general population.⁸⁶ This excess risk was particularly high for children with greater degrees of intellectual disability⁸⁷ and for those younger than 15 years, who were reportedly 40 times more likely to die of injury.⁸⁶ Drowning, specifically, is a leading cause of unintentional injury deaths among children with ASD.⁸⁶ Wandering was the most commonly reported behavior leading to drowning, accounting for nearly 74% of fatal drowning incidents among children with ASD.⁸⁸ It has been proposed that swimming lessons be provided to children after the diagnosis of ASD is made.⁸⁶ A small pilot study of an 8-hour aquatic group therapy program demonstrated a statistically significant increase in water safety skills among children with ASD.⁸⁹ However, swimming instruction alone may not confer the necessary ability to transfer learned skills from one water setting to another. Supervision and barriers with alarms are critical layers of protection against drowning for children with ASD and other disabilities. Additionally, removal of enticing toys from the pool area when the pool is not in use is advised. The National Autism Association's Big Red Safety Box⁹⁰ is a resource that aids in development of a safety plan for public places where there is a handoff of supervision so that children with ASD and other disabilities do not wander off.

Attention-Deficit/Hyperactivity Disorder

Although it has not been specifically examined, children with a diagnosis of attention-deficit/hyperactivity disorder (ADHD) may have an

increased risk of drowning related to increased risk taking and impulsivity. Studies suggest a strong association between ADHD and risk of all unintentional injuries.^{91,92} Studies have demonstrated a reduction in unintentional injury risk among those children diagnosed with ADHD who are being treated with medication.^{92,93}

Other Neurologic Diagnoses

For children with neuromuscular junction and muscle diseases or peripheral neuropathies, risk of participation in water-based activities may depend on the degree of fatigability and whether the disease is rapidly degenerative. If engaging in water-based activities, consultation with the child's neurologist and one-to-one adult supervision (ie, constantly attentive and ready to quickly intervene) is advised. Children with movement disorders, hemiplegia or diplegia (eg, cerebral palsy, stroke), white matter diseases (eg, adrenoleukodystrophy), and neuroimmunological disorders (eg, multiple sclerosis), have varied effects of the diseases on water safety and may have individualized capabilities. Therefore, consultation with a child's neurologist is advised regarding participation in water-based activities. Children with implantable devices (eg, ventriculoperitoneal shunts, vagus nerve stimulators) are also advised to consult their neurosurgeon about water safety.

Cardiac Arrhythmias

Exertion while swimming can trigger arrhythmia among individuals with long QT syndrome.⁹⁴ Although the condition is rare and such cases represent a small percentage of drownings, long QT syndrome should be considered as a possible cause for unexplained submersion injuries among proficient swimmers in low-risk

settings. Additionally, Brugada syndrome and catecholaminergic polymorphic ventricular tachycardia may also lead to increased risk.⁹⁵ This increased drowning risk underscores the need to counsel on the importance of close supervision for any child or adolescent with these conditions when in or around water.

Interventions

In the Haddon matrix of injury prevention, safety interventions are aimed at changing the environment, the individual at risk, or the agent of injury (in this case, water). For drowning prevention, the environment and the individual are the prime targets (Table 3). Experts generally recommend multiple layers of protection be used to prevent drowning because no single strategy is likely to prevent all submersion deaths and injuries. Such layers might include environmental changes, such as adult supervision, antientrapment and antientanglement measures, pool fencing, pool covers, water entry alarms, lifeguards, and CPR training. Additional prevention layers focused on the individual would include strategies such as swimming and survival skills training and use of life jackets. A concise list of recommendations can be found in the AAP policy statement "Prevention of Drowning."⁹⁶

Adult Supervision

Close, attentive, and constant supervision of young children when they are in or around any body of water is an essential preventive strategy.^{18,53} Appropriate supervision also includes examination of any unfamiliar environment for water hazards (eg, unfenced pool or pond) and prevention measures (eg, doors locked, gates closed). Adequate supervision should include being

capable of recognizing and responding appropriately to a swimmer in distress. Diligent supervision, along with other measures, may be increasingly important among children with conditions that increase drowning risks, such as ASD or seizures, as noted above. Additionally, supervision is paramount in environments where barrier fencing is not possible.

