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Improvements to Drinking Water

Monitoring, Reporting and Record-keeping Needed to Protect Health

Abstract

Taumata Arowai, the new independent water services regulator, recently consulted publicly on the drinking water rules for water suppliers. We use a case study on nitrate and official information requests to demonstrate the current weaknesses in the drinking water monitoring and reporting systems and why the reforms proposed by Taumata Arowai seem unlikely to substantively address many of these deficiencies. To ensure sufficient public health surveillance and robust epidemiological research into the potential health impacts of drinking water contaminants, Taumata Arowai should: 1) establish a national database for water supply and quality; 2) mandate the standardisation of reporting requirements across water suppliers; 3) increase the frequency and range of water quality testing; and 4) maintain a national map of water supplies. These upgrades are particularly important in an era of rapid land use changes and climate change.

Keywords Taumata Arowai, three waters, public health, drinking water, nitrate

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In 2016, Havelock North's water-related campylobacteriosis outbreak made much of an entire town sick (around 8,000 people), with 58 hospitalisations and four deaths (Gilpin et al., 2020; Wilson et al., 2021). The outbreak was an outcome of systemic flaws in Aotearoa New Zealand's regulatory system for drinking water, which were highlighted in the subsequent government inquiry (Government Inquiry into Havelock North Drinking Water, 2017). This inquiry led to the Three Waters review (Department of Internal Affairs, 2020) and subsequent reforms called 'Three Waters' that are responsible for reforming the waste, storm and drinking water systems in Aotearoa. A key initiative of the Three Waters reforms was the establishment of a new independent water services regulator, Taumata Arowai.

Taumata Arowai recently consulted publicly on the drinking water standards and quality assurance rules for water suppliers. The standards, which define the maximum permitted concentration of key contaminants, remain relatively unchanged under the new proposals (Taumata Arowai, 2021a). In contrast, there are some major changes proposed to the rules that regulate water suppliers, including source water protection,

filtration requirements, and the number of water supplies covered by the legislation (Taumata Arowai, 2021b). However, these new rules do not address a fundamental problem with water quality testing, monitoring and reporting mechanisms required for effective public health surveillance and research. In this article we use a case study on nitrate and official information requests to demonstrate the current weaknesses in the drinking water monitoring and reporting systems and why the reforms proposed by Taumata Arowai seem unlikely to substantively address many of these deficiencies.

programme did not require ongoing monitoring. For example, if nitrate levels were less than 25mg/L during the testing programme, then that water supplier was not required to monitor for nitrate. Consequently, very few water supplies had ongoing testing for nitrate levels (serving a total of 53,900 people, around 1% of the population) in 2020 (Ministry of Health, 2020).

Nitrate in drinking water and health

Nitrate is one of the most common drinking water contaminants in Aotearoa, largely driven by agricultural activity (nitrogen fertiliser application and livestock urine) (Morgenstern and Daughney, 2012). The regulatory limit for nitrate set by the World Health Organization and adopted by Aotearoa is 50mg/L, a level intended to prevent rare cases of methaemoglobinaemia, which causes potentially fatal cases of asphyxia in infants (Ministry of Health, 2018; World Health Organization, 2017). Recent experimental, genetic and epidemiological evidence has linked nitrate in drinking water to other conditions, including colorectal cancer (Temkin et al., 2019; Chambers et al., 2022), preterm births (Sherris et al., 2021) and congenital anomalies (Stayner et al., 2022). These adverse health outcomes were observed at levels as low as 3.8mg/L, well below the current World Health Organization guidelines (Schullehner et al., 2018). A cross-sectional analysis in Aotearoa estimated that 800,000 people are on supplies containing over 4mg/L of nitrate. Approximately 50% of those people are receiving water from registered water supplies controlled by district councils (Richards et al., 2022).

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Current water testing and reporting rules for registered water suppliers

Water supplies in Aotearoa are broadly characterised as either a registered or an unregistered supply. The owner of a water supply serving more than 25 people (around 85% of the New Zealand population) is required to register with the Ministry of Health (Richards et al., 2022). District councils provide water to 98% of people on a registered supply. Unregistered supplies (around 15% of the population), including self-served water supplies sourced primarily from a groundwater bore or rainwater tank, are not subject to current Ministry of Health regulation (ibid.). However, the new Taumata Arowai proposal requires any person supplying water to more than one dwelling to register (Taumata Arowai, 2021b). The redefinition of a registered supply will increase our understanding of water quality for those people most at risk of water contamination.

