

Christmas is a joyous time for most, but for parents Scott and Amanda and older sister Abby, Christmas Eve 2006 was the day they found their 14-month-old daughter Ruby face down in their home pool grey, lifeless and without a heartbeat. The family was preparing for Christmas when Scott and Amanda realized Ruby was missing. Scott's first instinct was to check the pool which had a makeshift fence while they were landscaping, but he couldn't see her and returned inside to continue looking.

Unknown to them, children sink when they drown and Ruby was actually at the bottom of the pool. It wasn't until Amanda re-checked the pool from a different angle that she discovered every parent's worst nightmare. Ruby was pulled from the water and Scott began CPR while Amanda frantically called an ambulance which took 40 minutes to reach their house. Fortunately Amanda had her GP's home number and she and her husband – both doctors – rushed to assist. Ruby was given CPR but still remained unresponsive and without a heartbeat. As a last resort the lifesaving decision was made to give her an adrenalin injection straight to the heart. To everyone's relief her heart began to beat and she was rushed to hospital.

Ruby was given a 10% chance of survival and Scott and Amanda were warned that if she did survive long-term brain damage was highly likely. But after spending Christmas day in an induced coma and a total of three weeks in the Paediatric Intensive Care Unit and Neurological ward, against all odds, Ruby made a miraculous recovery.

Ruby slowly regained her strength and learned to crawl and walk again and has begun to talk. Her fine motor skills were affected so she visits with an occupational therapist and physiotherapist every two weeks. The family have been told that it is now a matter of ensuring Ruby meets milestones and that if there is any long-term neurological damage it is likely to become evident when Ruby starts school.

Although Ruby's survival and miraculous progress are not typical of children who have experienced a non-fatal drowning, the circumstances in which it occurred are very common. A lapse in adult supervision even for very short periods of

time is a major contributing factor to children drowning. Big sister Abby was also deeply affected by the incident and Amanda says that she is an extremely anxious mother now, and so much more aware of potential hazards. Amanda says: "Before this happened I was very relaxed as a mum, maybe too much so, and thought that nothing would ever happen to my child. It's terrifying how quickly things can happen. I don't even want to dwell on what could've been, we are amazingly lucky. So many people have stories that don't all turn out as well as ours."



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Chapter 3

Drowning

Introduction

Water touches every aspect of children's lives. They need it to grow, they are comforted by it, they are cleaned and cooled by it – and without it they cannot survive. Water to most children means fun, play and adventure – in a pool, pond, lake or simply in the road following a rain storm. Water, though, can be a dangerous medium. A small child can drown in a few centimetres of water at the bottom of a bucket, in the bath, or in a rice field. Drowning is an injury that displays epidemiological patterns that change according to age group, body of water and activity. In most countries around the world, drowning ranks among the top three causes of death from unintentional injury, with the rates highest among children under five years of age.

This chapter describes the magnitude of the phenomenon of childhood drowning around the world, in terms of deaths, morbidity and disability – pointing to the likelihood that the true size of the problem has been substantially underestimated. It summarizes the risk and protective factors, with the Haddon matrix as a framework, and sets out the various prevention strategies, both proven and promising. The chapter concludes with recommendations, urging that confronting this preventable injury should be made a priority and given proper resources for research and prevention efforts.

For the purpose of this chapter, drowning refers to an event in which a child's airway is immersed in a liquid medium, leading to difficulty in breathing (1). This event may result in death or survival. The definition used in this report – *the process of experiencing respiratory impairment from submersion/immersion in liquid* (2) – is one agreed upon by experts at a recent world conference on drowning. This definition is simple and comprehensive, encompassing cases that result in either death, a certain level of morbidity or no morbidity (2).

High-income countries, such as Australia and United States, have seen dramatic reductions in death rates from drowning, which have most likely come about as a result of both changes in exposure to risk and the implementation of specific interventions (3, 4). The lessons learned from these countries may be applicable to other countries around the world in helping to develop prevention programmes.

Epidemiology of drowning

According to the WHO Global Burden of Disease estimates, 388 000 people died in 2004 as a result of drowning around the world, of whom 45% were under the age of 20 years

(see Statistical Annex, Table A.1). Fatal drowning ranked 13th as the overall cause of death among children under 15 years old, with the 1–4 year age group appearing at greatest risk. The overall global rate for drowning among children is 7.2 deaths per 100 000 population, though with significant regional variations. The drowning rate in low-income and middle-income countries is six times higher than in high-income countries (with rates of 7.8 per 100 000 and 1.2 per 100 000, respectively).

For those children who survive drowning, many are left with long-term consequences and disability that create enormous difficulties for families, with prohibitively high costs of health care. Global data show that approximately 28% of all unintentional injury deaths among children are due to drowning and 1.1% of all disability-adjusted life years (DALYs) lost for children under 15 years of age in low-income and middle-income countries are from non-fatal drowning (see Statistical Annex, Table A.2).

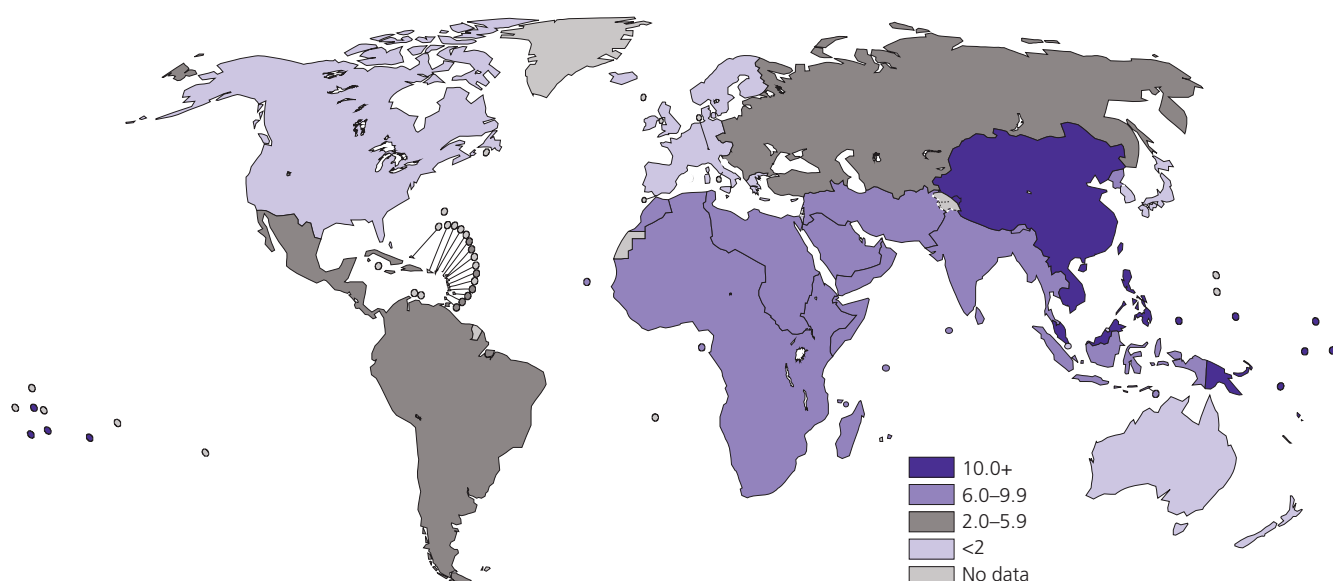
Available data show that there are substantial differences in drowning fatality rates across the globe. Comparisons, though, are difficult because of the use of different definitions, different categories counted or excluded in the data, the frequent lack of comprehensive national data and the variable quality of data. For some countries, mostly high-income ones, the pattern of fatal drowning is well documented. It now appears that there can be considerable differences both within and between countries and regions with regard to the nature and scale of childhood drowning. Although drowning rates have declined significantly in recent decades in some high-income countries, there are few established risk factors along with proven preventive strategies. This highlights the need for well-designed research to study the causes and origins of drowning injuries and to evaluate prevention measures.