Unfortunately, parents and caregivers may have misperceptions about what drowning looks like and how to appropriately supervise children.^{54,97} In a survey of 1003 parents of children aged 0 to 12 years with access to a pool, researchers found that 48% of parents mistakenly believed they would be able to hear splashing or crying if their child was in trouble in the water, 56% believed that a lifeguard, if present, is the primary person responsible for supervising their child, and 32% reported leaving their child entirely unsupervised in a pool for 2 minutes or longer.⁵⁴

Because young children who fall into water often make no noise and can be hard to see below the water surface, proper care of a young nonswimmer or beginning swimmer requires the supervising adult to be constantly attentive, in close proximity (ie, within arm's reach) and prepared to intervene. To stress the importance of supervision, as part of a water safety program, some communities promote "water watchers," encouraging a designated adult (identified with a hat or lanyard) to be responsible for constant supervision without engaging in any distracting activities.³⁹ However, these programs have not been evaluated. In an attempt to improve parental supervisory behaviors at public pools, an educational program (Keep Watch @ Public Pools) was piloted

in Melbourne, Australia. At intervention pools, researchers observed improved attention, proximity, and preparedness among parents of children aged 6 to 10 years but no significant changes among parents of younger or older swimmers.⁹⁸

Appropriate adult supervision for children around water is close, constant, competent, and attentive. In addition, supervisors need to know what a distressed swimmer looks like and how to safely intervene if needed. Development and evaluation of effective water safety education for parents are still needed.

Antientrapment and Antientanglement Measures

Entrapment and entanglement prevention measures include use of special drain covers, SVRSs, filter pumps with multiple drains, and a variety of other pressure-venting filter construction techniques.⁴⁹ Although such devices are required in commercial pools, they are often not required in residential pools.⁴⁷ Residential pool owners should be educated to include these effective safety measures.

Pool Fencing

Pool fencing is one of the most important prevention strategies to decrease the risk of drowning in swimming pools when children are not supposed to have access to the water. Compared with no fencing, installation of 4-sided fencing that isolates the pool from the house and yard has been demonstrated to decrease the number of pool immersion injuries among young children by more than 50%.^{99–101} A Cochrane meta-analysis of available studies found that the odds ratio for a drowning in a fenced versus an unfenced pool was 0.27 (95% confidence interval [CI]: 0.16–0.47). In this analysis, 4-sided fencing

TABLE 3 Haddon Matrix for Drowning Prevention Strategies With Associated Levels of Evidence

	Personal	Equipment	Physical Environment	Social Environment
Pre-event	Provide close, constant, attentive supervision of children and poor swimmers ^a Evaluate preexisting health condition ^c Develop water competency, including swim ability ^a Know how to choose and fit a life jacket ^c Avoid substance use ^a Know the water's hazards and conditions ^c Swim at a designated swim site ^d Learn CPR ^b Take a boater education course ^c — —	Install 4-sided fencing that completely isolates the pool from the house and yard ^b Install self-closing and latching gates ^b Wear life jackets ^b Install compliant pool drains ^a Install door locks ^c Enclosures for natural bodies of water ^c Promote life jacket loaner programs ^c Role model life jacket use by adults ^a Make rescue devices available at swim sites ^c Provide ability to call for help ^b Ensure functional watercraft ^c	Swim where there are lifeguards ^a Attend to warning signage ^c Swim at designated swim sites ^c Remove toys from pools when not in use to reduce temptation for children to enter the pool ^c Empty water buckets and wading pools ^c Lakefront slope gradient ^d	Mandate 4-sided residential pool fencing ^b Mandate life jacket wear ^b Adopt the Model Aquatic Health Code ^c Increase availability of lifeguards ^a Increase access to affordable and culturally compatible swim lessons ^c Close high-risk waters during high-risk times ^d Develop designated natural water swim sites ^d Enforce Boating Under the Influence laws ^b
Event	Water survival skills ^c	Rescue device available ^c	Lifeguard or bystander response ^b	Emergency Medical System ^b
Postevent	— —	AED ^c Rescue equipment ^c	Early bystander CPR ^b EMS response ^b	Advanced medical care ^c

^a Trials or diagnostic studies with minor limitations; consistent findings from multiple observational studies.

^b Well-designed and conducted trials, meta-analyses on applicable populations.

^c Expert opinion, case reports, reasoning from first principles.

^d Single or few observational studies or multiple studies with inconsistent findings or major limitations.

