

Monitoring Bathing Waters - A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes

Edited by Jamie Bartram and Gareth Rees

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Chapter 7*: PHYSICAL HAZARDS, DROWNING AND INJURIES

** This chapter was prepared by A. Mittlestaedt, J. Bartram, A. Wooler, K. Pond and E. Mood*

Physical hazards are generally perceptible and discernible. Physical hazards, unlike many microbiological, biological and chemical hazards do not require laboratory analysis for their recognition or description. The hazards that can lead to drowning and injury may be natural or artificial. By definition a hazard is a set of circumstances that may lead to injury or death. The term “risk” is used to describe the probability that a given exposure to a hazard will lead to a certain (adverse) health outcome.

In the context of this chapter, hazards are best viewed as both the potential causes of ill health and the absence of measures to prevent exposure or mitigate against more severe adverse outcomes. Thus, an area of dangerous rocks against which swimmers may be drawn by prevailing currents or wind, the absence of local warnings, the absence of general public awareness of the types of hazards encountered in the recreational water environment, and the absence of local capacity to recognise and respond to a person in danger, may all be readily conceived as part of the hazard. The number of injuries can be reduced by elimination of the actual hazard, by restricting access to the hazard, by members of the public recognising and responding appropriately to the hazard, and by ensuring deployment of effective management actions.

The severity of the adverse health outcomes considered in this chapter differs markedly from that described elsewhere in this book. The severity of the outcomes varies widely but includes death (for example through drowning) and lifelong disability through quadriplegia, as well as blindness arising from retinal displacement. It also addresses less severe health outcomes such as cuts and lacerations that are nevertheless important in determining the pleasure derived from recreational use of water environments. Whilst the overall frequency of severe outcomes may be low they are of considerable importance for public health.

Despite the importance of the health outcomes addressed in this chapter, methods for assessment of the associated hazards and mitigating factors are relatively poorly developed and have attracted limited research when compared with, for example microbiological pollution of bathing waters (see Chapters 8 and 9). Nevertheless, assessment may be rapid and simple and may be readily and rapidly associated with

short-and medium-term actions of immediate relevance to the protection of public health. This chapter draws heavily on the corresponding chapter of the *Guidelines for Safe Recreational Water Environments* (WHO, 1998) in which the issue of physical hazards and drowning is also discussed. This chapter summarises the key components of that chapter and provides a practitioners guide to the various issues.

7.1 Health outcomes

The most prominent health outcomes resulting from recreational use of water are:

- Drowning and near-drowning.
- Major impact injuries, especially spinal injuries, resulting in quadriplegia and less frequently, paraplegia, as well as head injuries.
- Slip, trip and fall injuries (including bone fracture and breaks).
- Cuts, lesions and punctures.
- Retinal dislocation resulting in near blindness or blindness.

7.1.1 Drowning and near drowning

Drowning and near drowning are important health issues and merit special consideration in the development and management of water recreational facilities. Informal peer supervision in more densely-used areas may contribute significantly to the prevention of drowning and, conversely, the desire for greater seclusion may be a significant contributory factor. Private pools (including ornamental, swimming and paddling pools) contribute significantly to drowning statistics, but are not addressed in this volume.

Males are more likely to drown than females (WHO, 1998) and this is, in part, associated with higher exposure to the aquatic environment (through occupational and recreational uses). In many countries, alcohol consumption is one of the most frequently reported contributory factors associated with drownings. Amongst children, lapses in parental supervision are the most frequently cited contributory factor in drownings and near drownings. Drowning and near drowning may often be associated with recreational water uses with low water contact, such as use of water craft (yachts, boats, canoes) and fishing (from water craft and from the waters edge or solid structures). Where these recreational water uses occur during cold weather, immersion cooling may be a significant contributory factor (Keatinge, 1979; Poyner, 1979). However, non-use of life jackets, even when they are readily available, is a significant contributory factor in all cases. The availability of cardiopulmonary resuscitation (CPR) and rescue skills have been reported to be important in determining the outcome of accidental immersions. However, attempted rescue represents a significant risk to the rescuer.

