Microbial health-based targets for drinking water: current state and Australian case study



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Through the avoidance of a substantial health burden globally, access to safe drinking water is an important foundation of public health[1]. An emerging development in this regard is the use of public health metrics, such as disability-adjusted life years, to inform water safety planning[2]. This paper examines the hypothesis that confidence in the protection of public health, on the part of water suppliers, health regulators, and ultimately consumers is strengthened through the implementation of a health outcome target for the microbial safety of drinking water. A case study demonstrating the implementation of the target is presented.

The recent contamination of *Campylobacter* spp. in drinking water supplies in Havelock North, New Zealand highlights that access to safe drinking water remains an area of importance to public health even in developed countries. It is estimated that, of the 14 000 inhabitants, 5500 (39%) contracted campylobacteriosis[3]. This was not an isolated issue: waterborne outbreaks in developed countries continue to be attributable to deficiencies in municipal drinking water services[4]. Even seemingly unrelated disturbances to municipal drinking water supply can be implicated in microbial disease outbreaks. Secondary impacts of the water supply lead contamination in Flint, Michigan, USA are thought to include the increased incidence of shigellosis and Legionnaires' disease[5,6]. Further, health impacts of waterborne microbial contaminants are not limited to infectious disease; elevated levels of microcystins (a group of toxic cyanobacterial metabolites) triggered the issuance of a precautionary 'do not drink' notice for the 400 000 inhabitants of Toledo, Ohio, USA, lasting several days in 2014[7]. Thus, drinking water supplies represent an environmental exposure route of far-reaching and wide-ranging public health consequence. Comprehensive planning for safe water supplies is therefore a prudent investment in public health.

The WHO promotes the use of a preventive risk management system (the water safety plan) as an international norm for the assurance of drinking water safety[8]. Water safety plans facilitate the establishment of a comprehensive set of preventive management actions for the quality assurance of drinking water safety, similar to the hazard analysis and critical control point (HACCP) principles and ISO 22000 standard for food safety management[9,10]. Its use has been demonstrated to be an effective public health intervention[11–13]. Water safety planning further considers the need to meet the unique challenges associated with drinking water supply. Challenges include variation in quality of source water, the

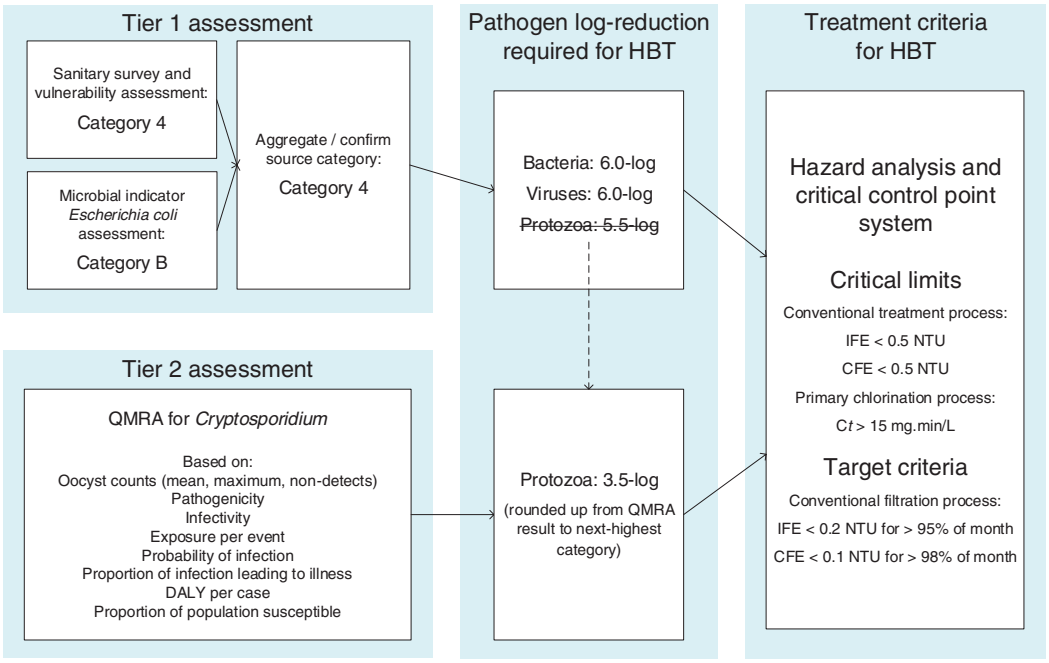

Figure 1. Derivation of water treatment process criteria for the achievement of the health outcome target for the microbial safety of drinking water, based on the Water Services Association of Australia method, showing results for a large water treatment plant in New South Wales, Australia. QMRA, quantitative microbial risk assessment; HBT, health-based target of 10^{-6} disability-adjusted life years per person-year; IFE, individual filter effluent; CFE, combined filter effluent; *Ct*, primary disinfectant contact-time; NTU, nephelometric turbidity units.

need for continuity of supply, and the consideration of aesthetic and other physical characteristics[10].

In Australia, water safety planning is authoritatively guided by the Australian Drinking Water Guidelines[14]. Since 2004, the Australian Drinking Water Guidelines has recommended preventive risk management of water supplies through the Framework for Management of Drinking Water Quality. In effect, implementation of water safety planning (in a manner consistent with the Australian Drinking Water Guidelines or an analogous regime) is required by the health regulators of all Australian states, the Northern Territory, and the Australian Capital Territory. The most recent development in Australian water safety planning is the expected incorporation of a health outcome target for drinking water treatment into the Australian Drinking Water Guidelines[2,15]. The health-based target approach is currently under development by the National Health and Medical Research Council to be included in the revised Guidelines. The target, 10^{-6} disability-adjusted life years per person-year, can be met by having drinking water treatment performance limits set commensurate to the microbial challenge expressed by the source water[16,17].

