Ten-Year Study of Pediatric Drownings and Near-Drownings in King County, Washington: Lessons in Injury Prevention

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Ten-Year Study of Pediatric Drownings and Near-Drownings in King County, Washington: Lessons in Injury Prevention

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ABSTRACT. The factors associated with submersion events among <20-year-old persons that occurred in King County from 1974 to 1983 were studied to focus prevention efforts. Near-drowning (n = 103) and drowning (n = 96) victims were identified from medical examiners' reports, paramedics' reports, and hospital discharge registers. Annual incidence was 5.5; the mortality rate was 2.6 per 100,000 children. Although preschool-aged children had the largest incidence (12.8), followed by older adolescents (4.9), adolescents had the largest case fatality rate, 77%. Lake and river victims had the largest incidence, mortality, and case fatality rate; swimming pools, the smallest case fatality rate (25%). A total of 89% of all victims had absent or no supervision; victims supervised by lifeguards had a 42% case fatality rate. Prior seizures were part of the history of 7.5% of all victims; 25% of fatal submersions by adolescents were associated with alcohol. Bathtub submersions were associated with child abuse in three of 16 preschool-aged children and epilepsy in four of five older children. Certain age groups and sites combined had the greatest incidence: preschool-aged children in swimming pools, infants in bathtubs, teenagers in lakes and rivers. Incidence decreased in public and semipublic pools coincident with fencing regulations. These findings suggest prevention strategies: extending fencing requirements to private pools, discouraging alcohol consumption during water sports, changing bathing practices of epileptics, and improving lifeguard efficacy. *Pediatrics* 1989;83:1035–1040; *submersion, drowning, near-drowning, injury prevention.*

Drowning is the second most common cause of unintentional injury death among children. Although near-drownings may result in mild to severe long-term neurologic deficits, in most epidemiologic studies of drowning, only episodes resulting in death have been examined.[1–7] Studies in which both fatal and nonfatal submersions were examined were done in tropical regions where swimming pools were the overwhelming water hazard.[8,9] In these communities, prevention efforts aimed at swimming pools would have major impact. In other regions, the risks for submersion as well as death should vary with the availability of other types of bodies of water. A study comparing different hazards could help a community focus its prevention resources.

Although specific risk factors for submersions such as epilepsy, alcohol, and intentional trauma (child abuse, homicide) are known, their relative impact in a community has not been studied. Knowing the relative frequency of these causes of submersion injuries could also help a community identify preventable aspects of submersions. The present study was undertaken to determine: (1) What pre-event characteristics such as activity, seizures, supervision, and child abuse are associated with pediatric submersion events? (2) Are these factors associated with specific settings? (3) What is suggested by these incidents for preventive strategies?

METHODS

Location of Study

King County, in western Washington state, is the most populous county of the Pacific Northwest. It includes the city of Seattle and contains a population of 1,269,750 (1980 US Census). Although 90% of the residents live in urban areas, the county's western border is Puget Sound and its eastern border is the crest of the Cascade mountains. The

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county contains 760 lakes and reservoirs and is drained by eight major river systems that contain innumerable tributaries and streams. The temperate climate has a distinct rainy winter season and relatively dry summer season. The average annual temperature ranges from 4.4° to 15.6°C (40° to 60°F) and average annual precipitation is 86.6 cm (34.1 in). The popularity of boating, fishing, and other water sports, and the proximity of densely populated areas to the water all contribute to the risk of submersion incidents.

Case Identification

Detailed information concerning all drowning fatalities in King County for persons less than 20 years of age during the years 1974 to 1983 was obtained from the King County Medical Examiners' Office. This office conducts investigations including alcohol and drug assays for all drowning fatalities in the county and has done so since 1968. Near-drowning victims were defined as all children in this age group who had a submersion incident in King County necessitating hospitalization. These children were identified by searching: (1) reports of the Seattle Fire Department Emergency Medical Services Medic Units; (2) the discharge registers of 22 of the 23 acute care hospitals in King County, including the Children's Hospital and the regional trauma center, for charts coded for drownings (*International Classification of Diseases*, ed 9 = 994.1). One small community hospital in which children are rarely hospitalized did not participate.