(which isolates the pool from the house and yard) was superior to 3-sided fencing (which allows direct access to the pool from the house) with an odds ratio of 0.17 (95% CI: 0.07–0.44).¹⁰¹ In an Australian study, researchers found that the risk of a child drowning in a pool with 3-sided fencing was almost twice that seen in pools with 4-sided fencing (incidence rate ratio, 1.78; 95% CI: 1.40–1.79).²⁸

Unfortunately, laws and ordinances regarding pool fencing may have dangerous loopholes. The Virginia Graeme Baker Pool and Spa Safety Act defined minimum state law requirements as “the enclosure of all outdoor residential pools and spas

by barriers to entry that will effectively prevent small children from gaining unsupervised and unfettered access to the pool or spa.”⁵¹ Three-sided fencing with self-locking or alarming doors between the house and pool area are often considered acceptable, and, in some locales, pool covers can substitute for a fence. Often, a fence law pertains only to new pool construction or to homes in which a young child is actually living at the time of the pool installation. Furthermore, in the United States, pool fences are rarely inspected and ordinances are often not enforced. In a recent Australian study, researchers found that government inspections raised the rate of

compliance with pool fencing laws from approximately 50% to 97%.¹⁰² Another study from Australia revealed that in the 5 years after enactment of legislation to improve the effectiveness of pool fencing, the number of private swimming pool drowning deaths halved.¹⁰³

Children’s ability to climb fences varies with the type of fence. In one study, chain-link fences were easily scaled by children, whereas ornamental iron bar fences proved more difficult to climb.¹⁰⁴ Fences should be at least 4 feet high, and no opening under the fence should be more than 4 inches (some building codes require a 5-foot fence and a maximum fence-to-ground

distance of only 2 inches). Vertical members of the fence should be less than 4 inches apart to keep a child from squeezing through, and there should be no foot- or handholds that could help a young child climb the fence. The fence should not prevent a clear view of the pool. Gates should be self-closing and self-latching, with the latch placed at least 54 inches above the bottom of the gate. The gate should open away from the pool (so that it will not open if leaned on) and should be checked often to ensure good working order. Pool gate alarms may provide additional protection, but no research exists on their efficacy. Detailed guidelines for safety barriers for home pools are available online from the CPSC,⁴² but homeowners must also be aware of local laws and building codes regarding pool fence construction and after installation continue to check the fence and gate's integrity.

Pool Covers

Retractable pool covers and pool nets capable of holding the weight of a child have been advertised as effective barriers for drowning prevention. Because these covers must be removed and replaced each time the pool is used, they are less likely to be effective. Active interventions requiring an action each time they are to be used are proven to be less effective than passive interventions, which are always in effect.^{105,106} The CPSC states that power safety covers can be installed on pools to serve as a security barrier, especially if the pool is not completely separated from the house and the yard by a fence.⁴² However, there is currently no evidence to support this recommendation, and pool covers may impart a false sense of security. Because there are no studies regarding the efficacy of pool covers,

they cannot be recommended as a substitute for isolation fencing.

On the contrary, some types of pool covers actually present a hazard for children. In 1980, the CPSC issued a warning about solar pool covers that are designed to keep the water warm and minimize pool chemical and water evaporation. When children try to walk on or remove these thin sheets of plastic, they can drown when they become entangled in the cover or hidden from view.¹⁰⁷ Additionally, even weight-bearing pool covers can make it difficult to see beneath them, potentially concealing a drowning victim.

Alarms

Pool Alarms

The CPSC has evaluated the performance of surface, subsurface, and wristband pool alarms. Several of these alarms functioned properly; however, the report concluded that alarms "should not be relied on as a substitute for supervision or a barrier completely surrounding the pool." No study has demonstrated whether pool alarms prevent drowning.¹⁰⁸ Additional research is needed to evaluate the efficacy of pool alarms, door alarms, and pool covers in the prevention of drowning.

Door Alarms

Many homes with pools, including private residences and homes used as vacation rentals, have doors that open directly into the pool area. It is important that all homes with pools have security measures in place so that children cannot enter the pool area unsupervised. Door alarms are one way to alert that the child has gained access to the pool area. The CPSC recommends that door alarms sound for at least 30 seconds within 7 seconds of the door opening, that the alarm be loud and distinct from other sounds in the house, and that the alarm have an automatic reset

feature.⁴² Effectiveness of door alarms has not been studied, and they should only be used as an adjunct to other proven layers of protection against drowning.

Lifeguards

Although no formal scientific study has quantified the value of lifeguards, anecdotal reports indicate that drowning rates are lower when lifeguards are present.¹⁰⁹ The United States Lifesaving Association (USLA) reports that more than 75% of drownings at USLA sites occurred at times when the beaches were unguarded, and the estimate that a person will die by drowning while protected by USLA-affiliated lifeguards is 1 in 18 million.¹¹⁰ In addition to rescue efforts, lifeguards serve to make beaches safer by monitoring the aquatic environment, enforcing rules and regulations, and educating beachgoers about safety and injury prevention. Lifeguards most often perform prevention activities (54.8%), with rescues representing only 1.9% of lifeguard interventions.¹¹¹ Studies indicate that lifeguards are cost-effective^{112,113} and reduce situations likely to end in injury or drowning.¹⁰⁹ Those choosing to swim in natural bodies of water or other sites accessible to the public should swim in designated swim areas with lifeguards present.

