AMERICAN ACADEMY OF PEDIATRICS

TECHNICAL REPORT

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Prevention of Drowning in Infants, Children, and Adolescents

ABSTRACT. Drowning is a leading cause of injury-related death in children. In 2000, more than 1400 US children younger than 20 years drowned. Most (91%) of these deaths were unintentional and were not related to boating. For each drowning death, it is estimated that at least 1 to 4 children suffer a serious nonfatal submersion event, many of which leave children with permanent disabilities. Environmental strategies, such as installation of 4-sided fences around swimming pools, and behavioral strategies, such as increased supervision of children while around water, are needed to prevent these tragedies.

ABBREVIATIONS. YPLL, years of potential life lost; CPR, cardiopulmonary resuscitation; *ICD-9, International Classification of Diseases, Ninth Revision*; *ICD-10, International Classification of Diseases, 10th Revision*; CPSC, Consumer Product Safety Commission.

BACKGROUND

Drowning and near-drowning are major causes of childhood morbidity and mortality from injury. From 1990 to 2000, drowning was the second leading cause of unintentional injury death among US children between 1 and 19 years of age.[1] Among toddlers 12 to 23 months of age, it was the leading cause of injury death and the second leading cause of death overall. Because injuries occur disproportionately among youth, they are the leading cause of years of potential life lost (YPLL). Among unintentional injuries, drownings are the third leading cause of YPLL, with 120 470 YPLL attributable to drownings in 2000.[1]

Drowning, by definition, is fatal; near-drowning, defined as initial survival after submersion, is sometimes fatal. Drowning has been defined as death resulting from suffocation within 24 hours of submersion in water; victims of near-drowning survive for at least 24 hours.[2] In 2000, more than 1400 US children younger than 20 years drowned. Most (91%) of these deaths were unintentional and were not related to boating.[3] Case fatality rates vary by age and from study to study. It is estimated that for each drowning death, there are 1 to 4 nonfatal submersions serious enough to result in hospitalization.[4–8] Children who still require cardiopulmonary resuscitation (CPR) at the time they arrive at the emergency department have a poor prognosis, with at least half of the survivors suffering significant neurologic impairment.[8–12]

The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

RISK FACTORS

Sociodemographic Factors

Rates of drowning vary with gender, age, socioeconomic status, and race.[13–15] After 1 year of age, males are at greater risk than are females (Fig 1). Among females, drowning rates peak at 1 to 2 years of age and decrease thereafter. Among males, there are peaks in both the toddler and adolescent age groups. For all ages combined, drowning rates vary inversely with per capita income.[13] However, a study of pool drownings conducted in California found that among children younger than 10 years of age, drowning rates were highest in cities or regions with higher median family incomes.[16] In this study, income was not significantly associated with the rate of drowning after adjusting for pool density; thus, the higher drowning rates in more affluent communities are likely attributable to increased exposure to residential swimming pools.

Racial disparities in childhood drowning rates are most marked after 5 years of age. For example, among males 5 to 19 years of age, drowning rates are higher among American Indian/Alaska Native, black, and Asian/Pacific Islander males than among white males (Fig 2). One study, which examined the site of drowning by age and race, found that white and black adolescent males were most likely to drown in natural bodies of freshwater (eg, rivers and lakes); however, much of the increased risk among black males was attributable to high rates of drowning in swimming pools.[17] Additional research is needed to understand factors that contribute to disparities in risks of drowning among different populations.

Temporal and Geographic Variation

Among all causes of unintentional injury death, drowning shows the greatest seasonal variation.[13,18] Among drowning victims younger than 15 years, two thirds of deaths occur from May through August.[18] Drowning also occurs disproportionately on Saturdays and Sundays.[13] Among children 5 through 19 years of age, 39% of drowning deaths in 1995 occurred on the weekend (R. A. Brenner, Investiga-