Only children residing in King County were included. The names from these sources were cross-checked to ensure that drowning and near-drowning categories were mutually exclusive. Information abstracted included the child's age, sex, activity at the time of the incident, site of the incident, submersion time, characteristics of supervision, and outcome. Residual neurologic impairment in survivors was categorized as severe (marked spasticity, no self-help skills), mild (ataxia, mild hypertonia), or none, based on review (L.Q.) of hospital charts. Lakes and rivers include official and nonofficial swimming areas. Public pools include pools available to the public or those of greater than 1,500 square feet in surface area; semipublic pools include pools provided for multiple users or cooperative groups. Private pools are those maintained by an individual for family use. Supervision was categorized as present (witnessing the event) and not present (not witnessing the event). Adequate supervision was defined as present adult supervision.

Examination of yearly population estimates for the county showed no discernible trends among the age groups of interest. Therefore, age and sex-specific drowning and near-drowning rates per 100,000 children were tabulated using King County population estimates from the 1980 US Census. Incidents involving intentional injury (child abuse) were not included in the rates. Case fatality rates were calculated to explore the association of various risk factors with survival.

RESULTS

A total of 204 submersion incidents were identified. Charts for five survivors could not be obtained; therefore these five were excluded. There were 96 fatalities: 72% died at the scene, 9% in a hospital emergency room, and 19% after admission to the hospital. Of the 103 survivors, 11% sustained mild and 5% sustained severe neurologic impairment. The rest were normal at the time of hospital discharge. There was no trend in the number of incidents throughout time. As would be expected, a seasonal trend was evident, with 67% of all drowning and near-drowning incidents occurring between May and August.

Age

Preschool-aged children were at greatest risk for drownings, near-drownings, and both combined, with rates of 4.1, 8.7, and 12.8, respectively (Table 1). The group at next greatest risk were those 15 to 19 years of age. Case fatality rates in older age groups were more than double those of younger age groups.

Sex

Most victims were boys (73%). After 1 year of age, boys had two to eight times greater risk than girls. The risk associated with being a boy increased with age (Table 2) for both incidence and mortality. The case fatality rate was greater for boys in every age group.

TABLE 1. Submersion Incidents and Mortality, King County, Washington*

Age Group (yr)	No.		Rate/100,000 Population/yr	
	Drowning	Near-drowning	Drowning	Near-drowning
<1	1	6	0.6	3.4
1–4	25	53	4.1	8.7
5–9	9	17	1.1	2.2
10–14	18	13	2.0	1.4
15–19	41	12	3.8	0.1
<1–19	94	101	2.6	2.8

* Based on 1980 US Census data. Does not include four child abuse victims.

TABLE 2. Sex Distribution of Drownings and Near-Drownings by Age, King County, Washington

Age Group (yr)	Male to Female Ratio			Case Fatality Rate (%)		
	No.	Incidence	Mortality	Male	Female	All
0–4	88	2.1	2.9	33	25	31
5–9	26	1.9	2.0	35	33	35
10–14	32	3.6	8.5	68	29	59
15–19	53	4.3	4.9	79	67	77
0–19	199	2.8	4.2	53	35	47

Supervision

Only 22 (11%) of 199 incidents occurred in a setting in which there was adequate supervision. Of the 137 identified supervisors, 56% were adults, 30% were peers, and 14% were lifeguards. Supervision varied with age. All infants had been left unattended by an adult or left with a preschool-aged child. Although supervisors could be identified for 84% of 1- to 4-year-old children, only 18% were present to witness the event. In contrast, 59% of supervisors for older adolescents witnessed the submersion; however, 57% of these were peers. The case fatality rate for victims supervised by adults was 30%, by lifeguards 42%, and by peers 71%.

Site

Only four incidents occurred in salt water. The largest proportion (67%) of fatalities occurred at lakes or rivers (Table 3). In contrast, swimming pools accounted for 49% of near-drownings. The number of submersion incidents at swimming pools steadily decreased during the 10-year period. Public and semipublic pools were the only sites at which a temporal trend occurred (Table 4). Risk of drowning at specific sites varied by age and sex of the child. Children less than 5 years of age were at greater risk of submersion in bathtubs, pools, and unofficial swimming areas, whereas those 15 to 19 years of age were at greater risk of submersion in lakes and rivers, which often involved boating or motor vehicles. Characteristics of victims at specific sites are shown in Table 5.