Most drownings occur in non-swimmers and the value of swimming lessons as a preventative measure appears logical. However, there is significant debate regarding the age at which swimming skills may be acquired safely, and the role of swimming skills in preventing drowning and near drowning is unclear. Whilst evidence does not suggest

that water safety instruction increases the risk of young children drowning, their increased skills do not decrease the need for adult supervision; the impact of training on decreasing parental vigilance has not been assessed (Asher *et al.*, 1995).

Pre-existing diseases are associated risk factors and higher rates of drowning are reported amongst those with seizure disorders and paediatric seizures. Further documented contributory factors in drownings include water depth and poor water clarity (Quan *et al.*, 1989). Studies of “near drowning” show that the prognosis depends more on the effectiveness of the initial rescue and resuscitation than on the quality of subsequent hospital care. The principal contributory factors and preventative and management actions for drowning and near drowning are similar and are summarised in Table 7.1.

7.1.2 Spinal injury

Diving accidents have been found to be responsible for a variable percentage of traumatic spinal cord injuries. However, in diving accidents of all types, injuries are almost exclusively located in the cervical vertebrae and typically cause quadriplegia or, less commonly, paraplegia. In Australia, for example, diving accidents account for approximately 20 per cent of all cases of quadriplegia (Hill, 1984). The financial cost of these injuries to society is high, because those affected are frequently healthy young persons, principally males under 25 years of age (Blanksby *et al.*, 1997).

Data from the USA suggested that diving into a wave at a beach and striking the bottom was the most common cause of spinal injury, and 10 per cent of spinal injuries occurred when the person dived into water of known or unknown depth, particularly from high platforms, including trees, balconies and other structures (CDC, 1982). As with drowning, alcohol consumption may contribute significantly to the frequency of injury. Special dives, such as the swan or swallow dive are particularly dangerous because the arms are not outstretched above the head but to the side.

The role of water depth in determining the outcome of diving injuries has not been ascertained conclusively and the minimum depths for safe diving are often greater than expected. Technique and education appear to be important in preventing injury and inexperienced or unskilled swimmers require greater depths for safe diving. Most diving injuries occur in relatively shallow water (1.5 m or less) and a few in very shallow water (e.g. less than 0.6 m) where the hazard may be more obvious. The typical injurious dive occurs into a water body known to the individual.

Table 7.1 Drownings¹ and near-drownings - contributory factors and principal preventative and management actions

Contributory factors	Principal preventative and management actions
Alcohol consumption	Continual adult supervision (infants)
Cold	Provision of lifeguards
Ice cover	Availability of resuscitation skills/facilities
Waves (coastal, boat, chop)	Wearing of lifejackets when boating
Underwater entanglement	Provision of rescue services (lifeboats)
Pre-existing disease	Local hazard warning notices
Sea current (including tides, undertow and rate of flow)	Development of rescue and resuscitation skills amongst general public and user groups
Offshore winds (especially with flotation devices)	Development of general public (user) awareness of hazards and safe behaviours
Bottom surface gradient and stability	Access to emergency response (e.g. telephones with emergency numbers)
Impeded visibility (including coastal configuration, structures and overcrowding)	Co-ordination with user group associations concerning hazard awareness and safe behaviours
Water transparency	

¹ In most countries males and infants constitute a disproportionate number of drownings

Source: WHO, 1998

The principal contributory factors and preventative and management actions for spinal cord injury are summarised in Table 7.2. Evidence suggests that preventative education and awareness-raising offer most potential for diving injury prevention, partly because people have been found to take little notice of signs and regulations. However, because of the young age of many injured persons, awareness raising and education about safe behaviour is required early in life.

