Executive summary

This volume of the *Guidelines for Safe Recreational Water Environments* describes the present state of knowledge regarding the impact of the recreational use of swimming pools and similar environments upon the health of users – specifically drowning and injury, microbial contamination and exposure to chemicals. Control and monitoring of the hazards associated with these environments are discussed.

The primary aim of the Guidelines is the protection of public health. The purpose of the Guidelines is to ensure that swimming pools and similar recreational water facilities are operated as safely as possible in order that the largest possible population gets the maximum possible benefit and not to deter the use of these recreational water environments.

The Guidelines are intended to be used as the basis for the development of approaches to controlling the hazards that may be encountered in recreational water environments. The information provided is generally applicable to pools supplied with fresh, marine or thermal water, whether they are indoors or outdoors; public, semi-public or domestic; supervised or unsupervised. Information also relates to public, semi-public and domestic hot tubs (which, for the purposes of these Guidelines, is the term used to encompass a variety of facilities that are designed for sitting in, contain treated water usually above 32 °C, are often aerated and are not drained, cleaned and refilled for each user) and natural spas (facilities using thermal and/or mineral water). Although bathing houses, such as hammams, are not specifically covered, the principles outlined in the Guidelines should also be generally applicable to these environments. The preferred approaches adopted by national or local authorities towards implementation of guideline values and conditions may vary between these types of environment.

A guideline can be:

- a level of management;
- a concentration of a constituent that does not represent a significant risk to the health of members of significant user groups;
- a condition under which exposures with a significant risk are unlikely to occur; or
- a combination of the last two.

When a guideline is exceeded, this should be a signal to investigate the cause of the failure and identify the likelihood of future failure, to liaise with the authority responsible for public health to determine whether immediate action should be taken to reduce exposure to the hazard, and to determine whether measures should be put in place to prevent or reduce exposure under similar conditions in the future.

Drowning and injury prevention

Drowning, which is defined in these Guidelines as death arising from impairment of respiratory function as a result of immersion in liquid, is a major cause of death worldwide. Near-drowning is also a serious problem, as it may have lifelong effects. The recovery rate from near-drowning may be lower among young children than among teenagers and adults. Studies show that the prognosis for survival depends more on the effectiveness of the initial rescue and resuscitation than on the quality of subsequent hospital care. Most studies of accidental drowning have focused on children, and in some countries drowning is the leading cause of injury deaths among younger age groups. It has been suggested that in terms of swimming pools and similar environments most drownings occur in domestic pools and hot tubs, many while the child's supervisor assumed the child was safely indoors.

In swimming pools and similar environments, alcohol consumption is one of the most frequently reported contributory factors associated with drownings and near-drownings for adults, whereas lapses in parental supervision are most frequently cited for incidents involving children. Also of concern is the danger of drownings and near-drownings due to inlets and outlets where the suction is strong enough to cause entrapment of body parts or hair, causing the victim's head to be held under water.

Few preventive measures for drowning and near-drowning have been evaluated, although installation of isolation fencing around outdoor pools has been shown by some studies to decrease the number of pool immersion injuries by more than 50%. Pool fences around domestic pools should have a self-closing and self-latching gate and should isolate the pool. Barrier fencing should be at least 1.2 m high and have no hand- or footholds that could enable a young child to climb it. Fence slats should be no more than 10 cm apart. Above-ground pools should have steps or ladders leading to the pool that can be secured and locked to prevent access when the pool is not in use. For domestic or outdoor hot tubs, it is recommended that locked safety covers be used when the hot tub is not in use.

Preventive measures for hair and body entrapment in pools and similar environments include the use of grilles on drain gates that prevent hair entrapment, dual drains, an accessible and/or pressure-activated emergency shut-off for the pump and the wearing of bathing caps. Warnings displayed in the form of clear and simple signs as well as water safety instruction and adult supervision all may have value as preventive actions.