Mortality

In 2004, approximately 175 000 children and youth under the age of 20 years died as a result of drowning around the world. The overwhelming majority, 98.1% of these deaths, occurred in low-income and middle-income countries (see Statistical Annex, Table A.1). The low-income and middle-income countries of the WHO Western Pacific Region have the highest rate of drowning deaths (13.9 per 100 000 population), followed by the African Region (7.2 per 100 000), the low-income and middle-income countries of the Eastern Mediterranean Region (6.8 per 100 000) and the South-East Asia Region (6.2 per 100 000) (see Figure 3.1).

FIGURE 3.1

Fatal drowning rates per 100 000 children^a by WHO region and country income level, World, 2004



| Africa | | Americas | | South-East Asia | Europe | | Eastern Mediterranean | | Western Pacific | |
|--------|-----|----------|------|-----------------|--------|------|-----------------------|------|-----------------|------|
| LMIC | HIC | LMIC | LMIC | LMIC | HIC | LMIC | HIC | LMIC | HIC | LMIC |
| 7.2 | 1.3 | 3.4 | | 6.2 | 0.6 | 4.0 | 6.2 | 6.8 | 1.2 | 13.9 |

^a These data refer to those under 20 years of age.

HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

The overall death rate in high-income countries is 1.2 per 100 000 population. However, the high-income countries within the Eastern Mediterranean Region have a rate of 6.2 per 100 000 – comparable to that of the low-income countries of the South-East Asia Region. Even within high-income countries, there appears to be considerable variability. According to the International Lifesaving Federation, drowning rates for Australia, Germany, Sweden and the United Kingdom in 2003 ranged between 0.6 per 100 000 and 1.5 per 100 000 – with children under the age of 18 years accounting for between 8% and 28% of these deaths (5).

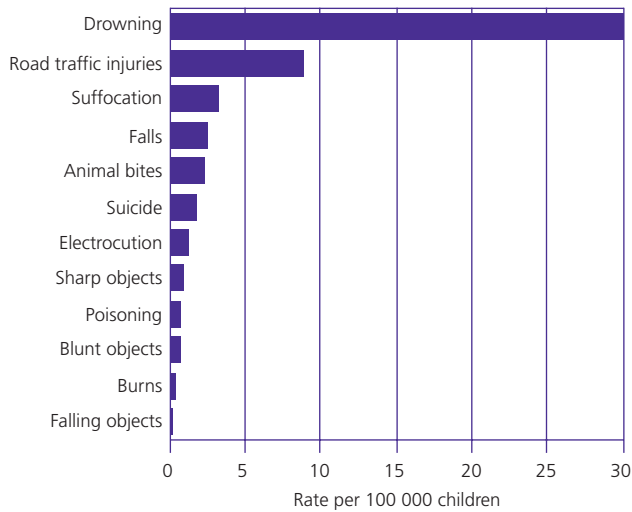
The actual number of drowning deaths in the world is likely to be much higher than the Global Burden of Disease figures suggest, particularly in certain regions of the world. In South and East Asia, for example, recent community surveys in five countries have indicated that drowning has been greatly underestimated by traditional methods of surveillance. In the countries studied, drowning was the leading cause of death among children under the age of 18 years (6). The death rate for drowning in these five countries was 30 per 100 000 population (see Figure 3.2), in stark contrast to the rate obtained by the Global Burden of Disease project of 6.6 per 100 000 population for the South-East Asia region and 13.9 per 100 000 for the Western Pacific Region in which these countries are located. For

example, the Bangladesh study found that the incidence of drowning fatalities among children aged 1 to 4 years was 86.3 per 100 000 children (7). In the Thai study, the rate for 5–9-year-olds was 31.2 per 100 000 population, with two-year old males having a drowning rate of a staggering 106.8 per 100 000 (8). One possible reason for this disparity is that the Global Burden of Disease estimates of death rates from drowning exclude submersions as a result of floods and water transport incidents. This exclusion is likely to lead to a significant underestimate of the death rates in low-income countries experiencing seasonal or periodic flooding (9).

Variability in drowning mortality rates within a region or within a country is also apparent. A possible explanation here is the exposure to open water. In Bangladesh, for example, a country with hundreds of rivers and tributaries, drowning was found to be the leading cause of death for children aged 1 to 9 years of age (7). Data from Beijing, China, on the other hand, showed a very low rate of drowning mortality (2.6 per 100 000 population) (10), possibly due to the fact that Beijing and its neighbouring districts have fewer bodies of water. However, in largely rural Guangxi province, which borders the ocean, drowning mortality rates are high – approaching 30 per 100 000 for children aged 0 to 4 years of age (11).

FIGURE 3.2

Fatal injury rates per 100 000 children aged 0–17 years in five^a Asian countries

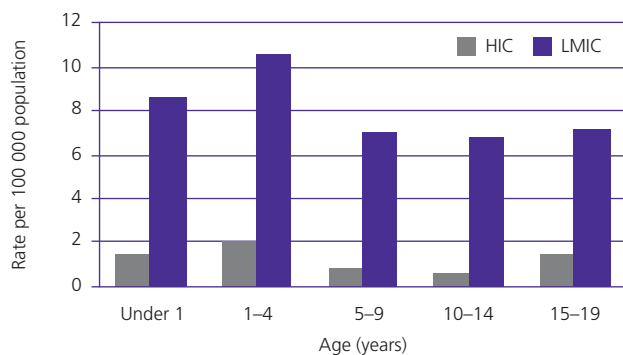


^a Bangladesh, China (Beijing, Jiangxi), Philippines, Thailand, Viet Nam

Source: reference 6.

FIGURE 3.3

Fatal drowning rates per 100 000 children by age and country income level, World, 2004



HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

TABLE 3.1

Fatal drowning rates per 100 000 children^a by sex, country income level and WHO region, World, 2004

| | Africa | | Americas | | South-East Asia | | Europe | | Eastern Mediterranean | | Western Pacific | |
|-------|--------|-----|----------|------|-----------------|------|--------|------|-----------------------|------|-----------------|--|
| | LMIC | HIC | LMIC | LMIC | HIC | LMIC | HIC | LMIC | HIC | LMIC | | |
| Boys | 9.0 | 1.8 | 5.0 | 7.1 | 0.8 | 5.5 | 10.7 | 9.0 | 1.7 | 17.5 | | |
| Girls | 5.4 | 0.7 | 1.8 | 5.2 | 0.3 | 2.4 | 1.6 | 4.5 | 0.7 | 9.9 | | |

^a These data refer to those under 20 years of age.

HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

Age

The death rates for drowning, by age group, for children and young people less than 20 years old show a rather higher rate in children in the 0–4-year age bracket, as compared with the rates for the other five-year age groups (see Figure 3.3).

Data from the studies conducted in South and East Asia show that drowning accounted for 90% of all injury deaths for children aged 1–4 years and over 50% of injury deaths for children aged 5–9 years (6). In Bangladesh, 26% of all deaths in children between the ages of 1 and 4 years are due to drowning (12).

Drowning is the leading cause of injury death in children aged 1 to 2 years in the United States (13) and among 1–14-year-olds in China (14, 15). In Brazil, drowning is the leading cause of injury death in 1–4-year-olds, and 26% of all unintentional injury deaths in children aged 0 to 14 years are from drowning (16).

Gender

Boys are overrepresented in every region of the world with regard to drowning death rates (see Table 3.1). In 2004, the overall fatality rate for boys under the age of 20 years was 9 per 100 000 population, nearly twice as high as the rate for girls (5.2 per 100 000 population). A similar skewing towards boys was found in the South and East Asian surveys (see Statistical Annex, Table B.1).