Table 7.2 Major impact injuries - contributory factors and principal preventative and management actions

Contributory factors	Principal preventative and management actions
Poor underwater visibility	Access to emergency services
Conflicting uses in one area	Use separation/segregation
Bottom surface type	Provision of lifeguards
Water depth	Local hazard warnings
Diving into a wave or into water of unknown depth	Development of general public (user) awareness of hazards and safe behaviours
Jumping into water from trees, balconies or other structures	Early education in diving hazards and safe behaviours

Source: WHO, 1998

7.1.3 Impact, slip, trip and fall injuries

Accidents involving limb fractures or breaks of different types have many causes and may occur in a variety of settings in or around water. The principal contributory factors and preventative and management actions are summarised in Table 7.3.

Table 7.3 Slip, trip, fall and minor impact injuries - contributory factors and principal preventative and management actions

Contributory factors	Principal preventative and management actions
Diving into shallow water	Selection of appropriate surface type
Underwater objects (e.g. walls, piers)	Use of adjacent fencing (e.g. around docks and piers)
Adjacent surface type (e.g. water fronts, jetties)	Development of general public (user) awareness of hazards and safe behaviours
Poor underwater visibility	

Source: WHO, 1998

7.1.4 Cuts, lesions and punctures

There are many reports of injuries sustained as a result of stepping on glass, broken bottles and cans. Discarded syringes and hypodermic needles may present more serious risks and may attract greater public outcry. Simple measures, such as the use of footwear on beaches, as well as adequate litter bins and cleaning operations may contribute significantly to prevention, as may educational policies to encourage users to

take their litter home. The principal contributory factors and preventative and management actions are summarised in Table 7.4.

Table 7.4 Cuts, lesions and punctures - contributory factors and principal preventative and management actions

Contributory factors	Principal preventative and management actions
Presence of broken glass, bottles, cans, and medical wastes	Development of general public (user) awareness of hazards and safe behaviours
Walking and entering water barefoot	Development of general public (user) awareness regarding litter control
	Local availability of first aid
	Provision of litter bins
	Beach cleaning
	Adequate solid waste management

Source: WHO, 1998

7.1.5 Retinal dislocation

Impact to the head, resulting from diving and jumping into the water from height have been known to cause detachment of the retina in the eye. The principal contributory factors and preventative and management actions are summarised in Table 7.5.

Table 7.5 Retinal dislocation - contributory factors and principal preventative and management actions

Contributory factors	Principal preventative and management actions
"Bombing" (jumping onto other water users)	Development of general public (user) awareness of hazards and safe behaviours
Diving into water	
Jumping into water from height	

Source: WHO, 1998

7.2 Interventions and control measures

Control of physical hazards may involve their removal or reduction, if possible, or measures to prevent or reduce human exposure or to minimise the adverse effects of exposure. As described at the beginning of this chapter the term hazard is generally used in relation to the capacity of a substance or event to affect human health adversely. However, in the context of this chapter, the absence of appropriate control measures may be treated as a component of the chain of causation. For example, the lack of

guards, rescue equipment, signs and other remedial actions can contribute to a variety of health outcomes.

The roles of various interventions and control measures in preventing human injury are discussed in the *Guidelines for Safe Recreational Water Environments* (WHO, 1998). The principal measures include public warnings and information (signs, flags, public information), lifeguarding, use separation (zoning, lines, designated areas), and infrastructure and planning, such as for emergency communication, rescue and resuscitation and emergency vehicle access. Whilst the requirement for each of these measures is largely determined locally by a variety of factors, it is important to note that most measures may be more or less effective; their effectiveness may decline after periods of limited or non-use and all are amenable to simple inspection. Importantly, for many measures, replacement or improvement may be within the capacity (financial or practical) of local authorities and, in some circumstances, user groups.

7.3 Monitoring and assessment

The assessment of hazards at a beach or water is critical to ensuring safety. The assessment should take into account several key considerations, which include:

- The presence and nature of natural or artificial hazards.
- The severity of the hazard in relation to health outcomes.
- The availability and applicability of remedial actions.
- The frequency, density and type of use of the area.
- The level of development.