Of sports-related spinal cord injuries, the majority appear to be associated with diving. Injuries in diving incidents are almost exclusively located in the cervical vertebrae, resulting in quadriplegia (paralysis affecting all four limbs) or paraplegia (paralysis of both legs). Data suggest that diving into the upslope of a pool bottom or into the shallow portion of the pool is the most common cause of spinal injuries in pools. Alcohol consumption may contribute significantly to the frequency of injury. Education and raising awareness appear to offer the most potential for diving injury prevention.

Other injuries associated with the use of swimming pools and similar environments include brain and head injuries and arm, hand, leg and foot/toe injuries. Expert opinion suggests that the latter are common and generally go unreported. Causes include slippery decks, uncovered drains, reckless water entry, running on decks, tripping on swimming aids left on the poolside and stepping on glass (from broken bottles).

Maintenance of surfaces (including appropriate waste disposal), supervision of pool users, providing appropriate warnings, ensuring good underwater visibility and pool safety education are among the actions that can reduce these incidents.

High temperatures in hot tubs, for example, can cause drowsiness, which may lead to loss of consciousness or to heat stroke and death, and it is recommended that water temperatures in hot tubs be kept below 40 °C. Exposure to low temperatures in plunge pools, which are used in conjunction with saunas or steam baths, may result in slowed heart beat, hypothermia, impaired coordination, loss of control of breathing, muscle cramps and loss of consciousness. Temperature extremes should be avoided by users with medical problems, pregnant women and young children. Educational displays and warning signs, warnings from pool staff and regulations on time limits for use can reduce these adverse outcomes.

Microbial hazards

The risk of illness or infection associated with swimming pools and similar recreational water environments is primarily associated with faecal contamination of the water. This may be due to faeces released by the bathers or contaminated source water or, in the case of outdoor pools, may be the result of direct animal contamination (e.g. from birds and rodents). Many of the outbreaks related to pools and similar environments have occurred because disinfection was not applied or was inadequate. Non-faecal human shedding into the pool water or surrounding area is also a potential source of pathogenic organisms.

Swimming pool-related outbreaks of illness are relatively infrequent, but have been linked to viruses, bacteria, protozoa and fungi. Viral outbreaks are most often attributed to adenovirus, although hepatitis A, norovirus and echovirus have also been implicated in pool-related disease outbreaks. It should be borne in mind that the evidence linking viral outbreaks to a pool is generally circumstantial, and the causative viruses have rarely been isolated from the water.

Shigella and *Escherichia coli* O157 are two related bacteria that have been linked to outbreaks of illness associated with swimming in pools. Symptoms of *E. coli* O157 infection include bloody diarrhoea (haemorrhagic colitis) and haemolytic uraemic syndrome (HUS), as well as vomiting and fever in more severe cases. HUS, characterized by haemolytic anaemia and acute renal failure, occurs most frequently in infants, young children and elderly people. Symptoms associated with shigellosis include diarrhoea, fever and nausea.

The risk of illness in swimming pools associated with faecally-derived protozoa mainly involves two parasites: *Giardia* and *Cryptosporidium*. These two organisms have a cyst or oocyst form that is highly resistant to both environmental stress and disinfectants. They also both have high infectivity and are shed in high densities by infected individuals. Giardiasis is characterized by diarrhoea, cramps, foul-smelling stools, loss of appetite, fatigue and vomiting, whereas symptoms of cryptosporidiosis include diarrhoea, vomiting, fever and abdominal cramps.

The control of viruses and bacteria in swimming pool water is usually accomplished by appropriate treatment, including filtration and the proper application of chlorine or other disinfectants. Episodes of gross contamination of pool water due to an accidental faecal release, however, cannot all be effectively controlled by normal treatment and disinfectant levels. Where pools or spas are not disinfected, accidental

faecal releases present an even greater problem. The only approach to maintaining public health protection under conditions of an accidental faecal release is to prohibit the use of the pool until the potential contaminants are inactivated.