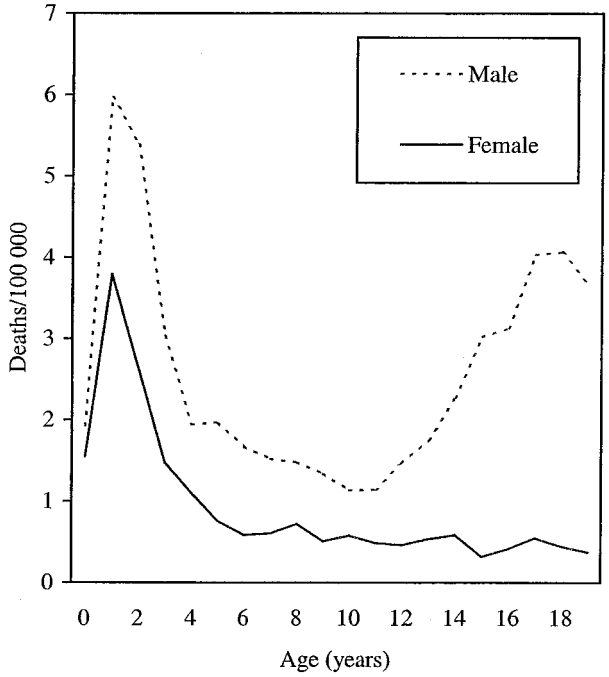

Fig 1. Unintentional drowning rates among children 0 to 19 years of age (United States, 1996–2000). Inclusion criteria for drowning deaths: 1996–1998 *ICD-9* codes E830, E832, and E910; 1999–2000 *ICD-10* codes W65-W74, V90, and V92.

tor, National Institute of Child Health and Human Development/Department of Health and Human Services unpublished data, personal communication). A population-based study in Houston, Texas, examined submersion incidents that occurred between 1990 and 2000 and required an emergency medical services response.[19] Among 473 submersions of children 0 through 14 years of age, 83% occurred between noon and 8:00 PM.

Childhood drowning rates vary from one state to another. For the 10-year period of 1989–1998, unintentional, nonboat-related drowning rates among children 19 years or younger varied from a low of 0.91 per 100 000 in New Hampshire to a high of 3.48 per 100 000 in Florida.[3]

Location and Circumstances

Analyses of all childhood drownings in the United States in 1995 showed that most drownings (78%) among infants occurred in the home, primarily in bathtubs (55%) and buckets (12%).[17] Children between 1 and 4 years of age were most likely to drown in swimming pools (58% of drownings among 1- to 2-year-olds and 51% among 3- to 4-year-olds). However, more than 25% of drownings in this age group were in other freshwater settings, such as ponds, rivers, and lakes. Children older than 5 years were most likely to drown in natural freshwater sites, such as rivers and lakes: (54% of drownings among 5- to 9-year-olds, 61% among 10- to 14-year-olds, and 69% among 15- to 19-year-olds). These results are consistent with most regional studies.[4,20,21] However, the most common sites of drowning vary with region of the country, socioeconomic status, and other factors. For example, in Harris County, Texas, the number of drownings in swimming pools exceeded the number in natural bodies of freshwater for all age groups younger than 15 years,[22] and in Pinnelas County, a coastal community in Florida, after 11 years of age, drownings were most likely to occur in natural bodies of saltwater.[23]

Few large studies have examined the circumstances of drowning deaths. A multistate study conducted by the US Consumer Product Safety Commission (CPSC) revealed that most children younger than 5 years who drowned or nearly drowned did so by entering the pool from their home through the unprotected side of the pool (the side of the pool that directly faces the house, with no intervening fence).[24] Most children were last seen in the home and were out of the parent's or caregiver's eye contact for only a moment, and the immersion was silent (no screams or splashing heard).

Lapses in Adult Supervision

A 10-year study of childhood submersions in King County, Washington, found that inadequate supervision was the most common factor associated with submersions.[4] Studies of bathtub drownings indicate that there is usually a history of leaving the infant