Location

Every year 70 Member States – mainly middle-income and high-income countries – submit to WHO mortality data that include the fourth digit of the International Classification of Disease codes, which allows disaggregation into subtypes of drowning. Analysis of these data show that even in these relatively better-off countries, information on where the drowning occurs is poorly documented. In more than 50% of cases the place is given as “unspecified”, making analysis of place of drowning difficult (17).

Some countries, however, do have alternative sources of data. In Brazil, for instance, more than 60% of drowning occurs in natural bodies of water (16), while in South Africa the location of drowning is strongly related to socioeconomic status. Among wealthier communities

in South Africa, swimming pools and the sea are the major sites of drowning, while for poorer communities the majority of drowning among children occurs in rural areas, typically in rivers, lakes and dams (18).

The place of drowning is also related to age. In the United States, infants most commonly drown in baths and buckets, 1–4-year-olds in swimming pools, and children over 5 years of age most often in pools, rivers and lakes (19, 20). Most young children who drowned in pools were last seen in the home, had been out of sight for less than five minutes, and were in the care of one or both parents at the time (21).

In some industrialized countries such as the United Kingdom, despite a reduction in overall drowning rates among children, the number of children dying in garden ponds or other ornamental water features has increased over the past decade (22).

Morbidity

Estimates of the number of serious non-fatal cases of drowning are more difficult to obtain. Reporting of non-fatal cases is generally less standardized and reporting to a central health statistics system is often not mandatory. This is true of most countries, regardless of income, although some countries are able to provide estimates from hospital data. Nevertheless, for children aged 0–14 years, WHO global estimates for non-fatal drowning range between 2 and 3 million.

Among reported drowning cases, case fatality rates are high. Once a drowning is significant enough to warrant reporting, there is a high likelihood that the event has resulted in death or significant disability. For each fatality, it is estimated that there are between one and four non-fatal events serious enough to result in hospitalization (23). Improvements in medical treatment are unlikely to change this pattern significantly in the near future. There is thus a need to focus on primary prevention, rapid and effective rescue, and immediate resuscitation in cases of drowning.

Consequences of non-fatal drowning

The long-term health consequences of non-fatal childhood drowning are not well known, as few studies have assessed functional outcome after drowning (23–25).

An Australian study on drowning for the five-year period 1999–2000 to 2003–2004, for hospital admissions of all ages, showed on average that 22.3% of cases were left with severe or persistent respiratory or neurological consequences (26). The study also indicated that at least 5% of child survivors from drowning who had been admitted to hospital were discharged with severe neurological deficits (meaning that they would survive in a vegetative state). In the early 1990s, a British study reported that among all drowning cases in children younger than 14 years of age who were admitted to hospital, 8% died and 5% had a severe neurological deficit (27). Similar findings were

reported from a South African study, which found that 12% of children admitted for drowning subsequently died and 6% suffered from a severe neurological deficit (28).

In studies in both the United States (23) and the United Kingdom (27), all children who had suffered drowning and who were alert on admission to hospital fully recovered. In the United States review, half of all children who were confused or comatose on admission had a poor outcome, 35% died and 15% had a severe neurological deficit (23). A high proportion of child drowning cases with poor outcomes has also been observed in a paediatric respiratory care unit in Thailand, where the mortality rate was 26% and 36% suffered from neurological long-term consequences (29).

Due to differences in patient populations and study designs, the figures on the health consequences of non-fatal childhood drowning are not properly comparable across countries. Moreover, many studies lack detailed information on functional outcomes. There is a need for studies measuring the consequences of drowning in childhood – and non-fatal drowning in particular – using comparable methodologies and international guidelines (30). This would allow for sound estimates of the prevalence of brain damage and other permanent disabilities resulting from non-fatal drowning in childhood.

Impact on families and communities

The lifelong health consequences of non-fatal drowning have a great impact on families, and include psychosocial consequences for those who have suffered drowning, their siblings, parents and other caregivers.

Disability-adjusted life years (DALYs) lost for drowning vary widely (see Statistical Annex, Table A.2). For children younger than 15 years, the higher figures come from low-income and middle-income countries of the WHO Western Pacific Region, where drowning is responsible for 4% of DALYs, from all causes (see Statistical Annex, Table A.2).

The impact of drowning on communities can be further estimated in terms of potential years of productive life lost and valued years of potential life lost. Both these measures estimate the loss of productivity due to premature death before the usual age of retirement at 65 years. The cases of Bangladesh, China and Viet Nam provide good examples of the huge impact on the economy of drowning (6). A study in China showed that injury death by far exceeded other major diseases – such as heart disease, cancer and infectious diseases – as a contributor to losses in production. The study also found that drowning ranked second, after motor vehicle traffic injuries, among all causes of injury, in terms of both potential years of productive life lost and valued years of potential life lost (31).

Economic impact of drowning

Studies to assess the costs of injury in several parts of the world (32–36) have up to now largely neglected or

else underestimated the economic impact of drowning. In spite of the scarcity of accurate and comparable data, available estimates indicate that non-fatal drowning may have serious economic consequences. Specific studies into the costs of hospitalizations for non-fatal drowning in the United States (34, 36, 37) have shown that while most cases can be discharged on the same day or after a single night's stay, a small proportion need to receive intensive treatment for very long periods. For this reason, the mean direct costs associated with hospitalization have been reported at \$US 13 000 to \$US 14 000 per case (36, 37). For cases with severe long-term consequences, such as brain damage, treatment costs alone can exceed \$US 100 000. In a cost of injury study undertaken in Australia, non-fatal drowning was found to have the highest average lifetime cost – an estimate that includes direct and indirect costs – per patient of any injury type (38). Studies of the impact of childhood drowning on families and communities show that the cost is highest for those low-income and middle-income countries in which families rely on older children for income (39).

Limitations of data

Statistics on drowning are based on a broad range of data sources. Although much progress has been made around the world in collecting data, the availability and quality of data on drowning varies greatly between countries, depending on the surveillance systems in place and the availability and quality of other statistical resources. Data on drowning deaths are lacking or unreliable in many low-income and middle-income countries, despite periodic surveys or local data that suggest that these countries have the highest rates of fatal drowning (40).

Even in countries where counts of drowning deaths appear relatively complete, important basic details about the event are often lacking, including information on the location of drowning, the intent and the circumstances. There are two main reasons for this lack of information. First, the data collection systems employed may not capture all the relevant information – such as the age of the person concerned and their swimming ability, the type of water in which the drowning occurred, the cause of immersion, whether there were immediate attempts at resuscitation, and the presence of any barriers. Second, the information may not be available at source. Many incidents are not witnessed and it is not always possible to reconstruct the specific circumstances around the event (41).

Both lack of information and misclassification have an effect on overall estimates of the impact of drowning. In cases where a person survives drowning for a period of time in hospital, but dies some days later, the primary cause of death may be coded as something other than drowning – for example, as respiratory failure. Underreporting also occurs because of the ways that intent can be classified (42).

Many countries classify deaths according to the International Classification of Disease (ICD) E-codes. These data are then used to characterize drowning in the region. The most recent (tenth) revision of the ICD is an improvement over previous editions of the ICD in that the newer codes are more specific as to the location of drowning. However, most countries do not use the fourth character of the ICD code which details where the drowning occurred.

Risk factors

Knowledge of risk factors is a critical prerequisite for the effective prevention of drowning (see Table 3.2). Available studies on drowning suggest that people living in countries – particularly countries that are densely populated – with a large amount of open water are at a higher risk of drowning. Other risk factors, such as gender and age, appear to be almost universal.