Pool operators can help prevent faecal contamination of pools by encouraging pre-swim showering and toilet use and, where possible, confining young children to pools small enough to drain in the event of an accidental faecal release. It is recommended that people with gastroenteritis not use public or semi-public facilities while ill or for at least a week after their illness.

As well as pathogenic enteric organisms, a number of infectious non-enteric organisms may be transferred through pool water and the surrounding environment via human shedding. Infected users can directly contaminate pool waters and the surfaces of objects or materials at a facility with primary pathogens (notably viruses or fungi) in sufficient numbers to lead to skin and other infections in users who subsequently come in contact with the contaminated water or surfaces. Opportunistic pathogens (notably bacteria) can also be shed from users and be transmitted via both surfaces and contaminated water. In addition, certain free-living aquatic bacteria and amoebae can grow in pool, hot tub or natural spa waters, in pool or hot tub components or facilities (including heating, ventilation and air-conditioning systems) or on other wet surfaces within the facility to a point at which they may cause a variety of respiratory, dermal or central nervous system infections or diseases.

Most of the legionellosis, an often serious infection caused by *Legionella* species, associated with recreational water use has been associated with public and semi-public hot tubs and natural spas. Natural spas (especially thermal water) and hot tub water and the associated equipment create an ideal habitat (warm, nutrient-containing aerobic water) for the selection and proliferation of *Legionella*. *Pseudomonas aeruginosa* is also frequently present in hot tubs, as it is able to withstand high temperatures and disinfectants and to grow rapidly in waters supplied with nutrients from users. In hot tubs, the primary health effect associated with the presence of *P. aeruginosa* is folliculitis, an infection of the hair follicles that may result in a pustular rash.

It is less easy to control the growth of *Legionella* spp. and *P. aeruginosa* in hot tubs than in pools, as the design and operation of hot tubs can make it difficult to achieve adequate residual disinfection levels in these facilities. Thus, in public and semi-public facilities, frequent monitoring and adjustment of pH and disinfectant levels are essential, as are programmed 'rest periods' to allow disinfectant levels to 'recover'. In addition, facility operators should require users to shower before entering the water and control the number of users and the duration of their exposure. Thorough cleaning of the area surrounding the hot tub on a frequent basis (e.g. daily), complete draining and cleaning of the hot tub and pipework on at least a weekly basis, frequent backwashing and filter inspection and good ventilation are all recommended control measures.

Molluscipoxvirus (which causes molluscum contagiosum), papillomavirus (which causes benign cutaneous tumours – verrucae), *Epidermophyton floccosum* and various species of fungi in the genus *Trichophyton* (which cause superficial fungal infections of the hair, fingernails or skin) are spread by direct person-to-person contact or indirectly, through physical contact with contaminated surfaces. As the primary source of these viruses and fungi in swimming pools and similar environments is infected bathers, the most important means of controlling the spread of the infections is educating the public about the diseases, including the importance of limiting contact between

infected and non-infected people and medical treatment. Thorough frequent cleaning and disinfection of surfaces in facilities that are prone to contamination can also reduce the spread of the diseases.

Chemical hazards

Chemicals found in swimming pool water can be derived from a number of sources, namely the source water, deliberate additions such as disinfectants and pool users themselves (these include sweat, urine, soap residues, cosmetics and suntan oil).

There are three main routes of exposure to chemicals in swimming pools and similar environments: direct ingestion of the water, inhalation of volatile or aerosolized solutes and dermal contact and absorption through the skin. The amount of water ingested by swimmers and bathers will depend upon a range of factors, including experience, age, skill and type of activity. Experimental evidence suggests that water intake varies according to age and sex, with adult women ingesting the least and male children ingesting the most. Swimmers inhale from the atmosphere just above the water's surface, and the volume of air inhaled is a function of the intensity of effort and time. Inhalation exposure will be largely associated with volatile substances that are lost from the water surface, but will also include some inhalation of aerosols, within a hot tub (for example) or where there is significant splashing. Dermal exposure depends upon the period of contact with the water, water temperature and the concentration of the chemical.