Although lifeguards are an important layer of protection against drowning, they are only one part of a multilayered approach. A study examining fatalities in lifeguarded US swimming pools found that, in fatal incidents, swimmers and pool bystanders were twice as likely to identify the submersion victim as were lifeguards.¹¹⁴ A survey found that 20% of parents interviewed thought that the lifeguard was the main person responsible for supervising

their child while in the water, leading to a false sense of security and a resultant lack of parental supervision.⁵⁷ Nevertheless, trained, professional lifeguards provide a significant layer of protection to swimmers, especially through trained rescue and resuscitation in the event of a significant submersion. However, lifeguards do not take the place of caregiver supervision.

Bystander CPR

Immediate resuscitation at the submersion site, even before the arrival of emergency medical services (EMS) personnel, is the most effective means to improve outcomes in the event of a submersion incident.^{2,3} Prompt initiation of bystander CPR and activation of prehospital advanced cardiac life support for the pediatric submersion victim have the greatest effects on survival and significantly improved neurologic prognosis.^{4,115}

Although the Centers for Disease Control and Prevention recommends all caregivers and supervisors of children be trained in CPR,³² several strategies can increase first response skills, including rescue and infant and child CPR training for caregivers of at-risk drowning populations. A video on drowning risk, pool fencing, and CPR shown to pregnant pool owners increased their likelihood of obtaining CPR instruction compared with those not shown the video.¹¹⁶ Another study, the American Heart Association's "Child CPR Anytime," a 25-minute CPR instruction given to parents while their children were in a community swim lesson, led to significant sustained improvement in parental knowledge and confidence in performing CPR.¹¹⁷

Drowning can be described as a continuum, with an initial phase of respiratory arrest but intact circulation that will progress to cardiac arrest if hypoxia persists. In the first stage of the drowning

continuum (ie, after a witnessed or brief submersion), rescue breathing to provide effective ventilation of the victim may be sufficient if circulation remains intact. As the drowning victim progresses from respiratory arrest to cardiac arrest (no palpable pulse), resuscitation using the compressions-airway-breathing sequence is initiated. "Hands-only" CPR is not appropriate for drowning victims because hypoxia is almost exclusively the cause of cardiac arrest resulting from drowning.¹¹⁸ In a recent study on bystander CPR after drowning, resuscitation of victims aged 5 to 15 years using compression and ventilation CPR was statistically significantly associated with neurologically favorable survival and survival to hospital discharge compared with compression-only CPR.¹¹⁹

Automated external defibrillator (AED) use may not be beneficial in resuscitation of the drowning victim as opposed to other etiologies of cardiac arrest. In a recent study, application of an AED before the arrival of EMS, even for patients found to have a shockable rhythm, was associated with decreased likelihood of favorable neurologic outcome.¹¹⁵ Authors postulated that lay rescuers may have prioritized AED application over ventilation provided by CPR or had prolonged resuscitation duration until arrival of EMS.¹¹⁵ The Heimlich maneuver is not recommended because positive-pressure ventilation by mouth or mask will accomplish adequate oxygenation without the delay caused by performing the Heimlich maneuver.¹⁰⁸ Current American Heart Association guidelines recommend that drowning victims who require any form of resuscitation (including only rescue breaths) be transported to the ED for evaluation and monitoring, even if they appear alert with effective cardiopulmonary function at the scene.¹²⁰

Swimming Lessons, Water Survival Training, and Water Competency

All children should eventually learn to swim. Swim skill and water competency may be the most important drowning prevention measures in natural water settings because fencing and lifeguarding may be impractical in these settings. The position of the AAP has focused on the child being "developmentally ready" for formal swimming lessons. Developmental readiness for swim lessons is multifaceted; the determinant of readiness is not the child's age but the confluence of physical, social, behavioral and emotional, and cognitive skills balanced against the environmental risks of drowning.

It has been demonstrated that children aged 2–4 years can acquire the motor skills for swimming and that most children aged 4.5 years are developmentally ready to do so; by 5 or 6 years of age, most can master the front crawl.^{121–123} Subsequently, Brenner et al revealed the preschool age group experienced a reduction in fatal drowning risk if they had had swim lessons,¹²⁴ as did Yang et al in a study of Chinese preschoolers.¹²⁵ School-aged children in the Bangladesh SwimSafe Program were demonstrated to have significantly decreased drowning rates.¹²⁶

Before a case-control study of swimming lessons,¹²⁴ concerns about early swim lessons were based on the fear that swim lessons might increase drowning risk,¹²⁷ with the premise that parents whose children were in swim programs would have a false sense of security, resulting in inadequate supervision around water. Several studies have shown that parents of small children enrolled in swimming lessons were more likely to endorse the statements "swimming lessons are the best way to prevent drowning,"

“toddlers can learn to save themselves if they fall into water,” and “it is better to develop swimming ability rather than rely on adult supervision.”^{128,129} When these parents were given a targeted educational program to reverse misconceptions about toddler water safety or given feedback about their child’s progress or stories of close calls, they were more likely to agree that their child required more, not less, supervision and more likely to disagree that swimming lessons were the best way to prevent drowning.^{58,128} Thus, swim lessons should include parental training to improve the parents’ understanding of their child’s actual swimming abilities and continued risk.