Child-related factors

Age and development

As already stated, children under five years of age appear to have the highest drowning mortality rates worldwide, with rates among all age groups peaking in 1–4-year-olds. In late adolescences another, smaller peak is seen. This pattern is generally consistent across the world. The likely explanations for these peaks relate to developmental processes in young children and experimentation among adolescents, especially with substances such as alcohol.

With child drowning, risk and circumstances are generally related to the developmental stage of the child. Because infants under one year of age are usually unable to access water by themselves, unintentional drowning at this age is mostly the result of a child being left alone or with an unqualified caregiver – such as a young sibling – in or near water. By contrast, children who are more mobile and inquisitive, but still too young to have developed an awareness of hazards or avoidance skills, often wander away from the supervising adult and fall or climb into a nearby body of water (3, 43–45). Often the parent or caregiver is unaware that the child has approached or has fallen into the water (46).

The increased risk during adolescence is possibly as a result of less supervision and increased independence, increased risk-taking and greater exposure to open water during work or leisure (6, 26).

Gender

Based on global data, rates of fatal drowning are higher in males than females. This is true in all age groups with the exception of infants less than one, where rates among females are higher than males (see Table 3.3). Infanticides of females, misclassified as unintentional events, may be a factor here. Among males, drowning death rates peak

TABLE 3.2

Haddon Matrix applied to the risk factors for childhood drowning

| Phases | Factors | | | |
|------------|--|--|--|---|
| | Child | Agent | Physical environment | Socioeconomic environment |
| Pre-event | Developmental issues; gender; vulnerability; underlying medical condition, e.g. epilepsy; lack of supervision; lack of knowledge about water risks; need to access water for functional purposes, e.g. drinking, washing or fishing; transport on water; recreational use of water; alcohol consumption by adolescent swimmers or caregivers | Unprotected water hazards; unsafe watercraft; overloaded watercraft | Lack of barriers; unfamiliar environment; slippery, uneven, unstable or steep surfaces near or in water; weather conditions, e.g. floods; strong sea currents; inadequate physical infrastructure, such as bridges or safe crossings; lack of safe water supplies; lack of warning of severe weather | Lack of supervision or child care; reliance on peer or older child supervision; poverty; large families; unemployed or illiterate parents; failure of authorities to remove or protect hazards; lack of pool-fencing legislation; lack of water safety instruction and community awareness programmes |
| Event | Child not wearing personal flotation device; rescuer unable to swim; lack of swimming and/or water survival skills; overestimation of swimming ability; lack of strength; lack of comprehension of situation; panic response; swimming alone; lack of personal alerting devices or knowledge of emergency signals (such as waving arms) | Deep water; strong river water current; ocean rip current; very cold water; big waves; lack of personal flotation devices or other life-saving devices in boat; lack of lifeguards | Variable water depth; unstable footing; lack of escape mechanism, e.g. ladder, ropes, flotation device; snags in water | Poor access to information and resources for minimizing risk; inadequate communications or infrastructure to call for emergency health services |
| Post-event | Delay in rescue; inaccessible first-aid kits; lack of knowledge by caregiver about what to do immediately; lack of alerting mechanisms (such as mobile phone, flares) | Victim carried away from shore by current | Long emergency or fire department response time; inadequate rescue and treatment skills; poor access to water; inadequate transport for prompt medical care | Inadequate care; poor access to acute care hospitals and rehabilitation services; little community support for victims and families |

in the 1–4-year age group. In females, rates are highest in infants and decline thereafter. The greatest difference in drowning death rates by gender occurs in adolescents aged 15–19 years, where rates among males are 2.4 times greater than rates among females.

This gender pattern is seen across the world, irrespective of a country's wealth (4, 47, 48). Males in the WHO African and Western Pacific Regions have the highest drowning-related mortality rates worldwide (39). In most regions, with the exception of the Americas and the Eastern Mediterranean, males' death rates from drowning are roughly double those of females.

TABLE 3.3

Fatal drowning rates per 100 000 children by age and sex, World, 2004

| | Age ranges (in years) | | | | | |
|-------|-----------------------|------|-----|-------|-------|----------|
| | Under 1 | 1–4 | 5–9 | 10–14 | 15–19 | Under 20 |
| Boys | 6.4 | 11.8 | 7.8 | 8.3 | 9.3 | 9.0 |
| Girls | 9.8 | 7.6 | 4.9 | 4.0 | 3.8 | 5.2 |

Source: WHO (2008), Global Burden of Disease: 2004 update.

The reason for this may be that boys are more involved than girls in work that takes place in or near open bodies of water, and that they indulge to a greater extent in recreational aquatic activities. This is illustrated by the high number of young males who drown in Uganda while working on fishing boats (49). There is some evidence from high-income countries that greater risk-taking behaviour also contributes to higher drowning rates among boys. There is also evidence that, during aquatic activities, they are more likely than girls to swim alone, to swim at night and to consume alcohol when swimming or boating (47, 50–53).

Poverty

As previously noted, even within a given region of the world, there are considerable differences in drowning mortality rates between high-income and low-income countries. This is also the case within certain countries. A lack of educational opportunity, associated with poverty, may be one factor involved. There is some evidence to suggest that drowning in children is affected by the level of education of the family head or the caregiver. A study in Guadalajara, Mexico, for example, found that the risk of a child aged 1 to 4 years dying from drowning was higher

among those children from households where the head of the family had not completed elementary school (54). In Bangladesh, children whose mothers had only primary education were at significantly greater risk of drowning compared to children whose mothers had secondary or higher education (9). Against this, the study of child drowning in Xiamen, China found that the educational level of the father or mother was not a risk factor for drowning mortality (55).

Within countries, social and demographic factors also appear to affect the risk of drowning. Evidence from child drowning studies in low-income and middle-income countries such as China (6, 11, 55) Uganda (24) and Bangladesh (9, 12) consistently show that rural children have much higher drowning rates than those in urban areas. Many of these deaths occur in fishing communities where water transport takes place in non-motorized watercraft (49). In Bangladesh, the annual drowning rates in children aged 1–4 years are 136.9 per 100 000 in rural areas and 18.9 per 100 000 in urban areas (7, 9, 12). Case-control studies conducted in this country (9, 12) also found that child drowning risk increased as maternal age and family size increased. This pattern, though, was not observed in the study of child drowning in Xiamen, China (55).

Within high-income countries, there are suggestions of large discrepancies in fatal drowning rates between population subgroups, with an increased risk of between two and four times for children and young people from racial or ethnic minority groups (13, 56, 57). In the United States, ethnic minorities and foreign-born young men have higher rates of drowning compared with their white counterparts (56, 58). In the Netherlands, ethnic minorities experience a nearly three-fold higher risk of drowning death than the native Dutch population (57). The factors that contribute to disparities in risk of drowning among different ethnic groups are not well understood. Suggested explanations include differences in swimming ability and experience in the water, lack of opportunities to learn to swim, and lack of supervision in environments where population groups are at high-risk swim (58, 59).

Underlying conditions

Epilepsy is known to increase the risk of drowning death in all sources of water, including baths, swimming pools, ponds and other natural bodies of water (60, 61). A case-control study conducted in Norway found that children with epilepsy were significantly more at risk of submersion and drowning than children who did not have epilepsy, in both baths and swimming pools (62). In this study, though, it was found that no child died of submersion if an adult was present. In Sweden, 10% of those with a history of epilepsy died from drowning over the period 1975–1995 (63). Other conditions that are likely to increase the risk of drowning are autism (22, 64) and certain cardiac arrhythmias, although the latter are less frequent in children (65).

