AUSTRALIAN DRINKING WATER RECORD

Preliminary Findings

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Agenda

01 SUMMARY

Summary

The Australian Drinking Water Record (ADWR) is being developed by the Water Justice Hub (WJH) in response to knowledge gaps on drinking water quality in Australia.

The objectives of building this knowledge base include: (a) supporting consumers, communities, community organisations, and the broader public to hold water service providers and governments accountable for drinking water quality outcomes, (b) enabling causal analysis of the direct and indirect health, social, and economic impacts of poor-quality drinking water, and (c) informing government planning and decision-making processes at the local, territory, state and federal levels.

As of November 2024, public reporting data has been collected for 1,392 locations with populations under 10,000 people in the Northern Territory (NT), Western Australia (WA), Victoria (VIC) (good data), and South Australia (SA) (fair data). Inconsistent data reporting is observed across regions, states, and years. Data for many Indigenous communities as listed in the Australian Government Indigenous Programs & Policy Locations (AGIL) has not yet been recorded.

There is limited progress in drinking water quality compliance for the period 2016-2023 in NT, SA and WA. On average, 65% of communities meet both Australian Drinking Water Guidelines (ADWG) for health and acceptability, 31% meet the ADWG guidelines for health but not acceptability, and 4% fail to meet ADWG guidelines for health.

Indigenous, small, remote, and/or more disadvantaged socio-economic communities appear to face greater disadvantages in accessing good quality tap water that meets ADWG guidelines for acceptability.

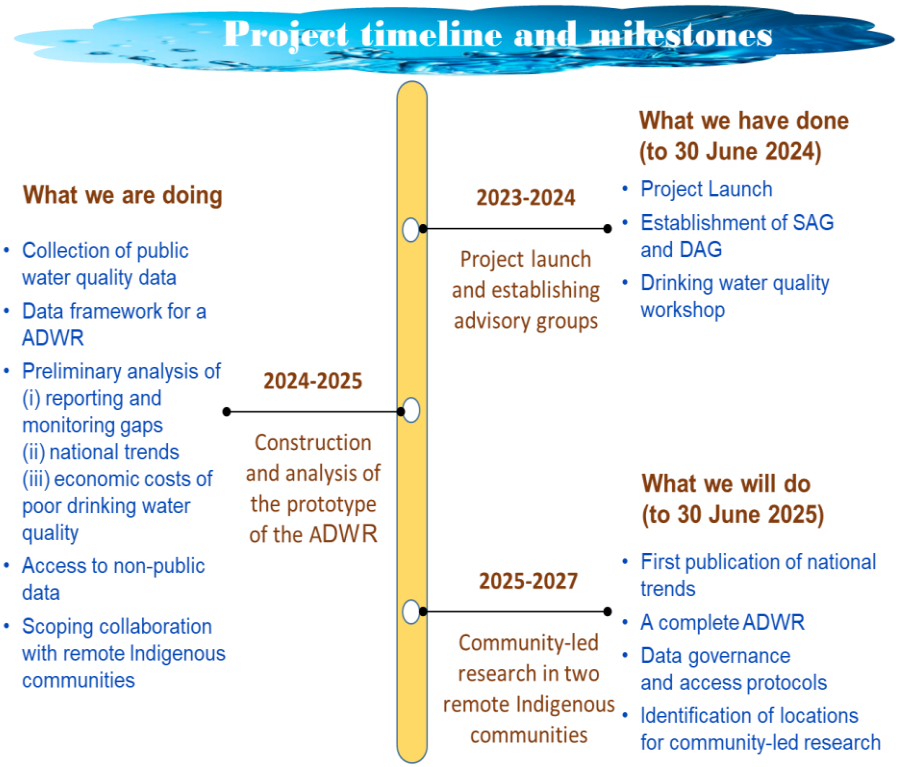
Estimated cost burden of bottled water purchases can be large compared to median weekly household income, particularly for Indigenous households, in communities where water fails to meet ADWG guidelines for health and/or acceptability. Bottled water purchase is one example of potential direct and indirect costs of poor-quality drinking water.

The results are preliminary and should be interpreted with caution due to limitations in data collation and analysis.

02 INTRODUCTION

Introduction

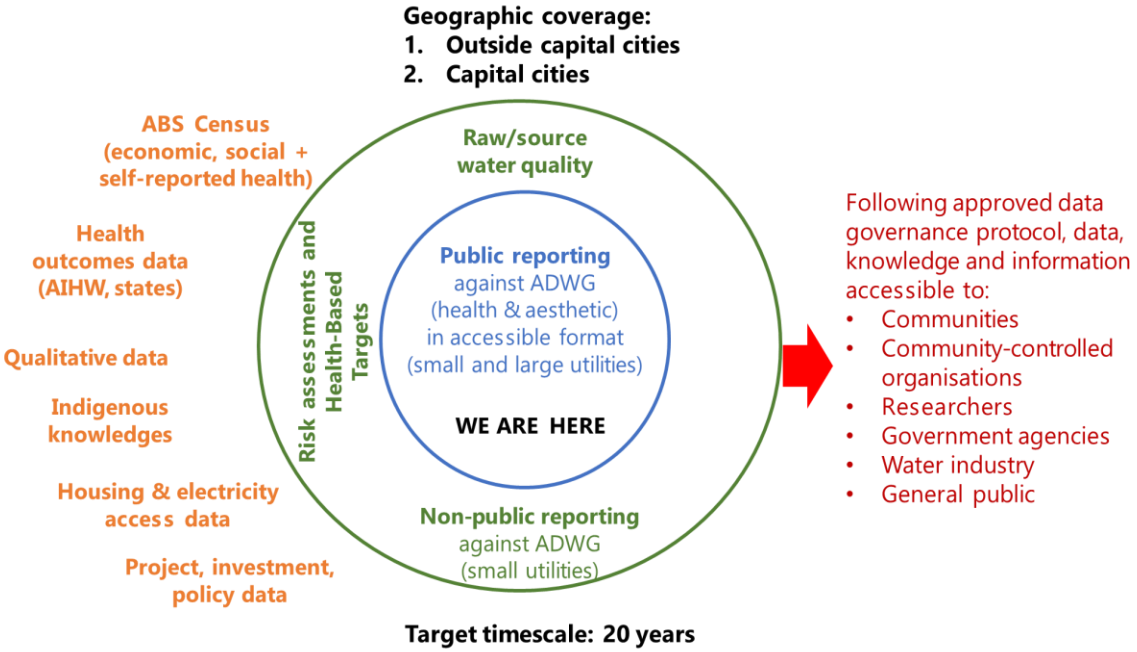
- The Water Justice Hub (WJH) has received funding from Equity Trustees for a five-year project to address knowledge gaps and contribute to improved drinking water quality and health outcomes in remote Indigenous communities.
- The project also receives financial and in-kind support from the Australian Research Council and the Australian National University.
- The project is (a) developing the Australian Drinking Water Record (ADWR), a database compiling historical water quality reporting against the Australian Drinking Water Guidelines (ADWG) to support community-led decision-making, academic research, and government investments in infrastructure and policy reforms, and (b) supporting community-led research on the health and economic impacts of poor drinking water quality.
- The Project Team is supported by Strategic and Data Advisory groups with expertise across economics, public health, hydrology, Indigenous sciences, policy and governance, risk science, and water management.



03 AUSTRALIAN DRINKING WATER RECORD

ADWR framework

- Public reporting against the ADWG are currently being collected for both small and large utilities.
- The record will be expanded to include non-public reporting data, as well as data on water source quality, risk assessments, and health-based targets where available.
- The ADWR can be matched with other socio-economic and health datasets to generate academic research that informs planning and investments.
- A data governance protocol is being developed in consultation with key partners and the Data Advisory Group to facilitate access to the record for communities, researchers, government agencies, the water industry, and the general public.