The American Red Cross Scientific Advisory Council defines basic swim skills as the following: ability to enter the water, surface, turn around, propel oneself for at least 25 yards, and then exit the water.¹²⁹ It is important to recognize that performance of these water survival skills, usually learned in a pool, is affected by the aquatic environment (water temperature, movement, depth, clothing, distance), for which a person may be unprepared. Demonstration of skills in one aquatic environment may not transfer to another. Effective swim lessons should provide repeated and progressively more experiential training, including swimming in clothes, swimming in life jackets, falling in, and self-rescue. Consequently, achieving basic swim skills requires multiple sessions of lessons. Thus, parents need to be aware of their child’s progress and keep their child in lessons until basic water competency skills are achieved. More research is needed to determine which types of swim instruction and water survival skills training are most effective in preventing drowning in children of all ages.

The international drowning prevention community has begun to expand the concept of water competency to include needed skills, knowledge, and behaviors.⁵ In addition to basic swim skills, water competency should include knowledge of local hazards in the aquatic environment, risk judgment and self-assessment of abilities, and recognition and response to a person in distress in the water, including safe rescue and CPR.⁵ Thus, acquisition of water competency is a protracted process that involves learning in conjunction with developmental maturation and physical skill sets by the child.

Barriers to swim lessons and water competency are more commonly based in cultural norms, economics, and access. Black communities have reported a legacy of reluctance to engage in swimming related to long-standing segregation and exclusion from public pools.¹³⁰ Vietnamese immigrant families reported that pool environments are alien and cold and recreational swimming is not valued.¹³¹ Clothing that protects modesty may not be allowed in some pools, and, for some religious and ethnic groups, single-sex aquatic settings are required.¹⁷ In addition, the multiple swim sessions required to achieve basic water competency can be costly, and access to affordable, convenient, and culturally appropriate swim lessons may be limited. Moreover, decreased municipal funding for swimming pools and lifeguards has worsened access to swimming lessons and safe water recreation in many communities. These barriers can, and should, be addressed through community-based programs targeting high-risk groups by providing free or low-cost swim lessons, developing special programs and changing pool policies, using language and culturally appropriate instructors to

deliver water safety classes, and working with health care clinics and places of worship to refer families to swim programs.^{17,132}

Although early instruction may be beneficial, there are currently no data to support a recommendation for infant swim lessons. Aquatic programs for young children (especially those younger than 1 year) pose some medical concerns, and initiation of a swim program should be discussed between an infant’s caregiver and pediatrician. These include the risk of gastrointestinal tract infections, dermatitis, and acute respiratory illness that result from exposure to infectious agents and pool chemicals. Hyponatremia from ingesting water and hypothermia are also health risks to the infant.¹³³ Fortunately, medical problems from swimming are rare, treatable, and preventable events.^{134,135} The World Aquatic Babies and Children Network has published guidelines for the operation of aquatic programs for children younger than 3 years. The guidelines recommend (1) required parental involvement, (2) a fun atmosphere with one-on-one teaching, (3) qualified teachers, (4) warm water to prevent hypothermia, (5) maintenance of water purity, and (6) a limited number of submersions to prevent water ingestion and hyponatremia.¹³⁶ The American Red Cross has resources for choosing a swim program.¹³⁷

Multiple studies have found that exposure to chlorination byproducts in swimming pools can damage respiratory epithelium and can result in a child’s predisposition to asthma and bronchitis and other allergic conditions.^{138–142} However, a longitudinal study of children from birth to age 7 to 10 years revealed no increased risk of respiratory symptoms, allergy, or asthma among those with chronic but

noncompetitive swimming pool exposure. In fact, their lung function was better.¹⁴¹

The AAP supports swimming lessons for children older than 1 year. Swim lessons are increasingly available for children with various disabilities, including autism, or other health conditions. A parent's decision about when to initiate swimming lessons must be individualized on the basis of a variety of factors, such as frequency of exposure to water, health concerns, emotional maturity, and physical limitations, while considering that toddlers aged 12 to 36 months are at highest risk of drowning. It must be stressed that swimming lessons, in isolation, will not drown-proof a child. The goal of swim lessons is to reduce the risk of drowning but also to promote and prepare for parent-child activities, exercise, fun, and enjoyment of the long process of acquiring aquatic learning and water competency. Swim ability must be considered as only one part of water competency and of a multilayered protection plan involving effective pool barriers, constant and capable supervision, life jacket use, and lifeguards. Parents and guardians of children should become an integral component of aquatic programs to facilitate and continue development of their child's water competence.