Bathtub. The majority (67%) of the 24 bathtub submersion victims were less than 5 years of age. Of these, all were bathing unattended or with another child less than 5 years of age. Of the five bathing victims who were 5 or more years old, four had a history of seizures; all died and none had detectable abusive drug or alcohol levels. Three of 16 (19%) of the bathtub submersion victims less than 5 years of age had signs of child abuse (prolonged absent supervision, delay by supervisor in seeking help, child's refusal to see parent). One infant was readmitted two days after submersion with a fatal head injury.

Pools. Twenty-two swimming pool submersions occurred at private homes, 13 in apartment complexes, and 24 in public or commercial settings. In private pools, 69% of victims submerged after falling into the pool; 20% were being supervised by an adult who witnessed the submersion. In contrast, 82% of public pool victims were submerged while swimming; 43% were being supervised by an adult who was present. A total of 21% of public and 31% of private pool submersion victims died. The case fatality rate of all pool submersion victims, 24%, was the least of all sites studied.

For most victims of swimming pool submersions, an identified adult was responsible for that child's welfare. However, an adult was present for only 25% of pool submersion incidents when lifeguards and swimming instructors were excluded.

Lakes and rivers. The largest proportion (41%) of lake and river submersion incidents involved older adolescents or young adults; 18% involved boating. Mortality in lake and river submersion incidents was the most of all sites studied. The case fatality rate of boat-, motor vehicle-, and dock-related submersions was 83%, 80%, and 86%, respectively.

Of 110 submersion victims tested for blood alcohol, ten had detectable levels. All of these submerged at lakes or rivers, five were boating, and three were in motor vehicles. The ten submersion victims with detectable levels of blood alcohol constituted 25% of teenage drownings: nine were 15 to 19 years old; the last was 13 years old.

Three submersion incidents occurred in hot tubs, all in 1982. All victims fell in and were less than 5 years old. Submersions were not due to spa suction apparatus.

DISCUSSION

The average annual submersion rate of King County for those less than 20 years of age is much less than rates reported elsewhere. Because the regional trauma center, Children's Hospital, and all emergency medical services-based hospitals are included, the likelihood of failure to detect a submersion victim is small. Presumably, the smaller submersion rates in King County are due to decreased exposure because of cooler climate. The rate for the summer months (May to August) is 11.0 per 100,000 population, similar to that seen in warmer cli-

TABLE 3. Submersion Rates per 100,000 Population by Age and Site, King County, Washington*

Age (yr)	Lake/River†		Pool		Bath	
	Incidence Rate (No.)	Mortality Rate (No.)	Incidence Rate (No.)	Mortality Rate (No.)	Incidence Rate (No.)	Morality Rate (No.)
<1	0.6 (1)	0 (0)	0 (0)	0 (0)	2.9 (5)	0.6 (1)
1–4	3.8 (23)	1.3 (8)	6.1 (37)	1.8 (11)	1.8 (11)	0.5 (3)
5–9	1.8 (14)	0.6 (5)	1.3 (10)	0.3 (2)	0.1 (1)	0.1 (1)
10–14	2.2 (20)	1.7 (16)	1.1 (10)	0.1 (1)	0.1 (1)	0.1 (1)
15–19	3.7 (40)	3.3 (35)	0.8 (9)	0.2 (2)	0.3 (3)	0.3 (3)
1–19	2.7 (98)	1.8 (64)	1.9 (66)	0.5 (16)	0.6 (21)	0.3 (9)

* Excludes four abuse victims and one victim whose submersion site was unknown.
† Includes motor vehicle accidents and boat- and dock-related submersions.