Agent factors

Lack of safety equipment

The lack of availability or accessibility of safety equipment in water transportation vessels are additional risk factors. Flotation devices such as life jackets are indispensable on all vessels, whether used for transportation or for pleasure. In the United States, for example, in 2005 the Coast Guard received reports for 4969 boating incidents. In these incidents, 3451 participants were reported injured and 697 died. Among those who drowned, 87% were not wearing life jackets (66). In addition to the lack of flotation devices, the poor maintenance of such equipment is an additional risk.

Safety equipment used by children while swimming should meet minimum safety standards. Items such as supporting rings or “water wings” may give parents a false feeling of safety, resulting in lapses in supervision with devastating consequences. The use of blow-up toys, rafts and air mattresses has also been recognized as being unsafe (67).

Unsafe vessels on water

There are regular media reports of the deaths of adults and children as a result of being transported in unsafe or overcrowded boats. Many of these boats are unseaworthy and will have been further compromised by turbulent weather conditions. These incidents account for unknown numbers of drowning deaths every year. In low-income countries, the capsizing of boats, launches and ferries is sadly commonplace, especially during the rainy season and at periods, such as national holidays, when there are high levels of mobility.

Alcohol consumption

Risk-taking behaviour figures strongly in unintentional drowning cases, particularly among adolescents. Alcohol use has been linked to between 25% and 50% of adolescent and adult deaths associated with water recreation (68). Alcohol influences balance, coordination and judgement, and its effects are heightened by exposure to the sun and heat (69). Alcohol consumption by parents and other caretakers while supervising children in water should also be considered. While many studies have investigated the direct contribution of alcohol to drowning, little work has been done to estimate the risk to children of alcohol consumption by those supervising them (40).

Estimates of the extent of alcohol involvement in drowning vary widely. This is because of differences in recording age groups or incomplete testing. Apart from affecting judgement and performance, alcohol is believed to have direct physiological effects that may affect survival once submersion has occurred – through mechanisms such as increasing hypothermia and retarding the protective

involuntary muscular contraction of the laryngeal cords (70).

Environmental factors

Type of body of water

Perhaps the strongest risk factor for child drowning mortality is exposure to a “risky” body of water. Patterns of child drowning across countries generally reflect the type of water to which the child is exposed. In low-income and middle-income countries, most drowning deaths happen during daily activities that involve playing, working, washing, collecting water and crossing water – for instance, to reach school. The bodies of water involved include ponds, ditches, lakes, rivers and water collecting systems, both above and below ground, such as buckets, barrels, wells and cisterns (24, 54, 71). By contrast, in high-income countries, most childhood drowning occurs in recreational settings. For younger children this is often a swimming pool and for older children a lake or river used for swimming. While approaches to prevention are transferable, specific prevention strategies and measures should be tailored for specific types of exposure.

In general, most children drown in or around the home. The younger the child, the closer to home the event is likely to occur. Baths are a very common location, though children mostly drown in them only when left unattended (72). For young children in high-income countries, the presence of a residential pool, particularly one that is inadequately fenced, is the strongest exposure factor (51), while in many low-income countries, the presence of open bodies of water or a well is strongly related to the risk of drowning. For instance, a study in a metropolitan area of Mexico found that children living in homes with a well experienced a seven-fold increased risk of drowning as compared with those in homes without a well (54). In Bangladesh, most young children aged 12–23 months who died from drowning did so in ditches and ponds, reflecting the fact that they were highly exposed to these water sources (71). A study of Australian farm injuries found that 78% of drownings in children under 5 years of age living on farms occurred in farm dams and irrigation channels (73).

Climate

Worldwide, large numbers of drowning deaths are associated with cataclysmic floods and ocean waves, which, in a single event, can leave thousands dead. Children accounted for about one third of those who died during the Indian Ocean *tsunami* in 2004 (74).

Holiday activities

A number of studies have found an increased risk of fatal drowning among both adults and children on holiday in

their own country or abroad. In Australia, between 1992 and 1997, 4.7% of all non-boating drowning cases, 18% of surf and ocean drowning cases and 25% of scuba drowning cases were among foreigners (75). Another Australian study, covering the period mid-2001 to mid-2005, showed that almost 25% of drowning deaths were among foreign tourists, including children (76). It has been reported that many more children from the United Kingdom drown in swimming pools abroad than in swimming pools in their home country. This finding is presumably related both to the increased exposure to water when on holiday and exposure to a new situation (77).

Access to treatment and rehabilitation

Several studies have confirmed that most lives are saved by the immediate action of bystanders at the scene, either lay people or professional rescuers. Without such immediate first aid – including basic cardiopulmonary resuscitation – subsequent advanced and invasive life support techniques appear to be of little value in most cases (78).

Following the initial attempts at resuscitation, rapid deployment to an emergency department of a hospital is essential to prevent further neurological damage or death. The initial management of non-fatal drowning should involve continued resuscitation and treatment of respiratory failure, after which the child should be gradually rewarmed.

Outcome studies have shown that submersion for longer than 25 minutes, a continued need for cardiopulmonary resuscitation for more than 25 minutes, and lack of pulses on arrival at the emergency room are all predictors of severe long-term neurological consequences or death (1, 79, 80). However, the existence of case reports of children surviving neurologically intact after prolonged submersion in icy water suggests that more aggressive interventions can be helpful in these cases (1).

Interventions

Given the complexity of drowning events, strategies for prevention require a holistic approach, based on the particular pattern of drowning observed in a given location. Passive prevention strategies – such as improving safety design – that require no action or else only a single action on the part of the individual, are generally regarded as more effective than active strategies, such as adopting safer behaviours, requiring repeated actions. However, for many types of drowning there are a limited number of passive strategies – or even none at all.

Most drowning deaths could be prevented by a sustained effort to implement safety interventions. The task ahead is clear - to translate what is now known into action on the ground (UNICEF Bangladesh).

Engineering measures

Eliminating hazards

Eliminating a hazard – where this is possible – is the most effective prevention method, since it does not rely on barriers or other protective measures which may be ineffective. Buckets and baths, for example, should be left empty when not in use, as children could drown in them if they contained a liquid. Similarly, holes in the ground, dug for building purposes, should be drained of rainwater or filled in to prevent water collecting. Small containers, such as washing tubs, should be safely stored so that they will not fill with rainwater (81).

Passive strategies relating to the creation of infrastructure include the building of safe bridges and the installation of piped water systems, both of which have historically been factors in reducing drowning rates in developing countries. Having piped water to hand means that people can avoid open bodies of water to bathe or wash clothes in or to collect drinking water from. It also makes exposure to stored rainwater and wells less likely, both of which are potential hazards (81).

Providing safe venues for recreational swimming can also help prevent drowning. Natural bodies of water contain a number of associated hazards for swimmers. The depth of water in them may be unknown and there may be underwater obstacles, sudden and unseen changes of depth or deep holes. Strong currents and a low temperature of water can create further problems. The provision of suitably designed pools, whose depth is known at each point and in which obstacles and currents are absent, makes it possible for children to learn to swim in an environment with considerably fewer hazards.

Environmental measures

Pool fencing

Another passive intervention is the creation of an effective barrier between child and hazard (see Box 3.1). In high-income countries it has been found that surrounding private swimming pools and spas with safety barriers that prevent unsupervised young children entering significantly reduces their risk of drowning (82–86). A meta-analysis of three case-control studies showed a significantly decreased risk of drowning in a fenced pool, as compared to an unfenced one (87). Furthermore, the study found that a barrier isolating the pool from all other structures – a four-sided fence – was shown to be far more protective than perimeter fencing, a three-sided fence where the house or another structure forms the fourth side of the barrier (87).

Research in the United States and Australia has found that laws and regulations requiring pool fencing are insufficient if perimeter fencing is not accompanied by adequate enforcement to ensure the self-closing system of the gate and the latching system are functioning properly (83, 88).