The principal management-derived chemicals are disinfectants, added to minimize the risk to pool users from microbial contaminants. Coagulants may be added as part of the water treatment process to enhance the removal of dissolved, colloidal or suspended material. Acids and alkalis may also be added to the water in order to maintain an appropriate pH for optimal water treatment and also the comfort of bathers.

The chemical disinfectants that are used most frequently include chlorine (as a gas, hypochlorite or, generally for outdoor pools, chlorinated isocyanurates), chlorine dioxide, bromochlorodimethylhydantoin (BCDMH), ozone and ultraviolet (UV) radiation (with ozone and UV usually being used in combination with a chlorine- or bromine-based disinfectant). Practice varies widely around the world, as do the levels of chemicals that are currently considered to be acceptable in order to achieve adequate disinfection while minimizing user discomfort. It is recommended that acceptable levels of free chlorine continue to be set at the local level, but in public and semi-public pools these should not exceed 3 mg/l and in public and semi-public hot tubs should not exceed 5 mg/l. It is recommended that total bromine does not exceed 4 mg/l in public and semi-public pools and 5 mg/l in hot tubs. Where chlorinated isocyanurates are used, levels of cyanuric acid in pool water should not exceed 100 mg/l. Where ozone is used, an air quality guideline of 0.12 mg/m^3 is recommended in order to protect bathers and staff working in the pool building.

A number of disinfectants can react with other chemicals in the water to give rise to unwanted by-products, known as disinfection by-products. Most is known about the by-products that result from the reaction of chlorine with humic and fulvic acids, but there is evidence from model studies with amino acids that other organic substances will also give rise to a similar range of by-products. Although there is potentially a large number of by-products, the substances produced in the greatest quantities are trihalomethanes, of which chloroform is generally present in the greatest

concentrations, and the haloacetic acids, of which di- and trichloroacetic acid are generally present in the greatest concentrations. Both chlorine and bromine will react with ammonia in the water (resulting from the presence of urine) to form chloramines (monochloramine, dichloramine and nitrogen trichloride) and bromamines.

Trihalomethanes have been considered more than other chlorination by-products, reflecting the level of available information. Concentrations vary as a consequence of the concentration of precursor compounds, chlorine dose, temperature and pH. Trihalomethanes are volatile in nature and can be lost from the surface of the water, so they are also found in the air above the pool.

The guideline values in the WHO *Guidelines for Drinking-water Quality* can be used to screen for potential risks arising from swimming pools and similar environments, while making appropriate allowance for the much lower quantities of water ingested, shorter exposure periods and non-ingestion exposure. Although there are data to indicate that the concentrations of chlorination by-products in swimming pools and similar environments may exceed the concentrations proposed by WHO for drinking-water, the evidence indicates that for reasonably well managed pools, concentrations less than the drinking-water guideline values can be consistently achieved. The risks from exposure to chlorination by-products in reasonably well managed swimming pools would be considered to be small and must be set against the benefits of aerobic exercise and the risks of microbial disease in the absence of disinfection. Nevertheless, competitive swimmers and pool attendants can experience substantial exposure to volatile disinfection by-products via inhalation and dermal absorption. The chloramines and bromamines, particularly nitrogen trichloride and nitrogen tribromide, which are both volatile, can give rise to significant eye and respiratory irritation in swimmers and pool attendants. The provisional guideline value for chlorine species, expressed as nitrogen trichloride, in the atmosphere of swimming pools and similar environments is 0.5 mg/m^3.

Managing water and air quality

The primary water and air quality health challenges are, in typical order of public health priority, controlling clarity to minimize injury hazard, controlling water quality to prevent the transmission of infectious disease and controlling potential hazards from disinfection by-products. All of these challenges can be met through the combination of the following factors: treatment (to remove particulates, pollutants and microorganisms), including disinfection and filtration; pool hydraulics (to ensure effective distribution of disinfectant throughout the pool and removal of contaminated water); addition of fresh water at frequent intervals (to dilute substances that cannot be removed from the water by treatment); cleaning (to remove biofilms from surfaces, sediments from the pool floor and particulates adsorbed to filter materials); and adequate ventilation of indoor facilities.