Importantly, parental acquisition of water competency knowledge and behaviors are critical to reinforce and promote the child's water competency. Because parents and caregivers are usually the most immediate layer of protection, they need to learn key physical skill sets, too. Untrained rescuers, such as a parent or bystander, often die when they enter the water to attempt the rescue of a drowning victim.^{143–145}

Even a small child can drown an untrained rescuer. Sometimes the primary drowning victim survives, whereas the intended rescuer, often

a male relative, fatally drowns; other times, both die.¹⁴⁴ Because rescuer safety must be the priority, only people trained in the advanced skills of water rescue should enter the water. Safer rescue techniques should be taught to children and their parents as a part of comprehensive water safety training during swim lessons.¹⁴⁶ These techniques involve reaching with an object or throwing something that floats to avoid water entry ("Reach, throw, or row; don't go"). Safe rescue of a drowning person requires knowing one's limitations, risks, and training to avoid putting oneself at risk.

Life Jackets

Life jackets prevent drowning by keeping the airway out of the water when the user is immersed. Life jacket requirements for boaters have been promoted by the US Coast Guard and watersports organizations. Life jackets prevent drowning deaths; the use of an approved life jacket decreased boat-related drowning morbidity and mortality by 50%.^{147,148}

Unfortunately, their use remains low; US Coast Guard boating statistics from 2017 indicate that in only 15.5% of fatal drownings among all ages, the victims were wearing a life jacket.⁷⁸ However, in the past 10 years, life jacket use among children and teenagers younger than 18 years in boats has increased from 56% to 65% nationally. Reasons commonly cited for not wearing a life jacket include beliefs that drowning risk is low; that life jackets restrict movement, are uncomfortable, or are unattractive; and that wearing a life jacket is a sign of fear or inexperience.⁶⁶ Recent changes in life jacket design address some of these concerns. Parents of children who do not always wear life jackets report reasons including the following: (1) the parent is in close

proximity to the child, (2) a life jacket for the child is onboard in case of emergency, and/or (3) the child has good swimming skills.⁵⁷ Importantly, many drowning incident reports include parents who drown while attempting to help their child.^{143,145}

Life jacket use has expanded beyond boating; they are increasingly used for children who are weak swimmers or nonswimmers when near or in the water wading or swimming. In one recent study, 50% of children younger than 5 years wore one when in the water at designated natural water swim sites.⁸¹ Although anecdotal reports remain the only evidence supporting the effectiveness of life jackets for preventing drowning when swimming, the means of protection would be similar by keeping the airway out of the water.

Legislation is the most effective way to increase life jacket use, leading to 90% to 95% compliance among specific groups, such as children, people on personal watercraft, and those in activities such as water skiing.¹⁴⁹ Moreover, local ordinances requiring life jacket use by those near or in the water of specific high-risk waterways have led to observed increases in life jacket wear.¹⁵⁰ Parental modeling¹⁴⁸ and educational campaigns¹⁵¹ can both increase life jacket use among children and teenagers in boats. Life jacket loaner programs at swimming and boating sites increase access to life jackets, often at no cost, and allow a family to choose to recreate at a safer site. Some states now require camps and other venues to provide life jackets for swimmer use.¹⁵²

To decrease consumer confusion and increase wear, standardization of life jacket wear requirements is needed. Many states that share

bodies of natural water have different laws. Few states mandate life jacket use among boating teenagers; only Louisiana requires use for those younger than 17 years.¹⁵³ Using a risk reduction approach, state life jacket laws should include adolescents, the highest risk age group, and address small vessels, including paddle craft.