Covering wells

In low-income and middle-income countries, creating barriers between young children and the bodies of water to which they are exposed can be an effective measure to prevent drowning. Covering wells or open barrels with grills, creating an embankment or fenced barrier near ponds and riverbanks, and building flood-control embankments, are all effective in preventing drowning (54) (see Box 3.1). Similarly, creating fencing around a dwelling where there is a hazard of open water outside the house can also provide protection.

BOX 3.1

Covering wells in Mexico

Wells and underground cisterns are important sources of household water. The former are common in rural areas, while the latter are used in some cities without a reliable community water source. A common characteristic of both is an opening large enough to allow access. This can create a major drowning risk for children, especially in developing countries. One study found that the presence of wells in homes increased the risk of drowning in the home by a factor of nearly seven, while cisterns increased the risk two-fold (54).

Using accepted strategies as well as the experience of swimming pool fencing, a child's risk of drowning could be substantially reduced if the opening to these household water sources was closed by a locked hatch. This preventive strategy is familiar to the Mexican public, who have a popular saying, "close the well after the drowned child."

Because water must be drawn daily, wells and underground cisterns cannot be sealed the whole time. The most hazardous method of obtaining water would be through a hatch or lid large enough to admit a bucket – and therefore also large enough to let a small child pass through. A more effective preventive measure would be to draw water using a manual or electric pump. This would make it easier to obtain household water and would eliminate the risk of children drowning.



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In Australia, farm safety researchers are investigating the feasibility of a “virtual fence”. The technology for an alarm system signalling that a child under adult supervision has wandered beyond predetermined limits from the home already exists. The researchers are examining whether this technology can be applied effectively to increase child safety in low-income countries, especially in relation to the risk of drowning in bodies of water such as dams.

Legislation and standards

Pool fencing laws and their enforcement

In many high-income countries, legislation requiring isolation pool fencing for all swimming pools (including private ones) has been recommended and sometimes also enacted and enforced. Such legislation has proved effective in decreasing drowning rates, though not to the extent that had been anticipated (86, 89, 90). This may be due to a lack of knowledge of the law and its inadequate enforcement.

Personal flotation devices

Although not yet thoroughly evaluated, wearing a properly-fitted personal flotation device, such as a life jacket, is a promising strategy to prevent drowning (91).

This is particularly the case with regard to swimmers who are unskilled or tired or who panic. If a young child wearing a properly-designed personal flotation device falls into the water, the device should keep the child afloat long enough to be rescued. Only certain types of personal flotation device will ensure that the child floats face-up. These devices should therefore be seen as short-term solutions and not as a substitute for supervision. The provision of personal flotation devices for all occupants of ferries and other vessels has the potential to save many lives (see Box 3.2).

Laws on alcohol

General minimum-age drinking laws and lowering the alcohol level do not appear to be associated with a reduction in drowning rates among adolescents (96). However, it is known that consuming alcohol before or during activities in bodies of water increases the risk of drowning. Adolescents should therefore be encouraged not to drink and swim. In addition, advertising that encourages alcohol use during boating and the sale of alcohol at water recreational facilities should be restricted.

BOX 3.2

Personal flotation devices and drowning

Lifejackets were developed to prevent drowning in emergencies at sea. In the water, they turn wearers to a position where the face points up, and with the head supported and the mouth out of the water. Buoyancy material is concentrated in front of the wearer, which makes the jacket bulky, uncomfortable and restrictive. Newer buoyancy devices are designed to keep the wearer afloat but do not meet the high performance requirements for lifejackets, with regard to buoyancy and keeping the face up. They are considered appropriate, though, for use by children, recreational boaters and water sports participants, who are undertaking activities in calm waters, close to the shore or close to help from rescuers.

The broader term “personal flotation device” is now used in many countries to cover all these new flotation devices as well as the lifejacket. Many governments now require all recreational vessels to carry one wearable personal flotation device, of a specified type, for each person on board. However, since drowning during recreational boating usually occurs suddenly or unexpectedly, lifejackets stored on board offer little protection unless they are actually worn. Various studies have shown that up to 50% of drownings resulting from boating-related incidents could have been prevented if the person had been wearing an appropriate personal flotation device (92).

Two main strategies – education and, to a lesser extent, regulation – have been employed by governments to try to increase the wearing of personal flotation devices among recreational boaters, including water sports participants. Only two evaluations of educational campaigns on personal flotation devices have been published, both reporting modest effectiveness (93, 94). Although the use of personal flotation devices among all boaters increased, the impact of the campaign on childhood drowning was undetermined.

Some countries have made the wearing of personal flotation devices mandatory. Preliminary data from an Australian study, which evaluates both the wearing rates and the effectiveness of regulations, shows promising results (95).

The available evidence therefore suggests that the use of personal flotation devices is potentially a strong measure to prevent drowning among recreational boaters, including children, and that regulation is more effective than education in increasing the use of these devices and preventing drowning.



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Developing education and skills

Teaching swimming and improving skills

Most studies show that swimming instruction improves swimming ability, but no conclusive evidence exists that swimming ability confers protection against the risk of drowning. There are, however, indications that swimming instruction and the consequent increased ability at swimming, as well as greater survival skills, do provide some protection, even at relatively young ages.

Longitudinal studies of child drowning are hampered by the lack of data regarding the proportion of children who can swim and the level of swimming ability of those who drown. A study conducted in the United States (see Box 3.3), a recent study in rural China of child drowning (46) and research in Bangladesh (7) all suggest that swimming lessons may be protective.

Even in the face of this preliminary evidence, there should be caution in recommending swimming lessons as a protective strategy for young children. Several studies show children as young as 24 months can improve their skills, but their learning period is much longer than that of older children (98).

Concern has been voiced that mass training in swimming skills for children could lead to more children, especially young ones, being exposed to water and becoming overconfident in it. Ultimately, according to this view, drowning rates in children could increase rather than decrease (99). A study in Australia, however, suggested a link between swimming lessons and decreased drowning rates in children (100). However, this may have also been because more safe places for swimming were opened, including large numbers of public pools (see Box 3.4).

BOX 3.3

Teaching children to swim

One possible strategy to prevent drowning is to improve children's swimming skills through formal instruction. Few studies have examined the association between either swimming skills or swimming instruction and drowning risk. While it seems intuitive that more skilled swimmers would be less likely to drown, it is also the case that skilled swimmers drown. Among older children especially, it is possible that those who are comfortable in water or who perceive themselves to be good swimmers might seek out water-related activities. These activities might occur in more risky settings – such as in deeper water or at locations without lifeguards or other appropriate supervision.

Preliminary results of a study in the United States (97) found that past participation in formal swimming lessons offered a protective effect for drowning. In this study, the families of children who had drowned and the families of matched controls were asked about their child's past participation in formal swimming lessons. For children aged 1–4 years, interviews were conducted with 61 families of children who had drowned and the families of 134 matched controls. In the 5–19-year age group, interviews were conducted with 27 families of drowning cases and 79 matched controls.

For the younger age group, 3% of those who drowned had participated in formal swimming lessons, against 26% in the matched controls. This represents a 90% reduction in drowning risk among those who had swimming lessons. Among older children, 27% of the drowning cases had taken formal swimming lessons against 53% of the controls – an association that was not statistically significant.

In general, increased swimming skills also appear protective with respect to drowning risk. This is particularly true in children over 5 years of age, with several of the skills showing a protective effect in adjusted analyses, despite the small sample size. For example, in the older age group, drowning cases were less likely to be able to swim on the stomach for a distance of 5 metres. However, among those aged 5–19 years, many of those who drowned were relatively skilled swimmers. Of those who drowned in this group, 58% were reported to be able to swim continuously for at least a minute and 48% to be able to swim at least 15 metres.