TABLE 4. Submersions at Pool Sites During 10-Year Period, King County, Washington

Pool Type	1974–1975	1976–1977	1978–1979	1980–1981	1982–1983	*P* Value (Kendall τ)
Public/semipublic	13	8	5	8	2	<.03
Private	3	5	6	3	5	<.35
Other	1	0	0	1	0	

TABLE 5. Characteristics of Submersion Victims at Selected Sites*

Characteristic	Lake/ River†	Pool	Bathtub
No.	99	66	24
Male to female ratio	3.5	2.3	1.2
Mean age (yr)	11.1	6.2	3.8
Case fatality rate (%)	65	24	42
Predrowning activity			
No.	91	58	24
Out of water (%)	28	45	4
Swimming (%)	45	50	0
Boating (%)	18	0	0
Other (%)	9	5	96
Supervision			
No.	63	48	19
Adult (%)	37	65	74
Lifeguard (%)	13	23	0
Peer (%)	44	13	26
Location of supervision			
No.	82	51	20
Present (%)	41	28	5
Not present (%)	59	73	95
Submersion time			
No.	70	49	17
<5 min (%)	39	71	65
6–9 min (%)	6	8	0
10–25 min (%)	23	16	29
>25 min (%)	32	4	6

* Includes four abuse victims. Numbers vary when data were not available for all incidents.
† Includes motor vehicle accidents and boat- and dock-related submersions.

mates.[7,8] A related factor is the relatively smaller pool to house ratio of King County (1:55 estimated for 1984) compared with Brisbane, Australia (1:13), and Honolulu (1:40), where submersions in pools accounted for the majority of submersions.[7,10]

In this study, case fatality rates varied with the victims' age and submersion site. The suggestion implicit in this finding is that any meaningful comparison of drowning fatality rates should be done in specific, comparable groups. The mortality rate of 2.3 per 100,000 children less than 16 years of age in King County is less than the corresponding rates of 3.1 in Honolulu, 3.2 in Georgia, and 5.2 in Brisbane.[4,7,8] In both Brisbane and King County, fatalities represented nearly 50% of submersions. However, the majority of Brisbane submersions involved preschool-aged children in pools. The same age group in King County submerged in pools had a smaller case fatality rate, 30%. The smaller case fatality rate for pool submersion victims in King

County may relate to other factors, such as the county's well developed prehospital emergency care system.

Incidences for boys were greater than those of girls at all sites, with the exception of bathtub submersions where exposure is most likely to be similar for both sexes. In few studies has there been an attempt to explain the sex differences in pediatric injury rates,[11] but behavioral sex differences are supported by these findings, even in the ambulating toddler.

Inadequate supervision was the most common factor associated with submersions. The two measures of "adequate" supervision related to the quality of the supervisor, adult *v* peer, and to the proximity of the adult to the victim. Proximity or closeness of supervision was a major factor associated with submersions of infants and preschool-aged children, whereas quality of the supervisor was a factor associated with submersions of teenagers. The presence of adequate supervision for 11% of submersions underlines the fact that in certain settings other preventive measures are needed as well.

Bathtub submersions occurred in all age groups. Three specific risk factors for bathtub submersions were identified: (1) absent supervision, (2) seizure history in the victim, and (3) child abuse. Because four of the five children more than 5 years of age who submerged in bathtubs were epileptics, a seizure in the bathtub is the most likely cause of submersion in these victims. The third factor, intentional injury or neglect, recognized in 19% of bathtub submersion victims younger than 5 years of age, must be considered as a potential cause in any bathtub submersion, as should alcohol and drugs that have been implicated in as many as 50% of adult bathtub fatalities.[12]

Prevention of infant and toddler bathtub submersions is difficult. The findings of this study suggest that younger children should not be left in the bath with a child less than 5 years of age. Providing this advice to families as anticipatory guidance is of unproven value, however.

Among all age groups with seizure disorders, changes in bathing behaviors could decrease risk. Although controversy exists concerning what constitutes the safest recommendations for bathing of seizure patients,[13–15] seizure patients and their families should be warned of the danger of children bathing unattended and given recommendations for alternatives such as showering or sponge bathing.

The residential swimming pool is the most common site of submersion for children less than 5 years of age. A lesson in prevention is provided in this. The incidence of swimming pool submersions decreased during the 10-year period, while the pediatric population was stable and the number of inground swimming pools increased by an estimated 2,000 (Swimming Pool Association of Washington, personal communication, March 1985). The trend of decreasing numbers of submersions only occurred in the semipublic (apartment, condominium, motel, swim club) and public pools, which were within the public health department jurisdiction. The incidence of private residential pool submersions remained unchanged; these pools were not within the jurisdiction of the public health department. This substantial decrease in submersion frequency could be attributable to increased use of fencing as a barrier. In 1981 a countywide ordinance required new and existing public and semipublic pools to have 152 cm (5 ft) high fences and self-closing gates. A pool inspection program was developed by the public health department. Fencing legislation in other areas has decreased numbers of drowning deaths.[16] It is unlikely that changes in parental supervision and pediatric behavior accounted for the observed trend; no major drowning or risk awareness campaign was conducted during this period. Although swimming programs for infants and toddlers are increasingly popular, they have not been shown to prevent drownings. (In this study, two drowning victims were graduates of "drown-proofing" courses.) Fencing requirements should apply to all pools, public and private, new and existing. Unfortunately, residential spa and hot tub submersions will continue to increase as spa use increases. The best barrier solution for these needs to be determined.