Newer life jackets address some of the barriers to their use. Inflatable life jackets are light and not bulky but are only for those aged ≥ 16 years, are costly, and require replacement of the inflating carbon dioxide cylinder. US Coast Guard–approved life jackets now include a model similar to the inflatable arm floats popular among preschoolers because it facilitates floating (eg, the Puddle Jumper). Parents need to check that any life jacket fits appropriately and is US Coast Guard approved because there are many similar products that do not meet safety requirements. It is important to recognize that air-filled swimming aids (such as inflatable armbands) are toys that can deflate or slip off and should not be used in place of life jackets. Information about infant and child life jackets for a variety of aquatic situations is available online from the US Coast Guard.¹⁵⁴

Boating Safety

Preventing boating-related injuries and deaths requires good boat maintenance and function and safe and sober operators and passengers. Parents can teach boating and water safety to their children and prohibit alcohol use during recreational water activities. They can check that the boat operator has had boater education, does not use or allow drug or alcohol intake while boating, has appropriately sized US Coast Guard–approved life jackets available for each passenger per federal law, and will both wear a life

jacket and require children to wear them.

Multiple studies using different methodologies consistently show that life jackets decrease boating-related injuries and deaths by 50%.¹⁴⁸ In a matched cohort control study of all boating deaths reported to the US Coast Guard, boaters who wore life jackets had 50% lower death rates compared with those who did not in the same boat.¹⁴⁷ In Australia, a mandatory life jacket law increased life jacket wear and also decreased boating drowning deaths by 50%.¹⁵⁵

In contrast to boating requirements, all states mandate that all people wear a life jacket when on a personal watercraft or when being towed behind a boat, such as water skiing or water boarding. Life jacket wear rates among people of all ages participating in these activities are greater than 90%.¹⁵⁶ A national law requires that every boat has available an appropriately sized life jacket for each passenger.¹⁵³ Almost all states require children to wear a life jacket when in boats; however, the mandated upper age varies from 5 to 16 years.¹⁵³ For states lacking life jacket laws, federal law mandates life jackets be worn by children younger than 13 years on a moving boat.¹⁵³ These mandates explain why national wear rates have increased since 1999 only among pediatric age groups, including teenagers. In 2017, wear rates were 94% in children younger than 5 years, 87% in those 6 to 12 years, and 46.5% in those 13 to 17 years.¹⁵⁶ In contrast, despite continued efforts and recommendations by multiple organizations to promote life jacket use while boating, wear rates among adult motor boaters, the largest group of boaters, remain stagnant and low.

Boaters' life jacket wear increases when mandated^{149,150,155}; the higher rates observed among teenagers, even when not mandated, may be spillover effects from pediatric laws. Wear rates also increase with adult modeling; in Washington state, if even 1 adult in the boat wore a life jacket, the likelihood of adolescent use rose to 81.4%, compared with only 36.1% of adolescents accompanied by adults not wearing a life jacket.¹⁴⁹

Drowning Chain of Survival

The Drowning Chain of Survival (Fig 1) refers to a series of steps that, when enacted, attempt to reduce mortality associated with drowning. The steps of the chain are the following: Prevent drowning, recognize distress, provide flotation, remove from water, and provide care as needed. The chain starts with prevention, the most important and effective step to reducing morbidity and mortality from drowning.¹⁵⁷ The subsequent steps of the Drowning Chain of Survival differ uniquely from the Cardiac Arrest Chain of Survival because of the water environment; flotation is needed to keep the victim's airway out of the water and to facilitate getting them to land. The drowning time line (Fig 2) shows the different levels of actions and interventions chronologically that could interrupt each sequence of the drowning process once drowning begins.¹⁵⁸ These interventions may be used by the drowning victim who has swim skills to self-rescue or the parent or lifeguard who needs to recognize the child in trouble, initiate a safe rescue, and provide CPR. The time line shows that rescue and resuscitation of a drowning victim must occur within minutes to save lives. It also shows that the lay rescuers' efforts should take place out of the water to prevent the rescuer from risk of also drowning.^{143,144} Moreover, it



FIGURE 1 Drowning chain of survival. Adapted from Szpilman D, Webber J, Quan L, et al. Creating a drowning chain of survival. *Resuscitation*. 2014;85(9):1151.

underscores the critically time-sensitive role of the parent or supervising adult in preventing a drowning and stopping it from becoming a fatality.

Outcome Predictors

The clinical outcome for pediatric drowning victims can be difficult to predict and depends on multiple factors.¹⁵⁹ Prognosis is ultimately dependent on the extent of cerebral hypoxia and resultant cerebral damage incurred during the initial drowning event and retrieval from

the water.¹⁶⁰ Good outcomes (survival with no neurologic sequelae) are increased with submersion durations of less than 6 minutes and EMS response times of less than 10 minutes,¹⁶¹ which can be facilitated by early rescue and initiation of bystander CPR.^{2,115} The Submersion Score, a compilation of clinical signs, has identified pediatric patients at low risk for injury after significant submersion.¹⁶² In addition, a recent study identified that low-risk patients had normal vital signs and pulse oximetry at the

time of arrival to the ED.¹⁶³ Despite the common belief that young age is protective, a meta-analysis found that young age did not correlate with better outcome.¹⁶¹