This study had a number of limitations, including the relatively small sample sizes in both age groups and a reliance on reports, rather than on observation, of swimming skills. In addition, it is quite possible that parents who enroll young children in swimming lessons could differ from parents who do not do so. These differences are difficult to measure and could have an effect on a child's risk of drowning.

In spite of these shortcomings, these early results, together with a previous study in rural China (46) that also identified a protective association between swimming instruction and drowning risk, suggest that formal instruction in swimming ought to be a component of a strategy to prevent drowning. However, those designing prevention programmes, and those targeted by them, must be aware that even the most skilled swimmers can drown. Swimming lessons and the teaching of water survival skills should therefore be regarded as one important component of a multiple approach to prevention.



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More good intervention studies are needed to evaluate the effectiveness of swimming lessons in preventing drowning in young children, and to specify what sort of swimming and survival skills should be taught. Imparting knowledge and skills beyond the basic swimming strokes is certainly necessary. This includes teaching children to swim safely in open water, to identify hazards such as rocks, currents and dangerous weather conditions, and to recognize, avoid and – if necessary – escape from rip currents.

Supervision by lifeguards

Lifeguards (also known in Australia, New Zealand and South Africa as lifesavers) – both voluntary and paid – have provided protection at swimming pools and natural bodies of water in various parts of the world since the 19th century. Voluntary lifeguarding still exists, particularly around natural bodies of water. At the same time, paid lifeguards are increasingly being employed in public and commercial swimming venues.

There have been no published studies formally evaluating the effectiveness of lifeguarding as a primary prevention measure. Australian studies, based on rescue and resuscitation data from associations of lifeguards, do, however, point to some effectiveness (101, 102). Trained lifeguards on beaches and at public swimming pools are likely to decrease the risk of drowning by being models for

safe behaviour, actively controlling the risk-taking actions of swimmers, monitoring water and weather conditions, and prohibiting or restricting swimming in the sea if behaviour or conditions pose a hazard. Lifeguards, furthermore, provide rescue and resuscitation to limit cases of drowning resulting in death or brain damage (103). For their work to be effective, though, they require ongoing training and need to adhere to high standards of performance, particularly as regards surveillance (104).

Supervision by parent or caregiver

Educating parents and caregivers about the risks for drowning is an important step for changing knowledge, beliefs and attitudes which in turn determine behaviour. People often underestimate the risk of drowning and are unaware of who is particularly at risk (6). A study of Americans of Vietnamese origin found that both parents and adolescents often attributed drowning to fate (105). Parents and caregivers need to understand that young children should never be left alone or with another young child in or around any body of water (see Box 3.5). They also need to learn basic life-saving and first-aid skills.

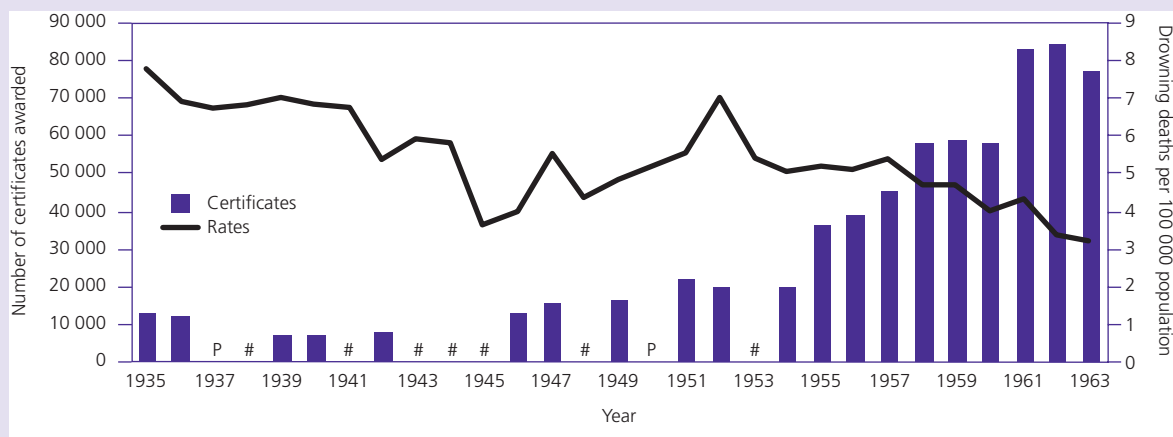
Numerous studies have shown that inadequate supervision is an important contributory factor for paediatric drowning of all types, especially drowning in the bath (106). However, the effectiveness of supervision as a drowning prevention measure has not been formally

BOX 3.4

A mass primary school swimming instruction campaign

From the 1950s onwards, a major collaborative swimming instruction campaign was implemented across the state of Victoria, Australia. The programme was named after a daily newspaper, *The Herald*, which had launched it and gave it publicity. Supported by the Education Department and the local government and championed by an ex-olympic swimmer, the campaign also coincided with the Olympic Games held in Melbourne in 1956.

The campaign was aimed at the later years of primary school children. These children received a “Herald Certificate” when they swam the target distance of 23 metres, and the annual award rates were published by the newspaper. By the summer of 1962–63, over a million children had participated in the *Herald* campaign. All children aged 10–12 years were covered by this programme, which was associated with a reduction in the drowning rate. This mass swimming campaign, together with an increase in the number of safe places to swim and other drowning prevention strategies, resulted in a significant reduction in the drowning rate (see accompanying figure).



BOX 3.5

Adult supervision and swimming training for very young children

In New Zealand, children under five years of age have the highest death rate from drowning of any age group in the country. In an attempt to prevent such deaths, a number of organizations have promoted swimming lessons for very young children, despite a lack of evidence that swimming instruction in this age group is effective in teaching protective skills. Some experts have warned that swimming lessons at this age may actually be harmful, making young children less fearful of water and giving parents a false sense of security. A study to examine the beliefs of adults about the benefit of swimming instruction was conducted, with 555 parents who had enrolled their preschool children in swimming lessons, together with a control group of 327 parents of similar children who had not (107). The study found that parents believed that children as young as two years could learn to swim, and that a sizable proportion thought that swimming classes were the best way to prevent small children from drowning. A third of parents considered it better to develop the swimming ability of their children than to rely on adult supervision in order to prevent drowning.

The study brought out parents' misconceptions over their young children's ability to be safe. Parents often place their children in situations where there is a mismatch between the child's skills on the one hand, and the demands of the tasks required for safety on the other. This has been shown not only for drowning, but also for pedestrian safety, driving skills and safety with firearms. Such misconceptions need to be combatted with a range of educational, regulatory and other interventions so as to reduce the risk of inadvertent injury to children.

evaluated. What constitutes adequate adult supervision for bathing and water safety has only recently been studied. Those who supervise children in and around water should receive appropriate training in rescue and resuscitation skills.

Infants and other children who lack mobility require continuous supervision on the site while in the bath. The age up to which children need such supervision has not been determined but is likely to extend to at least five years. Beyond this age, reported drownings in a bath are almost always related to seizures (62). For children and adolescents with epilepsy, being in a bath poses the highest risk for unintentional death. Children with epilepsy should therefore always use a shower rather than a bath and adhere strictly to other seizure control measures (62).

In some communities it is common to rely on other children of the same age or older to protect a young child. In the case of drowning, such a form of care appears to provide insufficient protection. A historical review of drowning in Australia found that throughout the 19th and 20th centuries many child drowning deaths occurred in the company of other children (81). Because drowning happens rapidly, companions are often unable to rescue the drowning child and may themselves drown in the process.

Interventions for adolescents

Adolescent drowning usually occurs in open water while swimming, boating or undertaking other leisure activities. Those who drown have generally been swimming with one or more friends of a similar age who do not recognize they are in trouble or cannot rescue them. Adults are usually absent, and there may be peer pressure to indulge in risk behaviours, such as consuming alcohol. With alcohol consumption, the risk of drowning increases as blood alcohol concentration levels rise. Measures to prevent the use of alcohol and recreational drugs around water activities are therefore likely to reduce the rate of adolescent drownings (108, 109).