The current drinking water testing and reporting requirements for many contaminants are largely based on a national testing programme that was conducted between 1996 and 2004 by the Institute of Environmental Science and Research (ESR) (ESR, 2019). Water supplies testing below 50% of the maximum acceptable value (MAV) for certain contaminants within this

Nitrate case study

In September 2021 we sent Local Government Official Information and Meetings Act requests to all district councils for all nitrate data for their drinking water supply components (source water, treatment plant and distribution system) and any spatial data (digital maps) on their water supply boundaries (the area served by any given water supply).

Data extraction

We received completed requests from all 67 district councils in the country, with these collectively providing reticulated water to 4,113,000 people (85% of the national population). Some councils were able to process the requests within days, while others took months (mean 54 days; range 2–130 days) (Table 1). The process involved over 500 email clarifications and phone and videoconference calls between researchers, council employees, commercial testing laboratories and infrastructure companies, and took over five months to complete, consuming substantial time and resources.

Data coverage

Table 1 shows the extent of nitrate testing conducted by district councils at the supply rather than council level (councils control multiple water supplies). Fifty-eight individual supplies (9%) serving 1,090,000 people (27%) continued to be tested for nitrate after the ESR testing programme ended in 2004. Continued testing occurred between 2005 and 2009 for an additional 24% of supplies serving 942,000 people, and between 2010 and 2014 for an additional 20% of supplies serving 1,307,000 people, while 10% of supplies have not tested their water for nitrate since the testing programme. 'Continued testing' in this context is loosely defined as either annual, bi-annual, five-yearly or spot tests after the ESR testing programme was completed.

In total, 42 councils (63%) provided spatial data, or confirmed spatial data held by the authors for their water supplies. While most data sets were spatially complete, many lacked descriptive elements in their data tables to facilitate linking to Ministry of Health compliance data (e.g., did not use ministry naming conventions). Further, data formats were not uniform across district councils. Substantial data cleaning was required to compile the data into a single spatial national data set. Twelve councils (18%) provided incomplete geographic information system (GIS) files, which meant one or more water supplies were missing. Four councils provided aerial snapshots from Google Maps or similar GIS to highlight the expected supply boundary, while nine councils (13%) were unable to provide any

spatial information on their water supply boundaries.

Data quality and standardisation

The nitrate testing information was received in various formats, including reports from the commercial testing laboratories, custom Microsoft Excel spreadsheets, highlighted in email correspondence, or redirection to environmental reporting data from regional councils. Again, each district council had their own data reporting systems, which meant collation of testing results required extensive data cleansing and data entry of all testing results to generate information in a uniform format. Additionally, district councils regularly used their own naming conventions (e.g., bore#231), which do not correspond to Ministry of Health compliance data.

Data loss

A number of district councils no longer possessed their water quality results, due to migrations to new data systems, the council's own data retention and disposal schedules, staff turnover, and reliance on commercial testing laboratories to archive testing results. A large portion of water quality results had to be retrieved by us from the major commercial testing laboratories upon appropriate permission from the relevant council. However, in some cases the laboratory no longer held the data because they had migrated to a new data system. In one case the laboratory no longer operated, preventing retrieval of all relevant testing results. The loss of testing data also poses serious questions about the ability of each council to independently monitor, store and analyse water quality data for the full range of contaminants.

Table 1: The extent of nitrate monitoring and spatial information for registered water supplies controlled by district councils throughout Aotearoa

Nitrate testing conducted	Number of water supplies		Population covered	
Testing since 1996–2004	58	(9%)	1,091,000	(27%)
Earliest testing 2005–09	154	(24%)	943,000	(23%)
Earliest testing 2010–14	131	(20%)	1,308,000	(32%)
Earliest testing 2015–19	199	(31%)	682,000	(17%)
Earliest testing 2020–22	40	(6%)	45,000	(1%)
No testing since 1996–2004	63	(10%)	45,000	(1%)
Total	645	(100%)	4,114,000	(100%)
Spatial data available	**Number of councils**		**Population covered**	
Complete GIS file	42	(63%)	3,600,000	(88%)
Incomplete GIS file	12	(18%)	266,000	(6%)
No files provided to researchers	9	(13%)	187,000	(5%)
Aerial images	4	(6%)	61,000	(1%)
Total	67	(100%)	4,114,000	(100%)

