

## Executive Summary

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The use of water for recreational purposes poses a number of health risks which depend on factors such as the nature of the hazard, the characteristic of the water body and the immune status of the user. Although evidence from outbreak reports and other epidemiological evidence have proven a link between adverse health effects and immersion in poor quality recreational water, the difficulties associated with attributing an infection to recreational water use are numerous and the majority of research in this field has focussed on infections associated with the use of recreational waters resulting in minor, self-limiting symptoms.

There are many unanswered questions regarding the severity and frequency of illness associated with recreational water use. It is plausible that more serious illnesses could result from the recreational use of water and this association has not yet been investigated to any great extent. It is also increasingly apparent that a number of micro-organisms or their products are directly or indirectly associated with secondary health outcomes or sequelae and a number of these sequelae may result from waterborne infections. The acute diseases attributable to waterborne pathogens and their epidemiology have been well described, but the sequelae that can result from these diseases have not. Assessing potential

sequelae of waterborne infections is a critical part of microbial risk assessment and the formulation of public policy.

Even where illness is severe, it may still be difficult to attribute it to recreational water exposure due to the large number of other transmission routes of the pathogens in question. Nevertheless, evidence does exist to show that although much less frequent, more serious and potentially fatal disease is a risk to recreational users of water. This book describes the more severe waterborne diseases (and their sequelae) which may be acquired while undertaking water-based recreation in marine, freshwater, hot tubs, spas and swimming pools. A 'weight of evidence' approach has been developed to establish the credibility of association of an illness with recreational water exposure. The approach takes into account epidemiology, microbiology and water quality information. Outbreaks are therefore categorised as being 'strongly', 'probably' or 'possibly' associated with water.

Consideration of whether an illness is severe or not is based on three factors:

- acute symptoms of the disease which are debilitating;
- the ability and probability that the illness will lead to sequelae; and
- the effect of the disease on certain susceptible subpopulations.

Each factor can be considered in its own right or in combination with one or both of the other factors. A simplified index of severity has been created and applied wherever possible to the illnesses considered, taking into account possible sequelae. The outcome measures used to ascertain the relative severity are case-fatality rate, average duration of illness, median percentage of cases requiring hospitalisation, the frequency of development of sequelae and the severity of sequelae. The index is limited by the availability of data and does not take into account the probability of infection following exposure. The index is designed to help public health professionals prioritize recreational water management decisions to reduce the potential for severe disease outcomes.

The following pathogens have been considered:

*Campylobacter jejuni* — one of the most common causes of bacterial gastroenteritis and chronic sequelae. The pathogen has been isolated from recreational waters on many occasions. However, few cases of illness have been reported through this route. *Campylobacter jejuni* is more likely to be found in recreational waters contaminated by animal and human waste.

*E. coli* O157 — although most outbreaks of *E. coli* O157 have been associated with food, a number of outbreaks have been reported from recreational use of waters, particularly in pools that were not adequately chlorinated. Haemolytic uraemic syndrome with possible long-term sequelae is evident although no follow-up studies appear to have been conducted in people who contracted the infection from recreational water use. The acute disease tends to be moderately severe and of moderate duration.

*Helicobacter pylori* — water has been implicated as one mode of transmission of *H. pylori* although the detection of the pathogen has proved difficult. Therefore, it is possible that *H. pylori* infection is waterborne, but these assumptions need to be substantiated. Current evidence for its association with recreational waters is slight.

*Legionella* spp. — there are a number of reports of Legionnaires' disease associated with the use of, and proximity to, hot tubs in particular. The illness is considered to be severe with a high risk of death and severe acute symptoms. There are a number of documented cases of persons suffering sequelae as a consequence of infection with *Legionella* spp.

*Mycobacterium avium* complex — there is clear evidence for the association of *Mycobacterium avium* complex with recreational waters. The species of *Mycobacterium* that are associated with water are associated with a variety of diseases. Some, such as *M. ulverans* are pathogenic in previously healthy individuals, others, such as *M. avium*, usually cause disease in compromised individuals. The majority of cases associated with recreational waters appear to be attributed to swimming pools and hot tubs resulting in skin and soft tissue infections in immunocompetent patients. However, hypersensitivity pneumonitis is also seen in immunocompetent persons with aerosol exposure to mycobacteria.