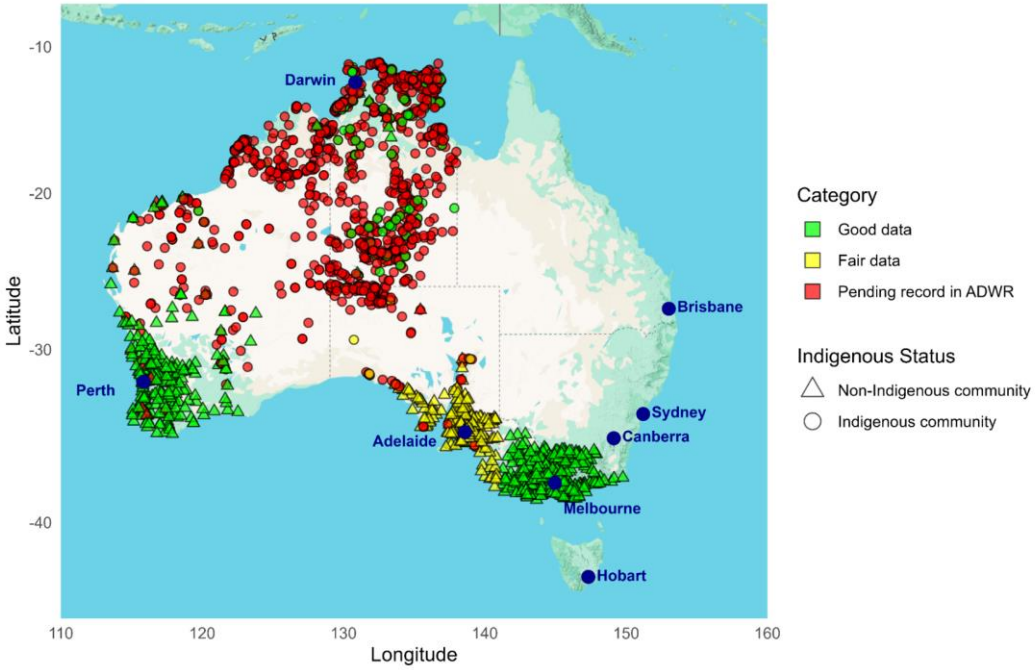


ADWR updates

- As of November 2024, public reporting data has been collected for 1,392 locations with populations under 10,000 people in the NT, SA, WA, and VIC.

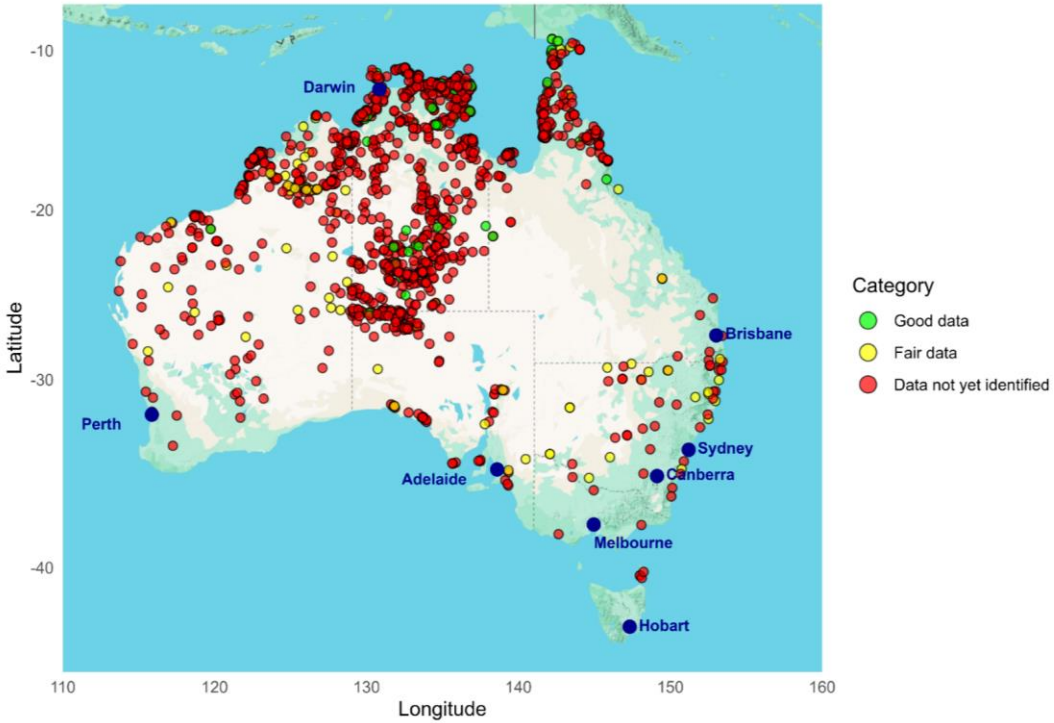
- Of these, 704 locations, primarily in the NT, WA, and VIC, have *good data*, meaning it includes many tested parameters and/or a high level of detail across multiple summary statistics. In contrast, 688 locations in SA have *fair data*, characterized by limitations that may include data reported by water systems rather than town, suburb or community; limited information (e.g., few parameters, reporting only exceedances without summary statistics, lack of sample counts); inconsistent results; and/or data presented in non-replicable formats (e.g., graphical presentation).

- Inconsistent data reporting is observed across regions, states, and years. Additionally, drinking water quality data for many Indigenous communities within these jurisdictions, as listed in the Australian Government Indigenous Programs & Policy Locations (AGIL), has not yet been incorporated. This is due to limited public reporting and monitoring.



ADWR updates

- Considering all Indigenous communities listed in the AGIL, data sources have been identified for 138 communities, comprising 52 with *good data* and 86 with *fair data*.
- Of these 138 communities, data has been collected for 51 communities to date, with further data collection ongoing.
- Pending access and collation of non-public data, it is planned that a subsequent version of the ADWR will list the names and contact details of government agencies, service providers, and other organisations that have been identified as holding drinking water quality data for each AGIL community.
- Data protocols that are under development will include explicit guidelines in relation to Indigenous Data Sovereignty and Governance, including the storage, use and accessibility of non-public data obtained from government agencies and service providers, and data generated by self-supplied communities.



04 PRELIMINARY ANALYSIS (NT, SA & WA)

Trends in drinking water quality for small communities

For the preliminary analysis, only the public reporting data collected for NT, SA, and WA has been used, while data from VIC remain under verification. The analysis focuses on communities with population under 10,000 people.

The ADWG define guideline values for: (a) health-based water quality characteristics (i.e. microbial, chemical and radiological contamination associated with short- and long-term health risks), and (b) “aesthetic" or acceptability characteristics (i.e. physical and chemical properties of water that affect smell, taste, colour, or have negative impacts on pipes and appliances). An exceedance in the context of a health-based characteristic relates to a verified test result exceeding the guideline value; for a characteristic that relates to acceptability, an exceedance occurs if the mean annual value across all test results exceeds the “aesthetic” guideline value.