The investigation of hazards in or near present or potential recreation areas, including land and water (natural and artificially constructed) results from a visual inspection procedure. The investigation of physical hazards involves an understanding of the process of causation leading to injury. Because of the importance of individual behaviours in causation, and of awareness in prevention, the involvement of the public, and of interest and user groups in particular (see Chapter 6), is especially important.

The assessment of hazards should take into account the severity and likelihood of health outcomes and the extent and density of use of the recreational area. Health risks that might be acceptable for a recreational area that is used infrequently and is undeveloped may result in immediate remedial measures at other areas that are widely used or highly developed.

Physical hazards vary greatly between sites. Monitoring of a site for existing and new hazards should be undertaken on a regular basis. The inspection and further investigation of hazards requires an understanding of the elements involved in such a programme. The identification of physical hazards, and the subsequent monitoring of any changes to the hazards depend upon potential and present water recreation areas and the hazards encountered. The purposes of inspection and investigation are to provide a routine, systematic, periodic and relevant verification of events, structures, conditions or other situations that represent hazards, whether “theoretical” or “actual” and under “real” conditions.

The following steps have been identified to evaluate an inspection process for hazards in recreational areas:

1. Determine what is to be inspected and how frequently.
2. Monitor changing conditions and use patterns regularly.
3. Establish a regular pattern of inspection.
4. Develop a series of checklists suitable for easy application throughout the system. Checklists should reflect national and local standards where they exist.
5. Establish a method for reporting faulty equipment and maintenance problems.
6. Develop a reporting and monitoring system that will allow easy access to statistics that record "when", "where", "why" and "how".
7. Investigate the frequency of positive and negative results of inspections.
8. Motivate and inform participants in the inspection process through in-service training.
9. Use outside experts to review critically the scope, adequacy and methods of the inspection programme.

7.3.1 Inspection forms and checklists

Because hazards vary greatly and because of the importance of social and behavioural factors (in causation and in prevention), it is important that checklists and inspection forms are developed, tested and refined according to local priorities and experience. Based upon Tables 7.1 to 7.5 some of the factors that may be included in an inspection protocol are described in Table 7.6. Many factors of importance described above are not included in this list because they are not amenable to an inspection-based approach.

Table 7.6 Factors to consider when designing an inspection programme relevant to physical hazards and drownings in recreational waters

Hazard	Factors
Drownings and near-drownings	Sea current (including tides, undertow and rate of flow) Offshore winds (especially with flotation devices) Possibility of underwater entanglement Bottom surface gradient and stability Waves (coastal, boat, chop) Water transparency Impeded visibility (including coastal configuration, structures and overcrowding) Lifeguard provision Provision of rescue services (e.g. lifeboats) Access to emergency response services (e.g. telephones with emergency numbers) Local hazard warning notices Availability of resuscitation skills and facilities Rescue and resuscitation skills amongst user groups Co-ordination with user group associations concerning hazard awareness and safe behaviours Wearing of lifejackets when boating
Cuts and lacerations	Presence of broken glass, bottles, cans and medical wastes Frequency of beach cleaning Solid waste management Provision of litter bins Local availability of first aid
Spinal injuries	Bottom surface type Water depth Conflicting uses in one area Jumping into water from trees, balconies or other structures Underwater visibility Local hazard warnings General public (user) awareness of hazards and safe behaviours Early education in diving hazards and safe behaviours Level of separation/segregation Lifeguard supervision Access to emergency services
Slip, trip and fall accidents	Underwater objects (e.g. walls, piers) Underwater visibility Adjacent surface type (e.g. water fronts, jetties) Surface type selection Adjacent fencing (e.g. around docks and piers)

7.3.2 Timetabling of inspections

The frequency of inspection will vary according to the intensity of use of the area and the speed with which the hazards encountered and the remedial actions in place change at a specific location. The timing of inspections should take account of periods of maximum use (e.g. inspection in time to take remedial action before major holiday periods) and periods of increased risk. The frequency of inspection therefore has to be predicted

based on the size of the facility, the number of features in the facility, and the extent of past incidents or injuries. The criteria for inspections and investigations may vary from country to country. There might be legal requirements and/or voluntary standard-setting organisations.