In spite of lifeguard staffing, public and semipublic swimming pools still represent a risk for school-aged children. The large case fatality rate of 42% for submersions in the presence of lifeguards seems high and reflects on the ability of the lifeguard to recognize, rescue, and resuscitate the drowning child. Cardiopulmonary resuscitation training and competency is not required for lifeguarding but should be. In this study, we could not evaluate how effective lifeguards were in preventing submersions. Better understanding is needed of factors that affect lifeguard supervision such as lighting, lifeguard positioning, and lifeguard to bather ratios. Upgrading lifeguard effectiveness in all these areas might improve outcome.

The percentage (7.5%) of patients with seizure disorders in bathtub and recreation-associated submersions is greater than previously reported.[13] Although water sports are a hazard to seizure patients, the proportion of victims dying from a submersion event was less if there was adult or lifeguard supervision.

Although lake and river submersions primarily involved adolescents engaged in water activities, there was also a risk for toddlers. Docks represent

a significant risk for death for both toddlers and adolescents. Water depth and poor water clarity preclude rapid rescue and probably explain the large case fatality rate for this group. Toddler-proofing of docks with rails that cannot be climbed could prevent toddlers from falling off the dock while allowing fishing and dock access from the water.

For adolescents, lakes and rivers in King County were the most common site for submersions. Lake and river submersion incidents were associated with (1) swimming in unofficial areas, (2) boating, (3) motor vehicle accidents, and (4) use of alcohol. The large mortality (88%) of adolescents involved in submersions in these sites is probably related to lack of supervision, difficulty of rescue, and the physiologic effect of alcohol.[17] Prevention of submersions by adolescents is difficult because of their risk-taking behavior and access to unsupervised bodies of water. Suicide and homicide may be factors in submersions by adolescents, although they were not identifiable as factors in this study.

Although public knowledge of the dangers of drinking and driving is now widespread, the dangers of alcohol consumption during recreational water activities should be publicized. In other studies, increased detectable blood alcohol levels were seen occasionally in preadolescents and 36% of persons 15 to 19 years of age who drowned.[5] The role of alcohol in near-drownings could not be evaluated in this study because blood alcohol studies were not obtained routinely in emergency rooms. All adolescent submersion victims should have blood alcohol and drug levels assayed to allow assessment for this risk factor. Programs to discourage alcohol use mixed with water activities are needed. Washington recently passed a driving while intoxicated law for boaters.

The multifaceted problem of near-drowning or drowning has outcomes that differ for various age groups and sites. Preventive measures for specific sites are obvious for selected age groups—toddlers near swimming pools or spas, toddlers near docks, school-aged swimmers with lifeguard supervision, and seizure patients in bathtubs. From a public health standpoint, relying on supervision of children will not be a sufficient means of prevention because supervision may lapse or, even if attentive, may be inadequate for the situation.

The relative availability of different types of bodies of water, ambient temperature, and recreational patterns vary in each community and determine the exposure and pattern of submersion. To compare and predict the impact of local prevention programs, each community or region must know its local epidemiology of submersions. Furthermore, because drowning deaths may represent only half of the submersions, surveillance systems should monitor both near-drownings and drowning deaths.

SUMMARY OF PREVENTION LESSONS

(1) Composing a sizable portion (7.5%) of submersion injuries, pediatric patients with seizures represent a specific target population for injury prevention. (2) Swimming pool submersions can be decreased by legislation requiring fencing. Pool-fencing programs need to apply to residential pools, where the majority of pool submersions occur. (3) Programs should be aimed at disassociating alcohol consumption and water activities such as boating and swimming. (4) Lifeguard efficacy should be improved.

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