For this analysis, drinking water quality is categorised in relation to these guideline values as follows:

(i) Water that fails to meet all ADWG guideline values for health (at least one health-based exceedance);

(ii) Water that meets ADWG guidelines values for health but not acceptability (no-health based exceedances but at least one exceedance in relation to 9 key acceptability characteristics: true colour, turbidity, hardness, total dissolved solids (TDS), pH, sodium, iron, manganese, chloride); and

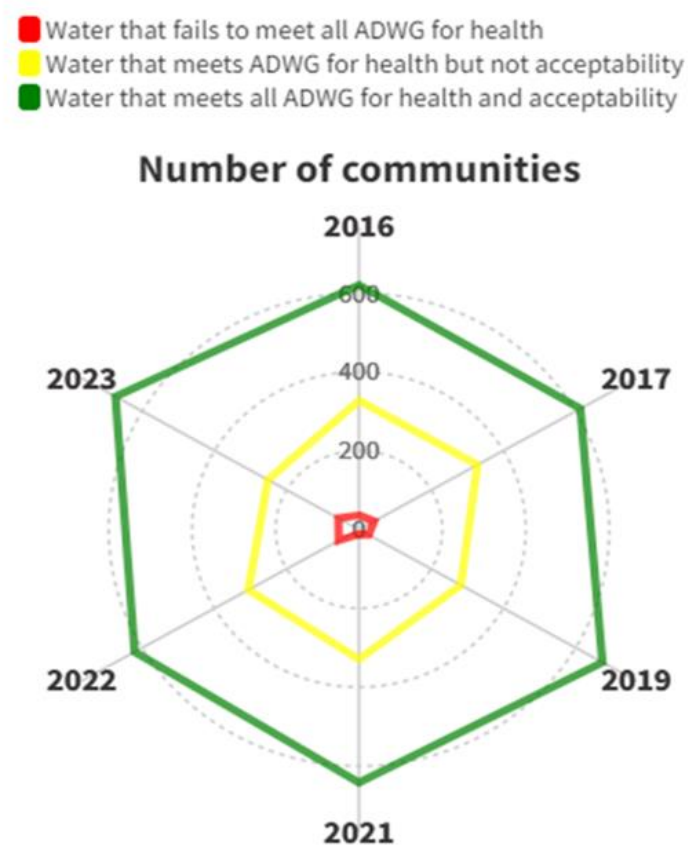
(iii) Water that meets all ADWG for health and acceptability (no exceedances related to health-based characteristics and none of the 9 key acceptability characteristics).

Water quality from 2016-2023 (NT, SA & WA)

- The radar chart illustrates the distribution of community drinking water quality across six years (2016, 2017, 2019, 2021, 2022, and 2023) based on three categories of water quality. Data for SA is unavailable for 2018 and 2020, so only six years are represented.

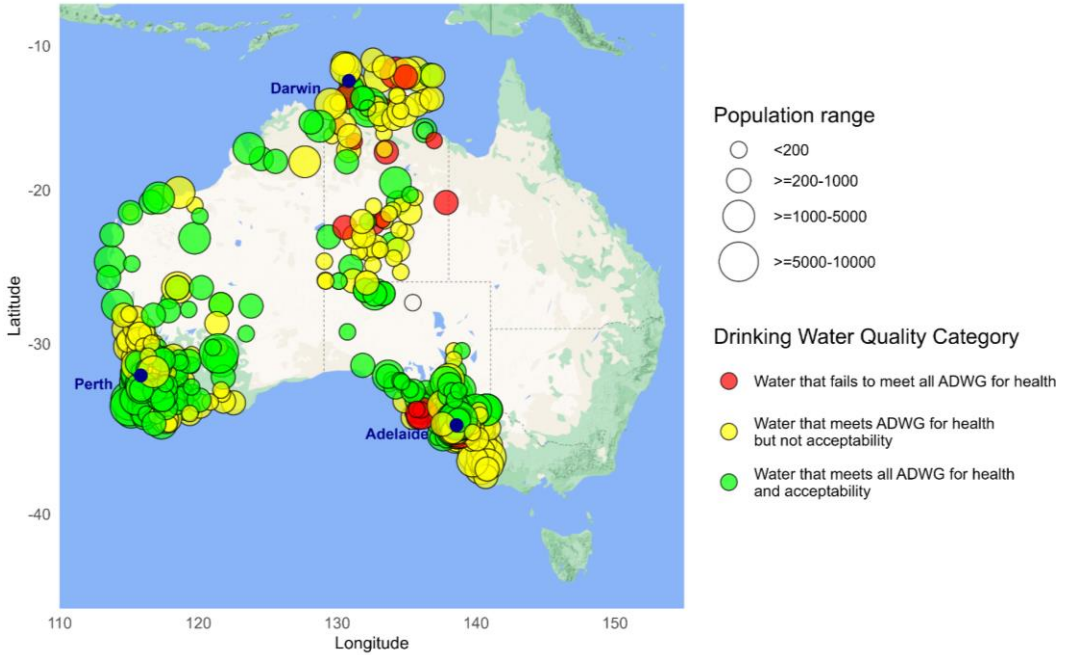
- Throughout the period, an average of 65% of communities meet both ADWG guidelines for health and acceptability (green category), 31% meet ADWG guidelines for health but not acceptability (yellow category), and 4% fail to meet ADWG guidelines for health (red category).

- The data reflects limited progress in drinking water quality compliance over time. While most communities are in the green category, with numbers fluctuating between 620 and 674, there is no identifiable trend. The yellow category shows a modest decline from 327 in 2016 to 252 in 2023. By comparison, the red category reveals variability, with a significant rise from 12 in 2021 to 57 in 2023.



Water quality in 2023 (NT, SA & WA)

- Analysis of 2023 currently collated in the database indicates that while SA leads in comprehensive compliance, NT faces significant challenges with both health and acceptability guidelines, and WA has challenges primarily with acceptability guidelines.
- In NT, only 18% of studied communities meet both ADWG guidelines for health and acceptability, with the majority (67%) meet health guidelines but not acceptability, and 15% fail to meet health guidelines entirely.
- SA has a high compliance rate, with 76% of communities meeting both ADWG guidelines, although 17% meet health guidelines only and 7% fail on health guidelines.
- In WA, about 66% of communities meeting both ADWG guidelines, 33% meet only health guidelines, and just one community fails to meet health guidelines.



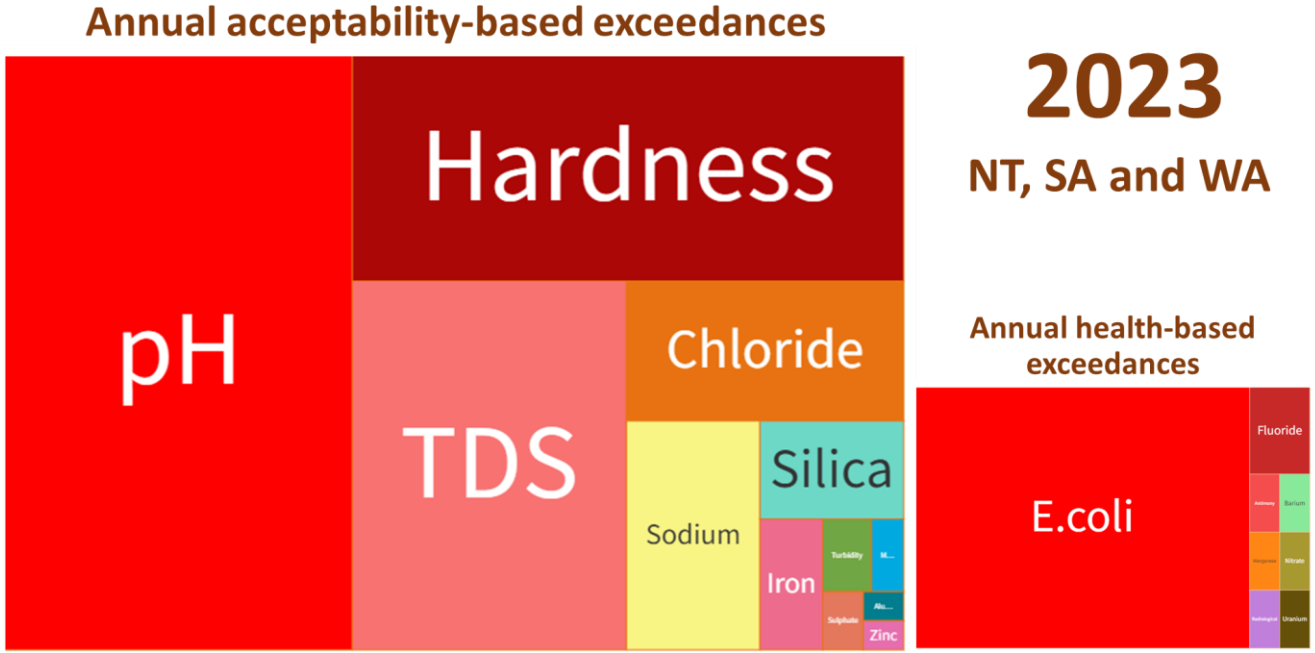
Annual exceedances in 2023 (NT, SA & WA)

This figure reflects the annual exceedances, represented by the average yearly test results of specific parameters that exceed the acceptable limits set by the ADWG.