Pre-swim showering will help to remove traces of sweat, urine, faecal matter, cosmetics, suntan oil and other potential water contaminants. Where pool users normally shower before swimming, pool water is cleaner, easier to disinfect with smaller amounts of chemicals and thus more pleasant to swim in. All users should also be encouraged to use the toilets before bathing to minimize urination in the pool and accidental faecal releases.

Disinfection is part of the treatment process whereby pathogenic microorganisms are inactivated by chemical (e.g. chlorination) or physical (e.g. UV radiation) means such that they represent no significant risk of infection. Circulating pool water is disinfected during the treatment process, and the entire water body is disinfected by the application of a residual disinfectant (chlorine- or bromine-based), which partially inactivates agents added to the pool by bathers. The choice of disinfectant depends upon a number of factors, including safety, compatibility with the source water, type, size and location of the pool, bathing load and the operation of the pool.

The concentration of disinfection by-products can be controlled to a significant extent by minimizing the introduction of precursors though source water selection, good bather hygienic practices (e.g. pre-swim showering), maximizing their removal by well managed pool water treatment and replacement of water by the addition of fresh supplies (i.e. dilution of chemicals that cannot be removed). It is inevitable, however, that some volatile disinfection by-products (such as chloroform and nitrogen trichloride) may be produced in the pool water and escape into the air. This hazard can be managed to some extent through good ventilation of indoor pool buildings.

Filtration is important in ensuring a safe pool. If filtration is poor, water clarity will decline and drowning risks increase. Disinfection will also be compromised, as particles associated with turbidity can surround microorganisms and shield them from the action of disinfectants. Particulate removal through coagulation and filtration is important for removing *Cryptosporidium* oocysts and *Giardia* cysts and some other protozoa that are resistant to chemical disinfection. For identifying bodies at the bottom of the pool, a universal turbidity value is not considered appropriate, as much depends on the characteristics of the specific pool. Individual standards should be developed, based on risk assessment at each pool, but it is recommended that, as a minimum, it should be possible to see a small child at the bottom of the pool from the lifeguard position while the water surface is in movement. In terms of effective disinfection, a useful, but not absolute, upper-limit guideline for turbidity is 0.5 nephelometric turbidity units.

Coagulation, filtration and disinfection will not remove all pollutants. Swimming pool design should enable the dilution of pool water with fresh water. Dilution limits the build-up of pollutants from bathers (e.g. constituents of sweat and urine), disinfection by-products and various other dissolved chemicals. Pool operators should replace pool water as a regular part of their water treatment regime. As a general rule, the addition of fresh water to disinfected pools should not be less than 30 litres per bather.

Good circulation and hydraulics in the pool ensure that the whole pool is adequately served by filtered, disinfected water. Treated water must get to all parts of the pool, and polluted water must be removed – especially from areas most used and most polluted by bathers. It is recommended that 75–80% be taken from the surface (where the pollution is greatest), with the remainder taken from the bottom of the pool.

Accidental faecal releases may occur relatively frequently, although it is likely that most go undetected. A pool operator faced with an accidental faecal release or vomit in the pool water must act immediately. If the faecal release is solid, it should be retrieved quickly and discarded appropriately. The scoop used to retrieve the faeces should be washed carefully and disinfected after use. If residual disinfectant levels are satisfactory, no further action is necessary. Where the stool is runny (diarrhoea) or if

there is vomit, the situation is likely to be more hazardous. The safest course of action in small pools or hot tubs is to evacuate users, drain, clean and refill. Where draining is not possible, the pool should be cleared of people immediately; as much of the material as possible should be collected, removed and disposed of to waste; disinfectant levels should be maintained at the top of the recommended range or shock dosing used; using a coagulant (if appropriate), the water should be filtered for six turnover cycles; and the filter should be backwashed.

