



Fact Sheet

Naegleria fowleri

Naegleria fowleri and human infection

Naegleria are free-living protozoa that occupy a range of thermal niches in sediments, fresh water, sewage and sludge. More than forty *Naegleria* species have been identified, and some are thermophilic (heat tolerant), and able to grow at temperatures as high as 46°C. One of the thermophilic species, *Naegleria fowleri*, can cause an infection called primary amoebic meningoencephalitis (PAM), an often fatal disease of the central nervous system.

Naegleria fowleri has been detected in a diverse range of warm-water environments, including geothermal pools, natural tropical lakes, irrigation channels, thermal discharges from the power and chemical industries, and water supply bores, tanks and pipelines. It is believed that exposure to this organism is common, but illness is very rare. Most reported cases of *N. fowleri* infection are associated with swimming or other recreational activities in natural surface freshwater bodies. Infection occurs through introduction of the organism into the nasal cavity, and cases are often associated with jumping or falling into the water, thus providing conditions where water is forced into the nose at pressure. The amoebae infect the olfactory bulbs and then spread to the meninges (the membrane surrounding the brain) and often to the brain itself. The incubation period for PAM is usually two to five days, and the infection cannot be transmitted from person to person. PAM is difficult to diagnose because it has non-specific symptoms which are similar to the more common viral and bacterial forms of meningitis. The disease progresses rapidly and most cases of PAM are fatal. A recent review reported only three survivors among 142 cases in the US between 1937 and 2013. Most victims are children (median age about 12 years) and the disease is more common in males, probably because they are more likely to engage in diving and vigorous play activities in water. It has been estimated that the risk from recreational water activities (such as swimming, diving or waterskiing) in potentially contaminated freshwater in the USA, is five cases of *N. fowleri* infection for every billion episodes of recreational water activity.

Main points to note

- *Naegleria fowleri* are found in warm (above 25°C), fresh water bodies around the world.
- [The risk of being infected by *Naegleria fowleri* from public water supplies in Australia is extremely low.](#)
- Recent cases of infection by *Naegleria fowleri* in Australia occurred in private water supplies that were untreated or poorly treated.
- Well-treated town water supplies with effective disinfection (such as chlorine) are not at risk from this organism.
- Infection can occur if water containing amoebae is pushed up the nose, through activities such as jumping, diving or falling into warm fresh water bodies.

Naegleria fowleri in public tap water supplies

The involvement of public tap water supplies in PAM infections was first documented in South Australia, where about 20 cases occurred between the 1940s and 1970s in several towns that received their water supply through long, above-ground pipelines. About half of the cases did not have a recent history of freshwater swimming, but had intra-nasal exposure to tap water such as inhaling bath water or squirting water from a garden hose into the nose. Investigations revealed *N. fowleri* in the water supply, and it was concluded that the high summer water temperatures in the pipelines combined with a lack of chlorine disinfection provided a suitable environment for growth of the organism. Tap water may also have been the primary source of infections attributed to swimming pools in these towns. No further cases of disease occurred after introduction of measures to reliably maintain disinfection levels along the above-ground pipelines and in the town water systems.

A few cases of PAM linked to water supplies were identified in Western Australia, Queensland and New South Wales during the 1970s and early 1980s. During the period 2006 to 2015 Queensland has seen four more confirmed cases of PAM, three of which are known to have resulted from exposure

to untreated private water supplies on remote farming properties. All three of these cases were fatal. *N. fowleri* has also been found in water supplies in the Northern Territory, but no human infections have been documented there.

For more than 30 years, Australia was the only country where PAM was linked to (and *N. fowleri* detected in) public tap water supplies. In 2002, two fatal *N. fowleri* infections in greater Phoenix (Arizona) were attributed to contact with water from a small-scale, company-operated water supply. The water was drawn from a geothermal (warm) groundwater source and was not disinfected. All previous North American PAM cases had been linked to bathing in freshwater lakes (USA) or in irrigation channels (Mexico). Three more fatal cases of PAM associated with tap water have since been recorded in Louisiana, and these were attributed to insufficient disinfection and warm water temperatures. Two of the Louisiana cases involved use of unboiled tap water in “neti-pots” for nasal irrigation, and clusters of recent cases in Pakistan have also been linked to nasal irrigation with tap water as part of religious practices.