7.3.3 Reporting and notifications

The importance of co-ordination and participation of all interested individuals or organisations is emphasised in Chapters 5 and 6. Except where minimum legal requirements are specified, action to address deficiencies identified in inspections depends upon the goodwill of local authorities (local government, user groups and other interested parties). Maintaining co-ordination with such persons and authorities contributes greatly to the overall success of a monitoring programme in containing hazards and preventing adverse health effects.

Whilst much reporting is necessarily of a local nature, it is worthwhile to interpret and report findings at regional or national levels (where this is possible). Moreover, some approval schemes (see Chapter 5) stipulate either general requirements that management plans should be developed and implemented or that specific safety-related requirements should be met. Safety-related data may, therefore, contribute to informed personal choice (and thereby assist individuals in contributing directly to the protection of their own health) and also encourage local authorities to support safety-related improvements.

In addition to the benefits of reporting mentioned above, the availability of information concerning the existence of hazards and the deployment of remedial or preventative, measures may help to generate new insight into the effectiveness of those, and other, measures. Information on this aspect is limited at present.

7.4 Elements of good practice

- The nature and extent of any risk to, or potential hazard to, human health or well-being must be identified and characterised fully. The individual hazards must be related to a likely adverse health outcome.
- To assess the extent of risk, a suitable inspection protocol must be adopted. Such a protocol must define the components of a bathing area that may pose a risk to human health, cataloguing the water conditions, substratum, effects of climatic factors, infrastructure, management and regulatory regime, etc.
- The end-use of the bathing area, including carrying capacity and density of bathers, influences the outcome of the risk assessment.
- On completion of the initial assessment, appropriate control measures including management responses, must be defined, such as zoning, warning mechanisms and public information schemes, lifeguard provision and bathing area infrastructure.

- All situations that may give rise to adverse health outcomes at a bathing area should be reported in a consistent format and stored in an incident database that can be used to inform the level and nature of future management procedures.

7.5 References

Asher, K.N., Rivara, F.P., Felis, D., Vance, L. and Dunne, R. 1995 Water safety training as a potential means of reducing risk of young children's drowning. *Injury Prevention*, **1**, 228-233.

Blankesby, B.A., Wearne, F.K., Elliott, B.C. and Blitvitch, J.D. 1997 Aetiology and occurrence of diving injuries: a review of diving safety. *Sports Medicine*, **23**(4), 228-246.

CDC 1982 Perspectives in Disease Prevention and Health Promotion. Aquatic Deaths and Injuries - United States. *MMWR Weekly*, **31**(31), 427-19.

Hill, V. 1984 History of diving accidents. In: *Proceedings of the New South Wales Symposium on Water Safety*. Department of Sport and Recreation, Sydney, New South Wales, 28-33.

Keatinge, W.R. 1979 *Survival in cold water: the physiology and treatment of immersion hypothermia and of drowning*. Blackwell Scientific Publishers, Oxford. 135.

Poyner, B. 1979 How and when drownings happen. *The Practitioner*, **222**, 515-519.

Quan, L., Gore, E.J., Wentz, K., Allem, N.J. and Novak, A.H. 1989 Ten year study of paediatric drownings and near drownings in Kings County, Washington: lessons in injury prevention. *Pediatrics*, **83**(6), 1035-1040.

WHO 1998 *Guidelines for Safe Recreational Water Environments: Coastal and Freshwaters*. Draft for consultation. World Health Organization, Geneva.