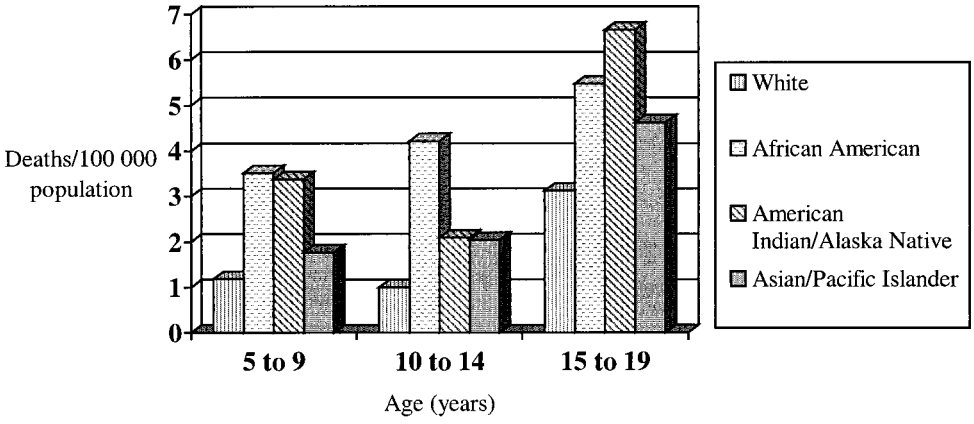

Fig 2. Unintentional drowning rates among males by age and race (United States, 1996–2000). Inclusion criteria for drowning deaths: 1996–1998 *ICD-9* codes E830, E832, and E910; and 1999–2000 *ICD-10* codes W65-W74, V90, and V92.

unattended or in the care of another child.[4,22,25–28] In most cases, the adult reports leaving the child for a short time to answer the phone or attend to household chores. In contrast, the study in King County found that among adolescents, 59% of events were reportedly witnessed; however, most (57%) of the witnessed events were witnessed by peers.[4] Swimming in remote locations, in sites that are not designated swim areas, and without lifeguards likely contribute to many drownings among adolescents.[5]

Alcohol

Alcohol is estimated to be involved in 30% to 50% of adolescent and adult drownings.[5,29] A study of drowning deaths in King County found that although the proportion of deaths in which alcohol is involved has decreased significantly in the past 25 years, alcohol was still involved in 31% of drowning deaths among people older than 15 years from 1990 to 1995.[30] A case-control study of boat-related deaths among adults, most of which were attributable to drowning, indicated that people with blood alcohol concentrations greater than 100 mg/dL (0.10) had a 16-fold increased risk of drowning compared with people with no alcohol in their blood.[31] It has been postulated that alcohol increases the risk of drowning not only by impairing judgment and performance but also through direct physiologic effects that affect survival once a submersion occurs.[5,32] Although a number of drugs are also likely to increase the risk of drowning, studies documenting this are lacking.[5]

Swimming Ability

Few studies have examined the relationship between swimming ability and the risk of drowning, and there is no clear evidence that drowning rates are higher in poor swimmers. Some have even suggested that, at a population level, increased swimming proficiency might lead to an increase in drowning rates through increased exposure to water.[33–35] For example, among older children and adults, better swimmers are likely to participate in more water-related activities and may feel confident enough to swim in higher-risk settings, such as remote natural bodies of water with no lifeguards present. However, research in this area is lacking.

We are aware of only 1 study that has attempted to examine swimming ability among childhood drowning victims and in a comparable population at risk of drowning. The CPSC conducted a study in 8 counties in the United States in 1986.[36] Information about swimming ability was gathered through interviews with families of children younger than 5 years who drowned in a residential pool and through interviews with families of children of comparable age who lived in homes with pools. Although the authors suggest that increased swimming ability decreased the risk of submersion injury and that this effect was greater for older children, limitations of the study also prompted the authors to state, "we have not calculated the relative impact of swimming ability on accident risk because of possible biases in the variable."[36]

Other studies have compared self-report or parental report of swimming ability within specific age, gender, and racial groups with population data on drowning rates among the same demographic groups. A study published in 1977 surveyed 9420 children in grades 2 through 7 in 2 communities in South Carolina.[37] In this study, 25% of white males, 33% of white females, 60% of black males, and 78% of black females reported inability to swim in deep water. Data regarding drownings in the same state demonstrated that rates were highest among black males, followed by white males and then black females, and rates were lowest among white females. Thus, in this study, the relationship between swimming ability and drowning rates was not consistent. However, it is difficult to make causal inferences from this type of study. A more recent study in New Jersey found that swimming ability increased with age of the child.[38] The percentage of parents reporting any level of swimming competence in their children increased from less than 20% for children younger than 2 years to more than 80% for children older than 11 years. This study also found that white children were reportedly stronger swimmers than nonwhite children of the same age.

Underlying Medical Conditions

Seizure disorder is a known risk factor for drowning. Children with epilepsy have been estimated to be at 4 to 14 times the risk of submersion compared with children without epilepsy.[5,39–41] Two recent studies suggest that children with autism may also be at increased risk of drowning.[42,43] However, both studies are based on a small number of drowning deaths. Additional research is needed to evaluate the relation between autism and other underlying conditions and the risk of drowning. Cardiac arrhythmias, in particular long QT syndrome, may be the cause of a small fraction of unexplained drownings.[44] This syndrome should be considered as an explanation for sudden, unexplained submersions (eg, submersion of a proficient swimmer in a low-risk setting).