Taumata Arowai's proposed monitoring and reporting programme

A number of changes are proposed in Taumata Arowai's recent consultation document that may, in part, address some of these data issues. However, problems remain. First, all registered supplies, regardless of size, will be required to routinely test for nitrate in source water. Supplies serving more than 500 people are proposed to be tested annually, and smaller supplies three-yearly (Taumata Arowai, 2021b). However, the temporal variation in nitrate levels in source water (Morgenstern and Daughney, 2012) means that the proposed testing regime is unlikely to provide a reliable estimate for nitrate in source water (e.g., testing each season may be more appropriate).

Second, testing for some contaminants is not required in complex treatment or distribution systems that combine water from multiple sources, on the basis that they are tested in the source water. However, relying on source water data for such systems prevents the accurate measurement of contaminants in the water, since the volume of water derived from each source varies. For example, if three different sources contributing to a distribution system have nitrate levels of 0.5, 5 and 7mg/L, it is difficult to accurately determine the exact nitrate concentration in the drinking water in the network at any given time. This is a major problem for exposure assessment in epidemiological research which relies on valid quantitative results on an exposure (e.g., nitrate levels) to calibrate risks to health. It also raises issues in terms of the accuracy and transparency of information ratepayers are receiving about the quality of the water they are paying for and receiving.

Changing the rules to correct for these shortfalls would not be difficult or costly. All suppliers are required to test annually for other contaminants in some water supply components (e.g., for lead in the distribution system), at which point they could also test for nitrate. Private correspondence with commercial labs suggests that the marginal cost of adding a nitrate test is around $6 per sample, while an estimated cost to test for the identified contaminants listed in Taumata Arowai's recent consultation document using a simple distribution system would cost approximately $50.[1]

A third issue is that although the proposed rules require water suppliers to collate, report and maintain data to demonstrate compliance with the rules, there is limited detail in the consultation document on the prescribed format of these requirements. Suppliers may report and maintain their data differently, preventing the collation of a national database without substantial public and analyst resources. Further, it is not clear if Taumata Arowai will require actual testing results (e.g., the more informative, precise value of any given test in mg/L) or merely document achievement of a regulatory threshold (e.g., does the contaminant comply with the drinking water standards, yes/no). The latter is the current system, which is preventing any meaningful surveillance of contaminants below the MAV. Without a national database of contaminant values there is no ability to centrally monitor these trends and progressively optimise risk reduction to the public with water quality interventions.

The current rules also do not specify what spatial information will be required from registered water suppliers. Section 53 of the Water Services Act 2021 specifies that registered water suppliers must provide information on the location of the drinking water supply and the drinking water supply boundary. Further, section 55 specifies that Taumata Arowai must maintain a separate publicly available version of this information. However, both sections are vague enough that any form of spatial information provided in response to our information requests could comply. Without specific instructions to standardise spatial information on water

supply components (sources, treatment plants and distribution systems), it will remain a time-consuming and error-prone process to compile spatial information at regional and national levels.

How Taumata Arowai could improve public health surveillance and research on drinking water supply

Establish a national database for drinking water quality

A national database for drinking water quality would facilitate ongoing surveillance, trend analyses and public health research, all of which would support improvements in drinking water quality in Aotearoa. Currently the Ministry of Health's central database for drinking water quality compliance, Drinking Water Online, contains nitrate testing results for only 7% of all registered supplies, with its earliest measurements starting in 2017. The majority of data contained within this central database is only for compliance purposes – e.g., does the supply comply with the drinking water standards? This compliance-based approach has severe limitations for public health surveillance and research targeted at assessing risk to the public. For public health surveillance, it is important to assess trends in water quality to identify areas of degrading and improving water quality and potentially pre-empt future problems. From an epidemiological perspective, without actual testing results it is impossible to assess the potential health impact of key contaminants at levels below the MAV. Our understanding of the human health impacts of some chemical contaminants is still limited; thus, research into exposure below the MAV is central to informing future drinking water standards and protecting public health.