In 2023, there were 623 acceptability-based exceedances, far surpassing the 59 health-based exceedances.

Among acceptability-based exceedances, the most common parameters are pH, Hardness, Total dissolved solids (TDS), Chloride, Sodium, and Silica.

For health-based exceedances, E.coli is the most frequently observed parameter.



Note: Size of coloured rectangles represents the number of annual exceedances associated with the corresponding parameter in 2023. Total of 59 health-based exceedances and 623 acceptability-based exceedances included.

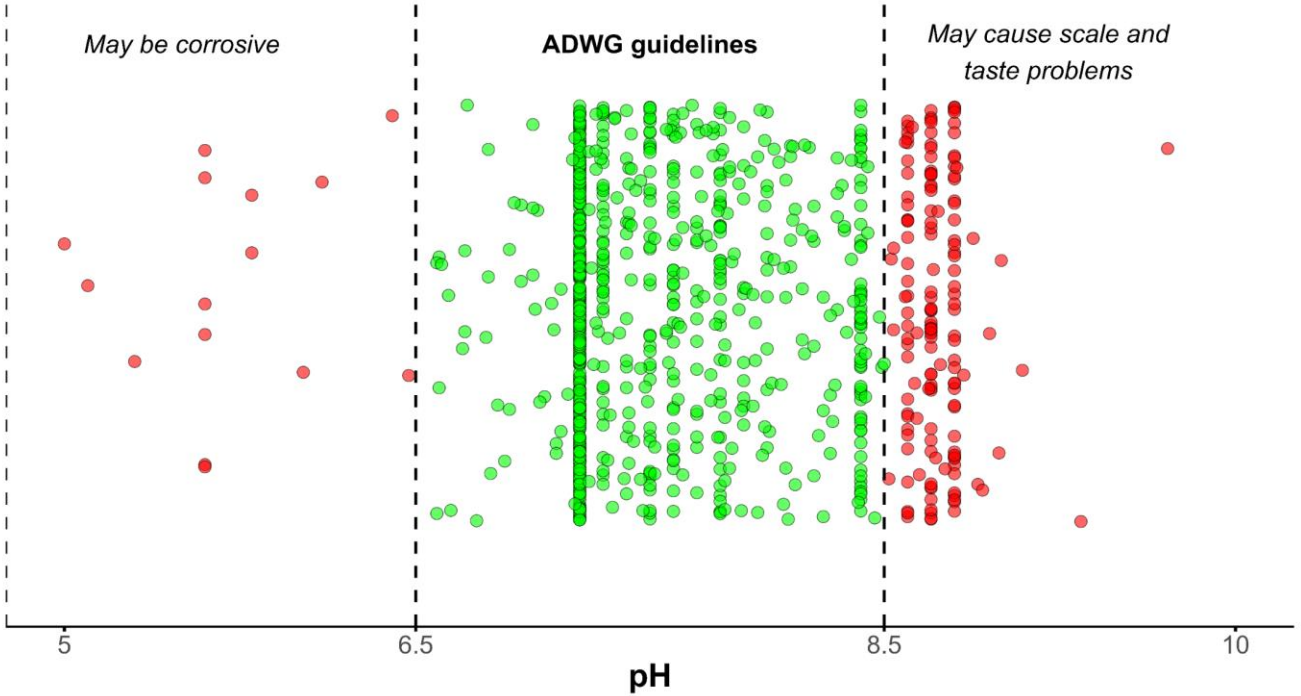
pH in 2023 (NT, SA & WA)

In 2023, many communities still fall outside the acceptable pH range of 6.5 to 8.5.

Each step on the pH scale represents a ten-fold change in acidity; for example, pH 5 is approximately 31.6 times more acidic than pH 6.5.

Water with a pH below 6.5 may have a bitter, metallic taste and cause corrosion, similar to the taste profile of black coffee, tea, or some beers.

When pH exceeds 8.5, the water may feel slippery, have a soda-like quality, and leave deposits.



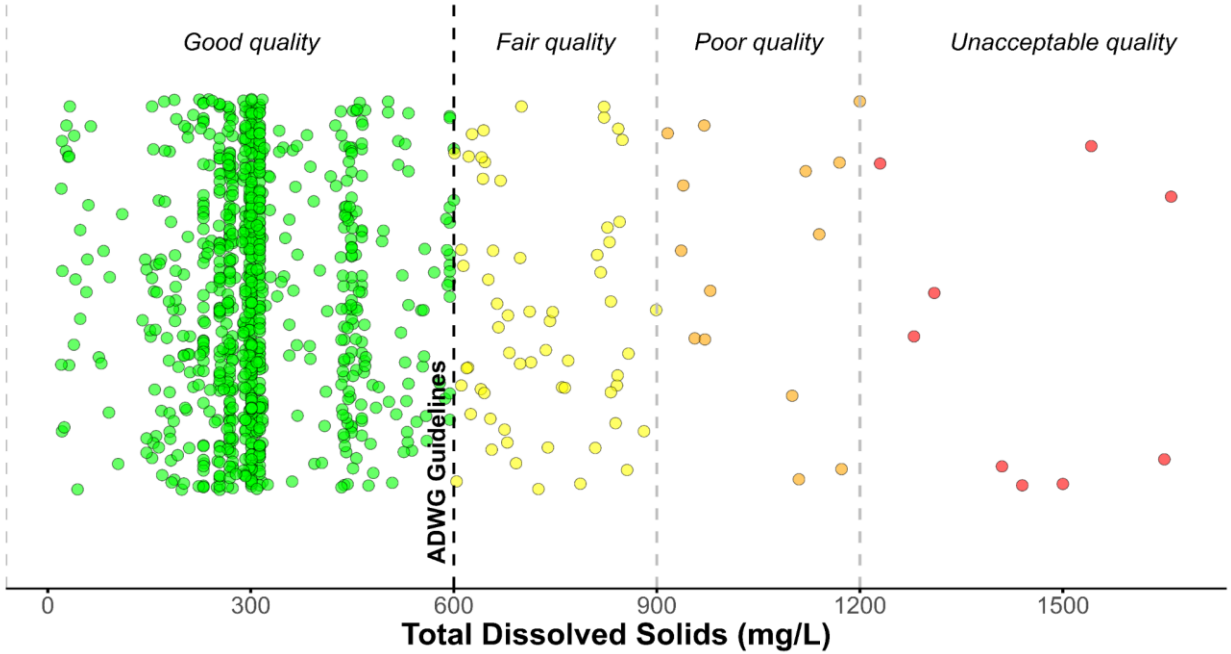
Total Dissolved Solids in 2023 (NT, SA & WA)

Total Dissolved Solids (TDS) consist of inorganic salts and small amounts of organic matter dissolved in water.

TDS includes sodium, potassium, calcium, magnesium, chloride, sulphate, bicarbonate, carbonate, silica, organic matter, fluoride, iron, manganese, nitrate, nitrite and phosphates.