In indoor facilities, it is important to manage air quality as well as water quality in swimming pools and similar recreational water environments. This is important not only for staff and user health, but also for their comfort and to avoid negative impacts on the building fabric, and building code ventilation rates should be adhered to.

Parameters that are easy and inexpensive to measure and of immediate operational health relevance (such as turbidity, disinfectant residual and pH) should be monitored most frequently and in all pool types.

For a conventional public or semi-public swimming pool with good hydraulics and filtration, operating within its design bathing load, experience has shown that adequate routine disinfection should be achieved with a free chlorine level of 1 mg/l throughout the pool. Lower free chlorine concentrations (0.5 mg/l or less) will be adequate when chlorine is used in combination with ozone or UV disinfection. Higher concentrations (up to 2–3 mg/l) may be required for hot tubs, because of higher bathing loads and higher temperatures. Total bromine concentrations should not exceed 4 mg/l in public and semi-public pools and 5 mg/l in hot tubs.

In public and semi-public pools, residual disinfectant concentrations should be checked by sampling the pool before it opens and during the opening period (ideally during a period of high bathing load). It is suggested that the residual disinfectant concentration in domestic pools be determined before use. If the routine test results are outside the recommended ranges, the situation should be assessed and action taken.

The pH value of swimming pool water (and similar environments) must be controlled to ensure efficient disinfection and coagulation, to avoid damage to the pool fabric and to ensure user comfort. The pH should be maintained between 7.2 and 7.8 for chlorine disinfectants and between 7.2 and 8.0 for bromine-based and other non-chlorine processes.

There is limited risk of significant microbial contamination and illness in a well managed pool or similar environment with an adequate residual disinfectant concentration, a pH value maintained at an appropriate level, well operated filters and frequent monitoring of non-microbial parameters. Nevertheless, samples of pool water from public and semi-public pools should be monitored at appropriate intervals for microbial parameters, including heterotrophic plate count, thermotolerant coliforms or *E. coli*, *Pseudomonas aeruginosa* and *Legionella*. The frequency of monitoring and the guideline values vary according to microbial parameter and the type of pool.

Guideline implementation

Recreational water activities can bring health benefits to users, including exercise and relaxation. Effective management can control potential adverse health consequences that can be associated with the use of unsafe recreational water environments.

Different stakeholders play different roles in the management of the recreational water environment for safety. The typical areas of responsibility may be grouped into four major categories, although there may be overlap between these and stakeholders with responsibilities falling within more than one category:

- *Design and construction.* People responsible for commissioning pools and similar environments, along with designers and contractors, should be aware of the requirements to ensure safe and enjoyable use of facilities. Many decisions taken at the design and construction phase will have repercussions on the ease with which safe operation can be ensured once the pool is in use.
- *Operation and management.* Facility operators play a key role and are responsible for the good operation and management of the recreational water environment. This should include the preparation of and compliance with a pool safety plan, which consists of a description of the system, its monitoring and maintenance, normal operating procedures, procedures for specified incidents, a generic emergency plan and an emergency evacuation procedure.
- *Public education and information.* Facility operators, local authorities, public health bodies, pool-based clubs and sports bodies can play an important role in ensuring pool safety through public education and providing appropriate and targeted information to pool users.
- *Regulatory requirements (including compliance).* National legislation may include different sets of regulations that will apply to swimming pools and similar recreational environments. Regulation may control, for example, the design and construction of pools, their operation and management and control of substances hazardous to health. Within regulations it is likely that there will be a requirement for the use of certified material and, possibly, staff registered to certain bodies. Local regulatory oversight can support the work of pool management and provide greater public health protection and public confidence. Inspections by the regulatory officials to verify compliance with the regulations are an important component of this oversight.

Successful implementation of the Guidelines will also require development of suitable capacities and expertise and the elaboration of a coherent policy and legislative framework.