Taumata Arowai could facilitate the integration of water quality data into the Integrated Data Infrastructure (IDI) in collaboration with Statistics New Zealand. The IDI is a series of large linked data sets of individual-level personal data from most of the country's ministries, linked by a single identifier (Milne et al., 2019). The integration of a centralised water quality database would facilitate high-quality research to assess health risks at very low cost. Very few countries have access to a centralised database of routinely collected health and social data at an individual level and a national database for water quality. In Aotearoa, both are possible, a scenario that would facilitate world-leading research and ensure that public health researchers could assess ongoing and emerging health threats from drinking water to protect public health.

Specify quantifiable test results in the reporting requirements for all water suppliers

Taumata Arowai should specify precise data reporting requirements and formats to water suppliers. First, water suppliers should be required to maintain records on quantifiable testing results from each test, rather than compliance-based reporting. Second, Taumata Arowai should provide a standardised template for water suppliers' record-keeping. Third, for publicly owned supplies (e.g., all district council supplies), testing results should be publicly accessible online. These changes would improve the efficiency in collating a national database of water quality and ensure transparency. Furthermore, such processes would probably reduce the burden on district councils, which are routinely required to respond to information requests from the public and media on water quality data.

Increase the frequency and range of drinking water monitoring

The current testing regime lacks the frequency of testing and range of contaminants covered to ensure effective public health surveillance. This gap is problematic in a time of rapidly changing land use patterns and climate change impacts. Therefore, testing frequencies should be increased for all supply types. Most suppliers are required to test at weekly or at least yearly rates for some basic contaminants (e.g., *E. coli*). The marginal cost of adding contaminants to this testing is negligible compared to the total operating costs and asset values. For example, Wellington Water has an operating budget of $225 million per year and controls water assets worth $6.1 billion for all three water assets (Wellington Water, 2021, 2022). The burden of any additional testing will be felt most by smaller suppliers. However, a yearly cost of around $50–100 to cover testing of a wider range of contaminants to ensure water is relatively safe is justified given the human and economic impact of failures (Government Inquiry into Havelock North Drinking Water, 2017). Increasing the frequency and range of drinking water monitoring will also improve our understanding of the health impacts of chemical contaminants. This is particularly important for contaminants at levels below the current MAVs, to support the adoption of a precautionary approach to water quality testing and monitoring.

Create a national spatial data set of water supply components

Taumata Arowai should maintain a national spatial data set of registered water supply components. In particular, it should specify a standardised format for spatial information for registered supplies. Ideally, this would be a spatial file format that is compatible with common geographic information systems, such as a shapefile or KML file. The information should include standardised naming conventions that align with testing and compliance information so they can be easily linked. Registered water suppliers should be required to review these files at each registration event to ensure they are representative of their current water supply boundaries. Taumata Arowai should maintain this database each year with any changes submitted by suppliers incorporated, so that trends in the size and location of water supplies can be assessed. Many councils have specialised GIS teams that maintain spatial records on many public assets. It is unlikely that these requirements would require substantial ongoing investment from large water suppliers. But, as an interim measure, GIS support could be offered to smaller suppliers to enable them to develop and maintain spatial information on their water supplies. Without specification in the Taumata Arowai rules document, the currently wasteful, ad hoc and fragmented development and storage of spatial information will continue. Correcting this information gap could help with identifying areas of declining water quality, informing people in areas with MAV exceedances, and public health research.

Conclusions

The marked fragmentation of district council water quality testing, reporting and data management structures in Aotearoa has created major inefficiencies and data losses that potentially increase public health risk. The new rules proposed by Taumata Arowai are unlikely to substantively address many of the major design flaws that have adversely affected public health surveillance and research to improve water quality and minimise risks to public health. To maximise efficiency and improve information to protect public health, we recommend that the new rules are revised to: 1) establish a

national database for drinking water quality; 2) mandate the standardisation of reporting requirements across water suppliers; 3) increase the frequency and range of water quality testing; and 4) create a national database of spatial information on water supply components.

1 The current simple distribution system testing proposed by Taumata Arowai includes antimony, cadmium, chromium, copper, lead, mercury, nickel and zinc.

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