Different thresholds of acceptability apply, but at levels above 600 mg/L, TDS can begin to make the water taste slightly salty, brackish, or metallic, affecting its overall palatability.

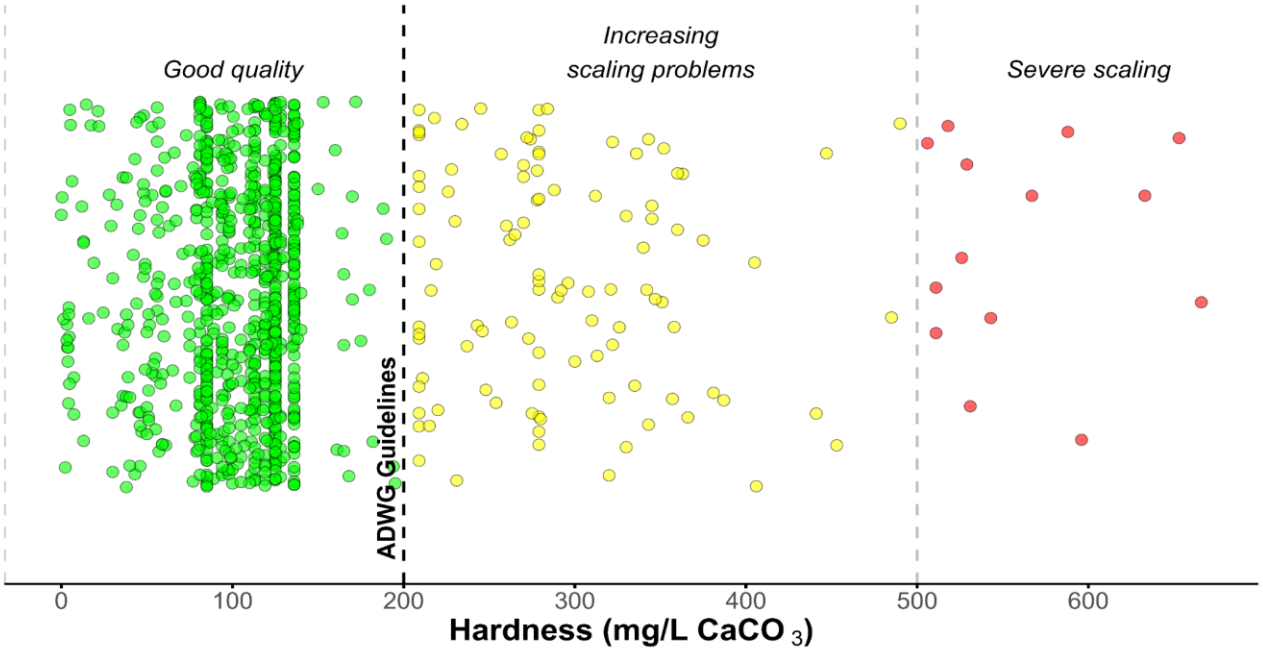
Additionally, elevated TDS levels contribute to scale build-up in pipes and fixtures.



Hardness in 2023 (NT, SA & WA)

Total hardness is the sum of the concentrations of calcium and magnesium ions expressed as a calcium carbonate equivalent.

When hardness levels exceed 200 mg/L, the water can taste chalky, salty, and mineral-like, and it may also lead to scale build-up in pipes and fixtures.

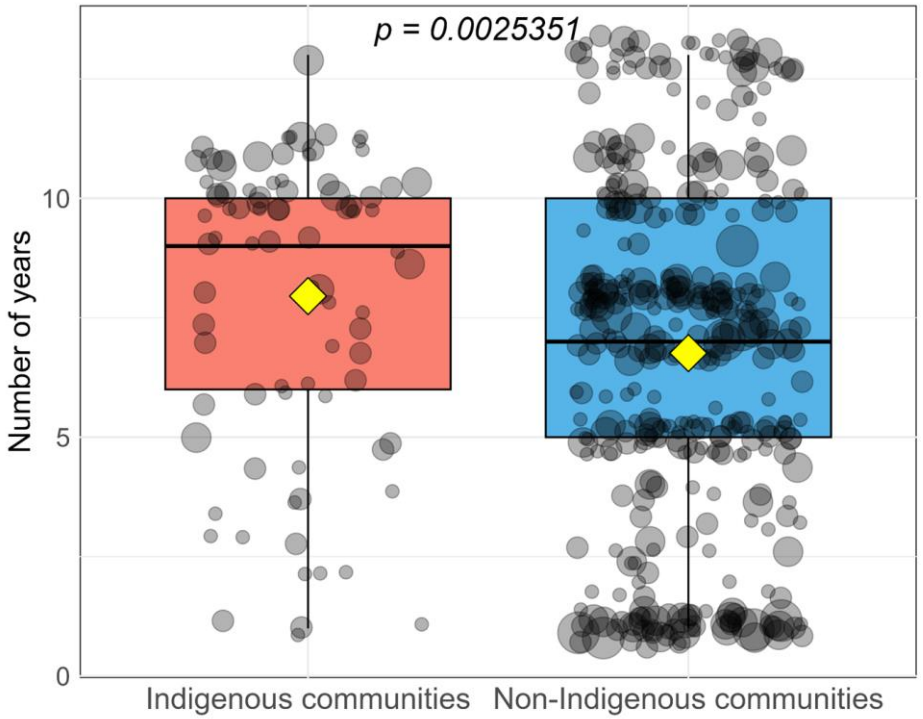


Unequal access to good quality tap water

- Some studies suggests that high water hardness levels may be linked to increased risks of cardiovascular disease and cancer morbidity and mortality (Perera, 2023), while TDS shows a relatively strong positive correlation with gastrointestinal diseases, including ulcers, gastritis, and duodenitis, as well as a moderate association with urinary tract infections (UTIs) (Martínez-Oviedo et al., 2024). Beyond direct health impacts, frequent acceptability exceedances can discourage tap water use, leading individuals to rely on potentially less healthy water sources or substitute beverages, which may negatively affect health.
- Data from 2011 to 2023 are used to calculate the number of years each community's water met health-based but not acceptability guidelines, with a higher count indicating a worse outcome. Different statistical tests were conducted, with a *p*-value below 0.05 signifying (i) significant differences in the number of affected years between studied community groups or (ii) significant associations between factors of interest (i.e. Indigenous status, remoteness, the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) quintile, and population size) and the number of affected years.
- Data from six years 2016-2023 (except 2018, 2020) covering 960 communities were analysed through preliminary logistic regression to examine the influence of Indigenous status, remoteness, IRSAD quintile, and population size on the probability of accessing acceptable water.

Number of years experiencing unacceptable tap water quality by Indigenous status

Indigenous communities in the study sample have significantly more years with unacceptable tap water, averaging nearly 8 years, on average compared to non-Indigenous communities, which averaged 6.8 years. This difference is statistically significant, as indicated by a very low *p*-value.