Management of *Naegleria fowleri* risks in public tap water supplies

The “Australian Drinking Water Guidelines” contains information on the occurrence, detection and management of *Naegleria fowleri* including Chapter 10 “Monitoring for specific characteristics in drinking water”, a Fact Sheet and specific consideration of this organism in Information Sheets relating to drinking water disinfection with chlorine and chloramine. No Guideline Value is provided, but given that the organism can grow rapidly under favourable conditions, it is recommended that a limit of 2 organisms per litre in treated water be used as a threshold level for remedial action.

Following the discovery of drinking water-associated PAM cases in Australia, effective management strategies were developed by water suppliers to address the key risks of above ground pipelines, prolonged warm water temperatures and water stagnation which may permit growth of thermophilic *Naegleria* species. This has resulted in a progressive decline in the rate of detection of *N. fowleri* in water supplies, and the elimination of human infections. The main considerations for risk management include:

- Risk characterisation - tap water supply systems should be considered at risk for occurrence of *N. fowleri* if water temperatures are seasonally above 30°C or consistently above 25°C, or if thermophilic *Naegleria* species have ever previously been detected in the system.
- Adequate disinfection must be applied (to achieve a free chlorine residual concentration and contact time > 30mg/L-min) and the chlorine (or chloramine) residual should be maintained at 0.5 mg/L or above throughout the distribution system. Disinfectant residuals must be monitored frequently and the monitoring regime should be based on a site-specific risk assessment.
- Proper design, management and cleaning of physical assets (e.g. pipes and storage tanks) is required to minimise sediment (which may harbour *Naegleria* cysts) and reduce water stagnation (which may lead to loss of disinfectant residual).
- A monitoring program should be developed in consultation with the appropriate health regulatory agency. This might comprise periodic surveys, temperature profiling or regular

monitoring for thermophilic *Naegleria* species, depending on the characteristics of the water system. Incident management protocols should also be developed to deal with detections in the treated water supply system.

- Where public access to undisinfected piped water supplies is permitted for non-drinking purposes (for example isolated rural properties may be permitted to extract water from a pipeline before it reaches a township where disinfection is applied), advice should be provided on a regular basis about potential *Naegleria* hazards and minimisation of behaviours that may place users at risk of infection.

This risk management approach is consistent with the overall philosophy of the Australian Drinking Water Guidelines and the Framework for Management of Drinking Water Quality.

There is currently no guideline value for the presence of *Naegleria fowleri* in drinking water. Water supply systems should be considered at risk if the water temperature seasonally exceeds 30°C or continually exceeds 25°C, or if thermophilic *Naegleria* species have ever previously been detected in the system.

Trends in occurrence

There has been some speculation that the geographic range of *N. fowleri* could increase as a consequence of global warming leading to higher ambient water temperatures in many temperate areas. Human activities such as discharge of large volumes of heated industrial cooling water may also create conditions conducive to thermophilic *Naegleria* growth in water bodies where they may previously not have thrived.

Evidence on this issue is sparse, but concerns have been raised in the US because of the recent occurrence of PAM cases in more northerly states, where it has been considered that the climate was unsuitable for proliferation of thermophilic *Naegleria*. Among the 142 US PAM cases covered by a recent review, the four most northerly cases had all occurred since 2010. However given the rarity of this illness, it is not possible to determine whether apparent changes in the frequency or geographic distribution of cases reflect changes in occurrence or increasing clinical awareness and diagnostic capability.

More information is available from Queensland Health, *Naegleria fowleri*: Qs and As
<http://conditions.health.qld.gov.au/HealthCondition/media/pdf/14/165/101/naegleria-fowleri-qs-and-as-v3>

References

- Dorsch, M. M., et al. (1983). The epidemiology and control of primary amoebic meningoencephalitis with particular reference to South Australia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 77(3): 372-377.
- Trolio, R., et al. (2008). Operational management of *Naegleria* spp. in drinking water supplies in Western Australia. *Water Science and Technology: Water Supply* 8(2): 207-215.
- Capewell, L. G. et al (2014). Diagnosis, Clinical Course, and Treatment of Primary Amoebic Meningoencephalitis in the United States, 1937–2013. *Journal of the Pediatric Infectious Diseases Society* pp. 1–8, 2014. DOI:10.1093/jpids/piu103