PREVENTION OF INJURY

A systematic review of primary strategies for prevention of childhood injuries has been conducted by the Injury Prevention and Research Center of Harborview Medical Center as part of the Cochrane Collaboration.[45] Many of the prevention strategies related to childhood drowning are summarized below. Experts recommend layers of protection, because no single strategy is likely to prevent all submersion deaths and injuries.

Four-Sided Fencing

Pool fencing is an important prevention strategy to decrease the risk of drowning in swimming pools. Installation of 4-sided fencing that isolates the pool from the house and the yard has been shown to decrease the number of pool immersion injuries

among young children by more than 50%.[46–48] One meta-analysis of available studies found the odds ratio for a drowning (or near-drowning) in a fenced versus an unfenced pool to be 0.27.[48]

Children's ability to climb fences varies with the type of fence. In 1 study, chain-link fences were easily scaled by young children, whereas ornamental iron bar fences, which retain visibility, proved to be more difficult to climb.[49] Fences should be at least 4 feet high, and no opening under the fence or between uprights should be more than 4 inches. Gates should be self-latching and self-closing, should open away from the pool, and should be checked often to ensure good working order. Detailed guidelines for safety barriers for home pools are available online from the CPSC.[50]

Pool Alarms and Pool Covers

The CPSC recently reviewed performance of a number of different types of pool alarms.[51] Although pool alarms and rigid pool covers may provide additional layers of protection, they should not be used in place of a 4-sided fence, because they are not likely to be used appropriately and consistently. Further, some types of pool covers present an additional hazard for young children. A 1986 study conducted by the CPSC found that, of 142 drownings or near-drownings in swimming pools, 8 involved pool covers. The scenarios generally involved children discovered under nonrigid pool covers (eg, solar or plastic covers) after apparently trying to walk on the covered pool.[24] Thus, these types of covers may actually increase the risk of a poor outcome, because a submerged child under the cover would be hidden from view, delaying rescue.[45]

Swimming Instruction

A number of studies have shown that swimming lessons improve swimming ability and that this effect can be seen with children as young as 24 months.[52–54] However, there are no data to show that swimming lessons actually decrease the risk of drowning. Thus, swimming lessons are not recommended as a means of drowning prevention, and the American Academy of Pediatrics states that "children are generally not developmentally ready for formal swimming lessons until after their fourth birthday."[55] Importantly, even among older children, knowing how to swim well in one body of water does not always make a child safe in another, and even the best swimmers are not "drown-proof."

Supervision/Lifeguards

Close supervision of young children around any water is an essential preventive strategy, but inevitable lapses make supervision alone insufficient. The presence of lifeguards increases the likelihood of a favorable outcome.[56–58] 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.

Resuscitation

Immediate resuscitation at the site of a submersion incident, before the arrival of paramedic personnel, is an important means of secondary prevention and is associated with a significantly better neurologic outcome in children with submersion injury.[9] Initial resuscitative efforts of bystanders should include rescue breathing (generally mouth-to-mouth ventilation, in the absence of resuscitative equipment) and chest compressions when signs of circulation are absent.[59] Although some have advocated abdominal thrusts (Heimlich maneuver) to expel water from the airways before initiation of CPR,[60,61] most experts agree that this maneuver should not be used as a first-line therapy in resuscitating drowning victims, because it delays the onset of CPR and may induce vomiting and the aspiration of gastric contents.[5,59,62] Additional education for health care professionals on resuscitation of pediatric patients is available through American Academy of Pediatrics programs, Pediatric Advanced Life Support (PALS) and Pediatric Education for Prehospital Professionals (PEPP).

Personal Flotation Devices

The use of an approved personal flotation device, although not well evaluated, appears likely to decrease drowning morbidity and mortality rates in older children when boating or playing beside streams, rivers, or lakes.[45,56] It is important to recognize that air-filled swimming aids (such as "water wings") should not be used in place of personal flotation devices (life preservers).

Advice pediatricians may provide to parents and recommendations for advocacy at the community level are specified in the accompanying policy statement.[63]

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