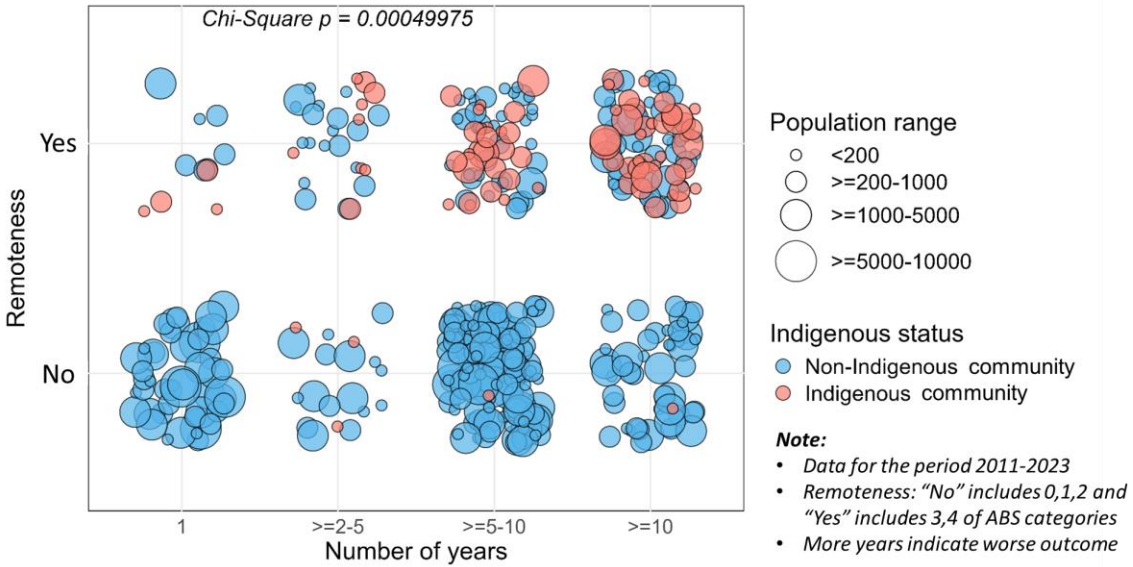
Note:

- *Data for the period 2011-2023*
- *Indigenous status is identified as share of Indigenous population >=50%*
- *More years indicate worse outcome*

Number of years experiencing unacceptable tap water quality by remoteness

A low *p*-value supports the significant existence of an association between remoteness and the number of years with unacceptable water quality. Remoteness are characterised by a measure of relative geographic access to services by the ABS (see Section 5- Data Appendix).

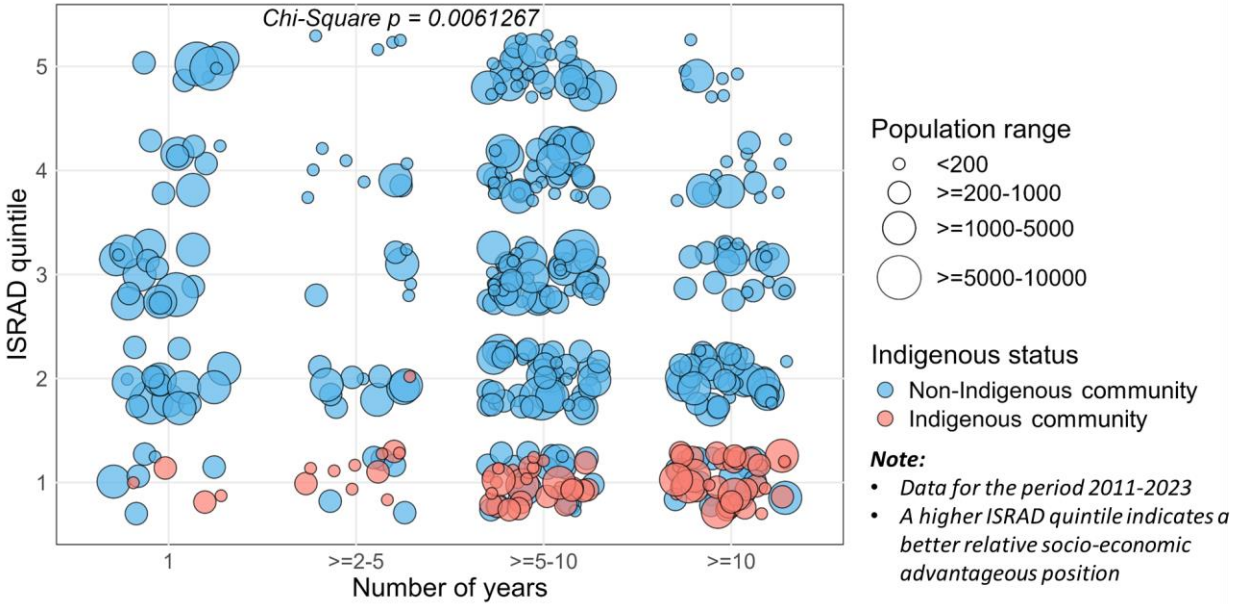
Among communities in the study sample, 23.7% of those in remote areas experienced 5–10 years of unacceptable water quality, compared to 19.8% in non-remote areas. Additionally, 33.5% of remote communities faced more than 10 years of unacceptable water quality, in contrast to 6.5% of non-remote communities. Overall, remote communities have significantly more years with unacceptable tap water, averaging nearly 8 years, compared to 6.3 years for non-remote communities. Approximately 95% of Indigenous communities and 40% of small communities (less than 1000 people) are located in remote areas.



Number of years experiencing unacceptable tap water quality by ISRAD quintile

A higher ISRAD quintile indicates a better relative socio-economic advantageous position. A very low *p*-value supports a statistically significant association between ISRAD quintile and water quality.

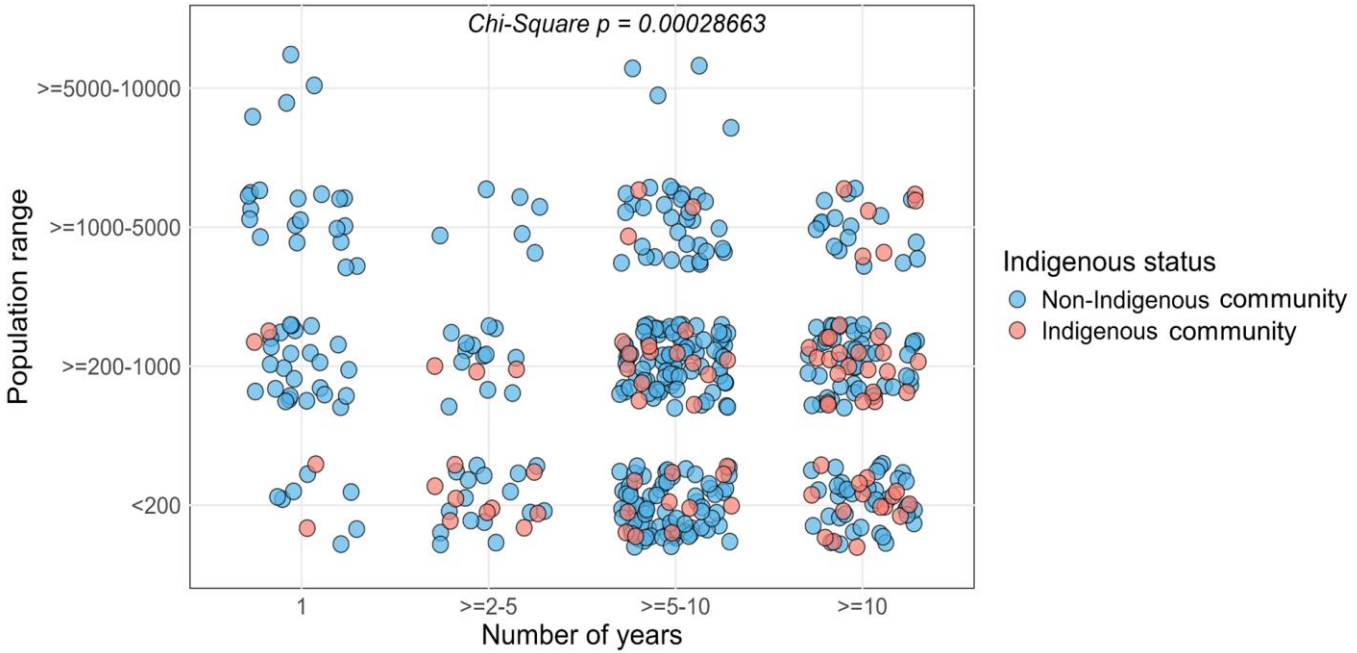
Approximately 45% of communities in quintiles 1 and 2 are affected by the 5–10 and over 10-year categories of unacceptable water quality, compared to 27% in the three higher quintiles. In other words, about 44% of communities affected by 5–10 years of unacceptable water quality and 67% of those affected by more than 10 years are in these lower ISRAD quintiles. Notably, 95% of Indigenous communities are situated in ISRAD quintile 1.