The strongest predictor of poor outcome (death or survival with moderate or severe neurologic sequelae) appears to be increased submersion duration of 6 minutes or longer, with a low likelihood of good outcome after submersion greater than 10 minutes.^{118,161} In a recent study on childhood swimming pool submersions, poor outcome was associated with submersions 5 minutes or longer in duration and those occurring on weekdays (possibly because events held at multiresident pools have a higher chance of bystander rescue on weekends).¹⁶⁴ The highest risk ratio in a recent systematic review and meta-analysis was submersion of 15 to 25 minutes' duration, with those longer than 25 minutes being invariably fatal.¹⁶¹

In addition to submersion duration, poor outcome predictors include additional prehospital factors (duration of apnea), initial ED presentation (fixed and dilated pupils, bradycardia or asystole, hypothermia, Glasgow coma scale score <5, prolonged CPR duration), and other hospital course determinants (intubation and use of inotropes); however, none are absolutely predictive of outcome.^{159,165} Current evidence has not found a protective

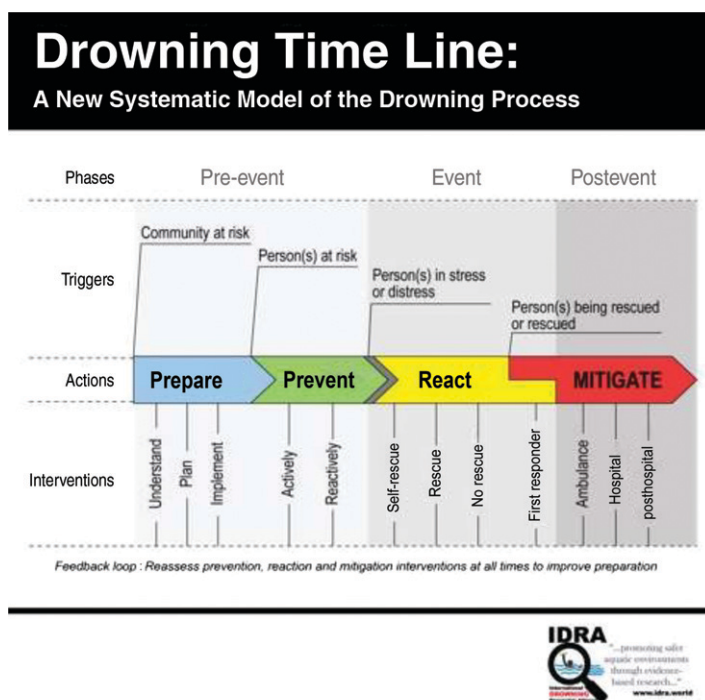


FIGURE 2 Drowning time line. Adapted from Szpilman D, Tipton M, Sempsrott J, et al. Drowning time-line: a new systematic model of the drowning process. *Am J Emerg Med*. 2016;34(11):2225.

effect of colder water temperatures for drowning victims, and hypothermia does not improve chances of survival.^{95,161,166} Although acidemia on blood gas analysis (as a surrogate for respiratory failure with hypoxia) and hyperkalemia may suggest poor prognosis, there are insufficient data to adequately predict poor outcome for patients with these laboratory findings.⁹⁵

The majority of pediatric nonfatal drowning victims have a good outcome without neurologic sequelae; however, some survivors may have significant long-term neurologic deficits. Children whose submersion duration exceeded 10 minutes had a significantly poorer health-related quality of life than those who were submerged for shorter durations.¹⁶⁷ Patients admitted to the hospital who demonstrated no neurologic improvement at 48 hours had a poor prognosis.⁹⁵ Factors independently associated with higher long-term mortality risk for survivors of nonfatal drownings include age 5 to 15 years and severe neurologic impairment at discharge.¹⁶⁸ Ultimately, because in-hospital treatment has not been demonstrated to improve drowning outcomes,⁶⁴ prevention of drowning incidents is critical.

Policy Statement

Advice pediatricians may provide to parents and recommendations for advocacy at the community level is

available in the accompanying policy statement.⁹⁶

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ABBREVIATIONS

AAP: American Academy of Pediatrics
ADHD: attention-deficit/hyperactivity disorder
AED: automated external defibrillator
AI: American Indian
AN: Alaskan native
ASD: autism spectrum disorder
BAC: blood alcohol content
CI: confidence interval
CPR: cardiopulmonary resuscitation
CPSC: Consumer Product Safety Commission
ED: emergency department
EMS: emergency medical services
SVRS: safety vacuum release system
USLA: US Lifesaving Association

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