The Water Services Association of Australia method for the derivation of water treatment process criteria for the achievement of the health outcome target[16] was followed for a large water treatment plant in New South Wales. A graphical representation of the method and the resultant set of process criteria are shown in Figure 1. The plant's historical drinking water treatment process data, as recorded through the supervisory control and data acquisition (SCADA) system, were then compared to these criteria. They were found to be consistent with meeting the targeted health outcome. The target's associated water treatment process criteria were then codified as critical limits—demarcating acceptable water treatment performance—under the water safety plan and SCADA system. This was to allow the water treatment plant operators an ongoing, instantaneous indication of the target's achievement. It also resulted in later infrastructure planning necessarily considering the water treatment plant's continued ability to meet the targeted health outcome over time.

The introduction of the health outcome target signifies a challenge and opportunity. For water suppliers and regulators, its implementation is a non-trivial investment of effort yet offers a substantial opportunity to gain increased confidence in the adequacy of drinking water treatment. It can thus provide valuable evidence for improvement to operations and infrastructure for the achievement of safe drinking water supplies.

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References

1. Bartram, J. and Cairncross, S. (2010) Hygiene, sanitation, and water: forgotten foundations of health. *PLoS Med.* **7**, e1000367. doi:10.1371/journal.pmed.1000367

2. Gibney, K. *et al*. (2013) Using disability-adjusted life years to set health-based targets: a novel use of an established burden of disease metric. *J. Public Health Policy* **34**, 439–446. doi:10.1057/jphp.2013.22
3. Government Inquiry into Havelock North Drinking Water. (2017) *Report of the Havelock North drinking water inquiry: stage 1*. Government Inquiry into Havelock North Drinking Water, Auckland, New Zealand.
4. Hrudey, S.E. and Hrudey, E.J. (2007) Published case studies of waterborne disease outbreaks—evidence of a recurrent threat. *Water Environ. Res.* **79**, 233–245. doi:10.2175/106143006X95483
5. Nelson, R. (2016) Crisis in Flint: lead and Legionnaires' disease. *Lancet Infect. Dis.* **16**, 298–299. doi:10.1016/S1473-3099(16)00082-7
6. The Lancet. (2016) Dangerous disregard for the right to water [Editorial]. *The Lancet* **388**, 2838. doi:10.1016/S0140-6736(16)32511-9
7. Jetoo, S. *et al*. (2015) The Toledo drinking water advisory: suggested application of the water safety planning approach. *Sustainability* **7**, 9787–9808. doi:10.3390/su7089787
8. WHO (2011) *Guidelines for drinking-water quality*, 4th edn. World Health Organization, Geneva, Switzerland.
9. International Organization for Standardization. (2005) *ISO 22000 : 2005 Food safety management systems – Requirements for any organization in the food chain*. ISO, Geneva, Switzerland.
10. Yokoi, H. *et al*. (2006) Study on the introduction of hazard analysis and critical control point (HACCP) concept of the water quality management in water supply systems. *Water Sci. Technol.* **53**, 483–492. doi:10.2166/wst.2006.153
11. Viljoen, F.C. (2010) The World Health Organization's water safety plan is much more than just an integrated drinking water quality management plan. *Water Sci. Technol.* **61**, 173–179. doi:10.2166/wst.2010.792
12. Mälzer, H.J. *et al*. (2010) Identification, assessment, and control of hazards in water supply: experiences from water safety plan implementations in Germany. *Water Sci. Technol.* **61**, 1307–1315. doi:10.2166/wst.2010.026
13. Ye, B. *et al*. (2015) Risk assessment and water safety plan: case study in Beijing, China. *J. Water Health* **13**, 510–521. doi:10.2166/wh.2014.101
14. NHMRC and NRMMC. (2011) *National water quality management strategy paper 6: Australian drinking water guidelines*. National Health and Medical Research Council, National Resource Management Ministerial Council, Canberra, Australia.
15. NHMRC. (2016) *Australian Drinking Water Guidelines: draft framework on microbial health based targets*. https://consultations.nhmrc.gov.au/public_consultations/adwg-microbial (accessed 15 August 2017).
16. WSAA. (2015) *Drinking water source assessment and treatment requirements: manual for the application of health-based treatment targets*. Water Services Association of Australia, Melbourne, Australia.
17. Walker, R. (2016) The water safety continuum: a practical way to implement a health-based target for microbial quality. *Water e-Journal* **1**, e1–6. doi:10.21139/wej.2016.008

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Public health impact of the Enteroviruses and Parechoviruses

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Enteroviruses (EV) comprise viruses originally classified on cell culture replication patterns and clinical manifestations into a number of groups: poliovirus, coxsackievirus A, coxsackievirus B and ECHOvirus. The closely related genus *Parechovirus* has more recently been associated with human disease. EVs are common commensals of the human gut, often found without any ill effects on the person, but are also associated with a wide range of diseases and syndromes including non-specific rash illnesses, hand, foot and mouth disease (HFMD), conjunctivitis, meningitis and encephalitis, myocarditis and polio. This results in a significant burden of disease worldwide, often due to a particular genotype of EV. An estimated 1 billion people are infected with EV every year.