Number of years experiencing unacceptable tap water quality by population size

A low *p*-value indicates a significant association between population size and the number of years with unacceptable water quality.

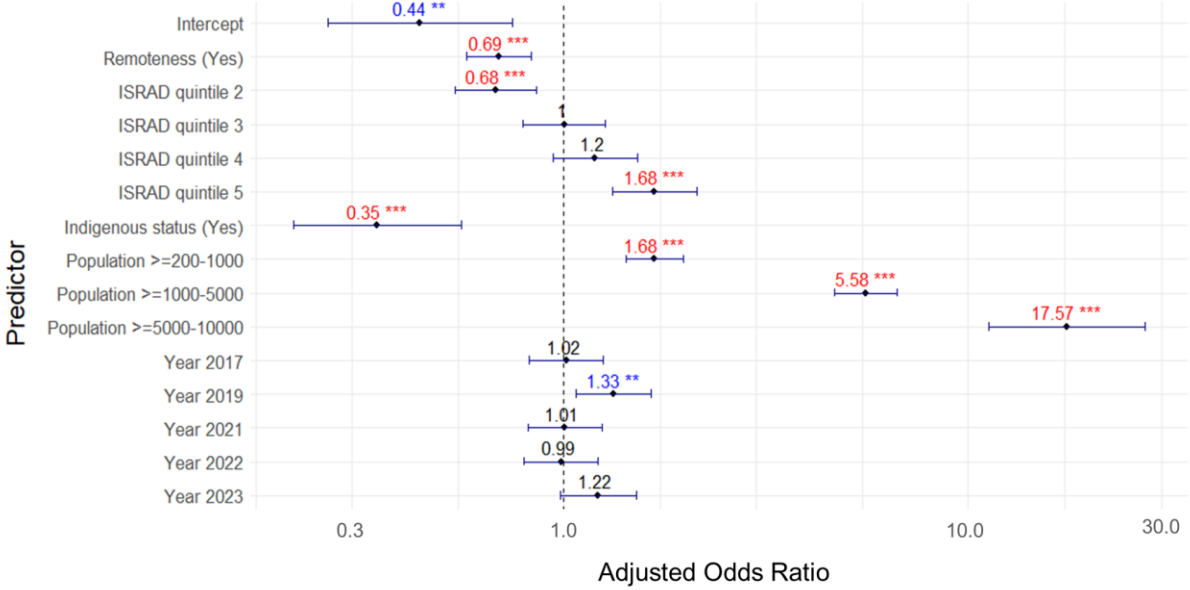
Approximately 48% of communities with fewer than 1,000 people fall into the 5–10 and over 10-year ranges of unacceptable water quality, compared to only 14% of communities with populations over 1,000. Put another way, approximately 83% of communities in the 5–10 and over 10-year categories have populations under 1,000 people.



Predictors of the probability that water meets ADWG for acceptability

Indigenous status and remoteness have a significant negative impact on acceptable water quality (indicated by values below 1). This means that an Indigenous community or a remote community is 2.9 times and 2.3 times correspondingly less likely to have access to water that meets guidelines for acceptability compared to non-Indigenous and non-remote communities.

Higher ISRAD quintiles and larger population sizes are positively associated with acceptable water quality (indicated by values greater than 1). Communities in ISRAD quintile 5 are approximately 1.68 times more likely to have acceptable water quality compared to those in quintile 1. The likelihood of acceptable water quality also increases with population size. For example, compared to communities with fewer than 200 people, those with populations of 1,000 to 5,000 people are approximately 5.58 times more likely to have acceptable water quality.



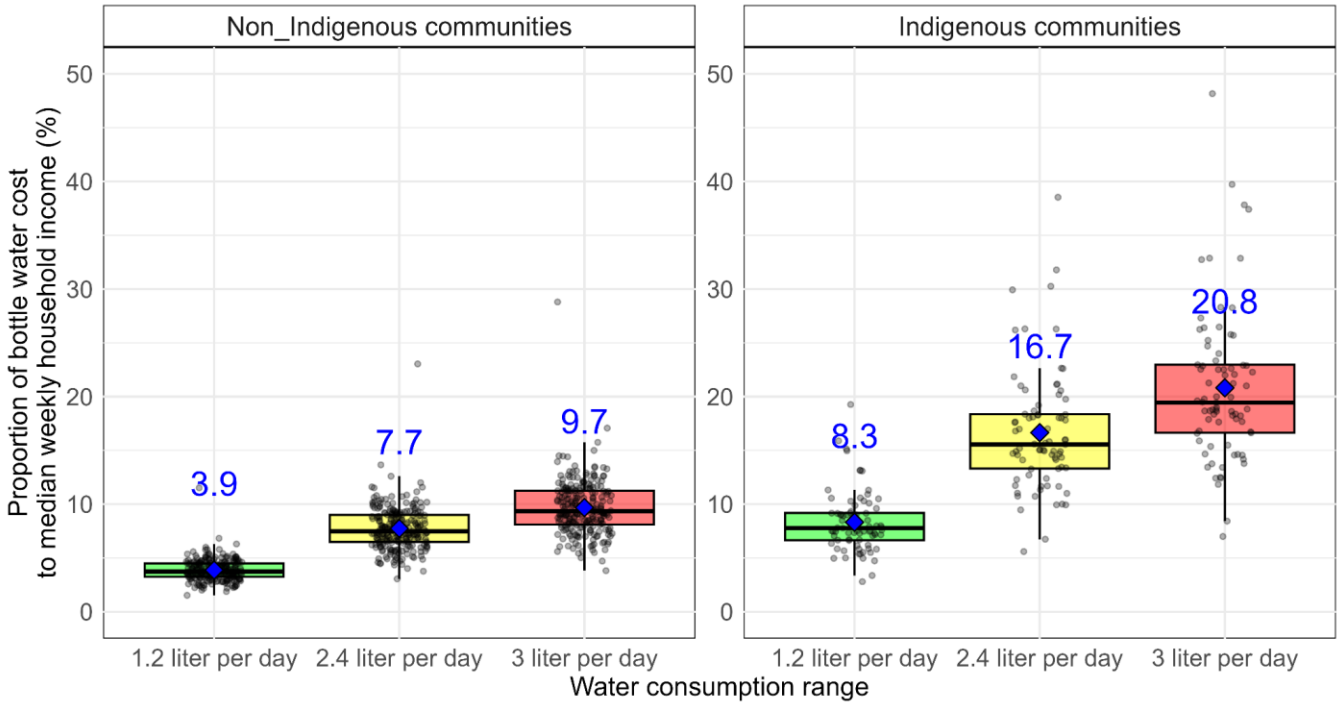
Estimated cost burden of bottled water purchases

- The purchase of bottled water is a common coping strategy in regional and remote Australia where drinking water often fails to meet safe and acceptable quality standards. For example, arsenic contamination in the water supply in Uralla, NSW forced the population of 2,700 on to bottled water (Barlass 2019) while 2023 survey of residents in Walgett, NSW found that 83% relied on bottled water during at least one month in the previous year (Tonkin et al. 2023).
- Bottled water purchase is one example of potential direct and indirect costs from a lack of good-quality drinking water that may also include: sugary drinks as a source of hydration, water filters, repair of broken appliances, travel to access alternative water sources, and reduced water consumption.
- A rough estimate of the potential cost burden is provided for communities in NT, SA, and WA where water fails to meet ADWG guidelines for health and/or acceptability. The assumption is that water consumption ranges are set at 1.2 litres, 2.4 litres, and 3 litres per person per day, with bottled water priced at $3 per 1.2-litre bottle (NT DoH, 2021).