From early adolescence onwards, preventive interventions for drowning should increase a person's cognitive skills around water. These skills include:

- better recognition of hazards;
- recognition of personal limits, including knowledge of one's swimming ability;
- the ability to resist peer pressure to take part in activities for which skills are lacking.

Such interventions, though, have not been properly developed or tested. For children and adolescents, a particular problem is to provide safe sites for swimming that are also attractive. To this end, trained and equipped lifeguards need to be present at places and at times that adolescents are most likely to congregate. In rural areas, safe settings for swimming need to be made available. Otherwise, children and adolescents are likely to gather at unsafe places such as irrigation ditches, quarries and other open water sites.

Managing drowning

Drowning injuries arise because a person cannot adequately breathe and obtain oxygen. Even if a person is quickly retrieved from the water while drowning, they may have stopped breathing, and suffer brain damage as a result of a lack of oxygen. A secondary prevention strategy, therefore, for all age groups, is training in resuscitation techniques. The strongest predictor of outcome following drowning is the mental status of the person being rescued (110).

Support from bystanders

Studies have shown that children who receive immediate resuscitation from bystanders – before the arrival of medical personnel – have improved outcomes (111, 112). Attempts by bystanders to provide “mouth-to-mouth” resuscitation to the child may stimulate the return of the child's spontaneous breathing. If the child does not begin to breathe, providing such resuscitation is critical for survival. Advanced life support provided by medical personnel may save a child who has deteriorated to a state of cardiac arrest. However, even in high-income countries

with local paediatric intensive care facilities, the window of opportunity for intervention is at the scene of the drowning (113, 114).

Psychosocial support

Coping with a sudden unexpected death, such as occurs with drowning, is always difficult. When the person in question is a child, the loss is generally even more devastating and one over which the parents frequently experience feelings of guilt. Childhood death is also stressful for health care providers. There needs to be greater support for families in which a childhood drowning has occurred, as well as for the health care providers. Greater attention should also be devoted to the long-term care of children who have become neurologically damaged through drowning (78).

Adapting interventions

To maximize their effectiveness, prevention strategies and measures against drowning should be appropriate to the child's developmental stage. While a barrier, for example, might be effective in preventing drowning in young children, this measure is not in general likely to keep older children and adolescents from accessing water. The cultural acceptability to children and parents of possible interventions also needs to be borne in mind.

Affordability and availability are further factors that may determine whether interventions are implemented. Fencing works well for swimming pools, for instance, but it may not be the solution in regions where canals and irrigation ditches are ubiquitous.

As another examples, items such as personal flotation devices may not be locally available. Measures to overcome this obstacle include the setting up of local loan schemes for such devices.

Potentially harmful interventions

Baby bath seats and flexible solar pool covers are not designed to prevent drowning, though they are sometimes used for that purpose. Several small studies have documented drowning among infants who were left unattended in a baby bath seat (115, 116). While in most cases it was not the bath seat itself that was unsafe, its use tended to make parents feel more comfortable about leaving their young child unattended. Similarly, flexible solar pool covers do not prevent drowning from occurring. There have been cases where unsupervised children drowned, having become trapped in them or hidden from view (117). More rigid, heavier devices may offer protection, though these have not been tested for effectiveness and are considerably more expensive, although they are sometimes used on public swimming pools.

Further research on interventions

For all interventions to prevent drowning, accurate and comprehensive data are vital for evaluating their

effectiveness. Many interventions still require rigorous evaluation. Above all, the debate around whether children under the age of five years should be taught to swim needs to be resolved, so that an unequivocal message can be given to parents. Research is also needed as to why pool fencing laws do not live up to expectations, including an examination of both the knowledge of users as well as their attitude to newer fencing. For young children, close supervision is a vital strategy for prevention. Such supervision includes safe play areas for children which have been proposed but not evaluated (118). What qualifies as "adequate" supervision, though, needs defining and evaluating.

Conclusions and recommendations

Drowning is a public health issue calling for worldwide attention. Recent community-based surveys indicate that the problem of drowning is likely to be much greater than present global estimates would suggest. This relatively neglected injury problem should be given a much higher priority by policy-makers and donors.

In 1997, drowning was described as "the final frontier of injury prevention" (119), because of the scarcity of evidence for the effectiveness of intervention strategies. Since that time, though, a certain amount of progress has been made. This chapter has described the many effective and promising interventions now available to reduce childhood drowning (see Table 3.4). More scientific investigation, though, is still required to identify significant risk and protective factors in drowning.

Recommendations

- *An agenda to address drowning, with targets* appropriate to the local situation, should be set up by every country. Because of the high rates of drowning fatalities, the main focus needs to be on *primary prevention strategies*.
- *Partnerships* between governments, communities, industry, private sector bodies and public health agencies should be created to address drowning. While the type of strategies to prevent drowning and treat children and adolescents will vary greatly between countries and regions, cooperative efforts at every level – including at the global level – are essential.
- To enable countries to compare data and share experiences and intervention strategies more effectively (120), the following need to be done:
 - the *collection of consistent epidemiologic data*;
 - the use of *standard definitions*;
 - the use of *coding schemes*.
- *Further research to evaluate protective factors* is urgently called for, using large intervention trials, examining the effect of measures such as providing instruction in swimming and survival skills.
- The design and evaluation of *interventions in specific settings* needs ongoing research.

TABLE 3.4

Evidence for key strategies to prevent drowning among children

| Strategy | Effective | Promising | Insufficient evidence | Ineffective | Potentially harmful |
|---|-----------|-----------|-----------------------|-------------|---------------------|
| Removing (or covering) water hazards | Effective | | | | |
| Requiring isolation fencing (4-sided) around swimming pools | Effective | | | | |
| Wearing personal flotation devices | Effective | | | | |
| Ensuring immediate resuscitation | Effective | | | | |
| Ensuring the presence of lifeguards at swimming areas | | Promising | | | |
| Conducting targeted awareness-raising on drowning | | Promising | | | |
| Teaching children older than 5 years to swim | | | Insufficient evidence | | |
| Introducing laws on pool fencing | | | Insufficient evidence | | |
| Introducing a law on the use of personal flotation devices | | | Insufficient evidence | | |
| Promoting drowning prevention through doctors | | | Insufficient evidence | | |
| Restricting access to areas unsafe for swimming | | | Insufficient evidence | | |
| Teaching children younger than 5 years to swim | | | Insufficient evidence | | |
| Introducing laws on blood alcohol content for swimmers | | | Insufficient evidence | | |
| Conducting prevention campaigns, such as on advertising hoardings, for drowning | | | | Ineffective | |
| Promoting solar pool covers ^a | | | | | Potentially harmful |
| Using baby bath seats ^a | | | | | Potentially harmful |

^a These are not primarily designed as drowning prevention interventions.

Source: references 121, 122.

- *Proven interventions* should be implemented where their relevance has been demonstrated. These include:
 - the elimination of water hazards;
 - the creation of barriers between children and hazards;
 - the use by children of personal flotation devices.
- *Immediate resuscitation*, prior to the arrival of paramedical personnel, should be promoted everywhere. Such resuscitation significantly increases the likelihood of a good outcome – irrespective of age, gender, duration of submersion or the presence of hypothermia.

“Considering that drowning is the second leading cause of unintentional injury death worldwide and the single leading cause of child death (including disease) in some countries, the focus this critical report brings to the problem and viable preventive measures is immensely valuable. Now comes the time for action.” Alan Whelpton, World President, International Life Saving Federation.

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