*Shigella* spp. — epidemiological evidence exists for the association of recreational use of water and self-limiting infection with shigella bacteria. The species responsible for the more severe illness, *S. dysenteriae*, is more common in tropical regions but no cases associated with recreational waters were found in the literature. However, it is biologically plausible that *S. dysenteriae* could be encountered in freshwaters used for recreation.

*Vibrio vulnificus* — this bacteria commonly occurs in marine and estuarine environments. Evidence exists for the association of recreational use of water and infection with *V. vulnificus* where the user has a pre-existing open wound. Surveillance of *V. vulnificus* infections is poor and the number of cases reported is likely to be underestimated.

*Cryptosporidium* — faecal accidents are implicated in most of the cases as the cause of the outbreaks of cryptosporidiosis, which have primarily occurred in swimming pools, although some cases have been documented from water slides, fountains and water parks. *Cryptosporidium* oocysts show resistance to chlorination. The risk of death and probability of developing long-term sequelae from this infection is low, however the acute illness can be prolonged and moderately severe especially in immunocompromised persons.

*Giardia* — recreational use of water is a proven risk factor for giardiasis. The majority of symptomatic patients of *Giardia* will clear their infection after one to several weeks although immunocompromised patients may not recover from giardiasis. The risk of death and the probability of developing sequelae from this infection is low, however the acute illness can be prolonged and moderately severe.

Microsporidia — although microsporidia are currently not common causes of recreational waterborne disease, their role as emerging pathogens is being increasingly recognised. Their small size makes them difficult to remove by conventional water filtration techniques and it is thought that, like *Cryptosporidium* they may show increased resistance to chlorine disinfection. Illness is generally reported in immunocompromised individuals although some infections in immunocompetent individuals have been reported.

*Naegleria fowleri* has been shown to colonise warm freshwater habitats, such as swimming pools and natural hot springs and there is a high risk of death in infected persons. The acute illness is severe with symptoms lasting more than seven days and death always occurs. Although the infection is rare, new cases are reported every year.

*Schistosoma* spp. — in some cases serious pathology associated with infection by *Schistosoma* spp. occurs and can lead to long-term health issues. Schistosoma is only a potential hazard in certain geographic areas (e.g., sub-Saharan Africa). Surveillance for schistosomiasis is currently poor, inferring that many more cases associated with recreational waters occur but are not published. Evidence shows that exposure to schistosomes is difficult to avoid but it has been shown that towel-drying after exposure to infested water can markedly reduce the risk of infection.

Adenovirus — the diseases resulting from infection with adenovirus include conjunctivitis, pharyngitis, pneumonia, acute and chronic appendicitis, bronchiolitis, acute respiratory disease, and gastroenteritis. Adenovirus infections are generally mild; however, there are a number of fatal cases of infection reported in the literature. Transmission of adenovirus in recreational waters, primarily inadequately chlorinated swimming pools, has been documented via faecally-contaminated water and through droplets, although no fatal cases attributable to recreational waters have been documented in the literature.

Coxsackievirus — although there have been very few outbreaks of coxsackievirus linked to recreational water recorded, and epidemiological evidence remains scarce the virus has been frequently isolated from marine and freshwaters. As with other viruses (hepatitis A virus (HAV), adenovirus and echovirus) transmission of the virus is possible and biologically plausible in susceptible persons. Coxsackievirus is responsible for a broad range of illness from mild febrile illness to myocarditis and other more serious diseases.

Echovirus — as with the other enteroviruses discussed in this review, there are few published cases of infection by echovirus in recreational water, those that are recorded are primarily from swimming pool water. The most likely source of the virus is through faecal contamination, although secretions from the eyes or throat are possible. There are likely to be many unreported cases of infection with echovirus.

Hepatitis A virus — has been isolated from surface waters which may be used for recreational purposes and a number of cases of HAV have been

documented associated with recreational water users. Fulminant hepatitis is rare and has not been reported in any cases linked with the use of recreational waters. No cases of sequelae of HAV contracted through the use of recreational waters were found in the literature and the probability of developing long-term sequelae is low. The acute disease is usually moderately severe and of moderate duration but risk of death is low.

Hepatitis E virus (HEV) — has been isolated from surface waters which may be used for recreational purposes. Fulminant hepatitis is rare. No cases of sequelae of HEV contracted through the use of recreational waters were found in the literature and the probability of developing long-term sequelae is low. The acute disease is usually moderately severe and of moderate duration but risk of death is low except where cases occur during pregnancy.