Estimated cost burden of bottled water (NT, SA & WA)

Households in Indigenous communities face a significantly higher cost burden for bottled water at all consumption levels. For example, at 2.4 litres per person per day, the estimated spend would be an average of 16.7% of median weekly household income, compared to 7.7% for non-Indigenous communities.

In comparison with a major city like Canberra, where residents can access safe and acceptable water, the weekly cost for water and sewerage for a typical 200-kilolitre household is $24 for 2023-2024 (Icon Water, 2024), representing approximately 1% of median weekly household income.



Caveats and limitations

Caution is required when interpreting these preliminary results due to limitations in data compilation and analysis. These limitations impact the confidence of initial findings and highlight the need for further investigation.

1. **Data gaps across years and communities**: Significant gaps in water quality data across years and communities, particularly for small and Indigenous communities, limit a complete understanding of trends and can lead to incomplete analysis, underrepresenting certain groups (i.e., small and Indigenous communities) or specific regions and periods.
2. **Inconsistent data reporting and complex data matching**: Variations in guideline values, reporting standards, timing, and methods across states, regions, and years can introduce discrepancies, making it challenging to create a unified dataset and compare findings across regions and time periods. Some of the water data is reported by water supply system rather than by locations, which can introduce errors when aligning water data for specific locations. Matching water data with other socio-economic datasets (e.g., the ABS Census) may introduce errors due to the lack and/or potential mismatch of precise geographical boundaries. This highlights the need for cautious interpretation of these preliminary results, as well as for Australia-wide standardization in data collection and reporting practices in the future.
3. **Influence of unaccounted factors**: Other factors like climate conditions, water source, etc. which may all affect water quality, are not fully accounted for in the analysis. Observed patterns may be influenced by these factors, complicating the interpretation of water quality findings and potentially obscuring key trends.
4. **Limitations in analysis and interpretation:** The statistical tests identify correlations but do not establish causation, meaning that while associations are observed, these findings should be considered indicative rather than definitive due to unexamined underlying mechanisms. In the logistic regression analysis, missing data and unaccounted factors introduce potential for bias and unstable estimates, impacting the consistency of conclusions.

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05 DATA APPENDIX

Data sources and matching

This analysis uses various datasets described below:

1. Public Water Quality Data Reporting: The data is extracted from public annual water quality reports of the Power and Water Corporation (NT), SA Water (SA), ad Water Corporation (WA).

The datasets cover 92 communities in NT from 2004 to 2023, 251 communities in WA from 2008 to 2023, 721 communities in SA (corresponding to 85 water supply systems) from 2003 to 2023 (except 2018 and 2020). It is noted that NT and WA provide data by location, while SA reports by water supply system. Hence, for SA, all communities served by the same water system have the same recorded water data. Additionally, there are missing values across communities and years in all 3 states.

The datasets record all available reported health-based and acceptability parameters with various statistics such as number of samples, number of samples having test result exceeding the ADWG guidelines value, test results (Min, Max, Mean, 95th percentile), and compliance with ADWG.

The assessment of compliance with ADWG varies across states and years. While most parameters adhere to ADWG guidelines, some states apply state-specific standards to certain parameters. Reporting practices differ by state and year: some states round the test results to significant figures, while others do not; some only indicate compliance status; and different metrics are used to assess compliance - such as maximum, mean, or the 95th percentile.

2. **Socio-Economic Data:** The data is collected from the Australian Bureau of Statistics (ABS) Census 2016 and 2021. The datasets include Remoteness Areas, The score of Index of Relative Socio-economic Advantage and Disadvantage (ISRAD), total population, Indigenous population, median total weekly household income.

3. **Data matching:** For matching water record with Census data, the Australian Statistical Geography Standard (ASGS) code is first matched with the community's name in the water record. For communities with multiple ASGS codes, the code is selected in the following priority order: UCL (Urban Centres and Localities), SAL (Suburbs and Localities), ILOC (Indigenous Locations), and then others. The identified code is then used as a key to match with Census data.

Data description

Data	Description
Water quality	
Duration of unacceptable water quality	Number of years in the period 2011-2023 that water meets ADWG guidelines values for health but not acceptability (no-health based exceedances but at least one exceedance in relation to 9 key aesthetic characteristics: true colour, turbidity, hardness, TDS, pH, sodium, iron, manganese, chloride whichever available in the water record)
Water quality acceptability	Whether the water meets ADWG guidelines values for acceptability (Code 0: Unacceptable, 1: Acceptable)
Parameter test results	The test results reported for parameters of interest represent the annual average of tests conducted throughout the year. Depending on availability, this may be reported as the Average, Maximum, or 95th percentile value.
Compliance of Parameters with ADWG Guidelines	Compliance status as reported by state's water corporation. Where compliance is not explicitly reported, we assess it by comparing the available test result metric with the ADWG guideline values applicable for that year.
Socio-economic characteristics	
Indigenous status	It is identified by a community having an Indigenous population share of 50% or more (Code No: Non-Indigenous, Yes: Indigenous)
Remoteness	Remoteness Areas (RA) divide Australia into five classes of remoteness which are characterised by a measure of relative geographic access to services. In this analysis, the categories of 0 (major cities), 1 (Inner regional), and 2 (Outer regional) are grouped as "No" (non-remote), while the categories of 3 (Remote) and 4 (Very remote) are grouped as "Yes" (remote).
ISRAD quintile	For ASGS codes without an available ISRAD score, the score is calculated as the population-weighted average of the scores for all SA1 areas that form that ASGS code. Then, the score is assigned to a quintile based on its relative ranking within a five-level scale, with higher quintiles indicating a more advantaged socio-economic position.
Population size	Population ranges: (i) less than 200 people (ii) 200 to 1,000 people; (iii) 1,000 to 5,000 people; and (iv) 5,000 to 10,000 people

Summary statistics

#	Variable	Number of observations	Category	Frequency	Percentage
1	Duration of unacceptable water quality for the period 2011-2023	428	1 years	39	4
			>=2-5 years	103	10
			>=5-10 years	241	24
			>=10 years	45	4
2	Indigenous status	1025	No	917	89
			Yes	108	11
3	Remoteness	1025	No	759	74
			Yes	266	26
4	ISRAD quintile	1000	1	205	20
			2	196	19
			3	198	19
			4	197	19
			5	204	20
5	Population size	1025	<200 people	254	25
			>=200-1,000 people	347	34
			>=1,000-5,000 people	349	34
			>=5,000-10,000 people	75	7

Summary statistics for logistic regression

#	Variable	Category	Frequency	Percentage
	Number of observations: 5760			
1	Water quality acceptability	0	1937	33.6
		1	3823	66.4
2	Indigenous status	No	5270	91.5
		Yes	490	8.5
3	Remoteness	No	4380	76.0
		Yes	1380	24.0
4	ISRAD quintile	1	1068	18.5
		2	1143	19.8
		3	1185	20.6
		4	1170	20.3
		5	1194	20.7
5	Population size	<200 people	1291	22.4
		>=200-1,000 people	1968	34.2
		>=1,000-5,000 people	2088	36.3
		>=5,000-10,000 people	413	7.2
6	State	NT	504	8.8
		SA	3888	67.5
		WA	1368	23.8
7	Year	6 years (2016, 2017, 2019, 2021, 2022, 2023)		
8	Community	960 communities		