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Working With an Aboriginal Community to Understand Drinking Water Perceptions and Acceptance in Rural New South Wales

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Working With an Aboriginal Community to Understand Drinking Water Perceptions and Acceptance in Rural New South Wales

Abstract
This study explored the Walhallow Aboriginal community's experiences with drinking water to gain a shared understanding about community concerns and to develop ways to address these concerns together. There is a strong connection between people and water, as well as a need to appreciate the social factors associated with the unique cultural and socioeconomic factors that the provision of drinking water has for Aboriginal communities. We used a mixed method design within a community-based participatory action Research (PAR) framework. Water hardness and parental influence were the key factors associated with participants' decisions to drink rainwater. This study provides important insights for water supply authorities when assessing health risks and when choosing appropriate mitigation measures for water quality improvement programs in Aboriginal communities.

Keywords
Aboriginal, community perceptions, drinking water, community experiences, mixed method research design

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Disclaimer
This article may contain information obtained from deceased persons. The information could upset some people; however, the authors wish no disrespect or distress to the respective families and the community.

The views and positions expressed in this article are those of the authors and are not necessarily representative of NSW Health.

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Working With An Aboriginal Community To Understand Drinking Water Perceptions and Acceptance in Rural New South Wales

Aboriginal Australians have a significantly higher incidence of many diseases, which occur with greater severity, compared with other Australians (MacRae et al., 2012). Mortality rates for Aboriginal Australians are almost twice as high as for non-Aboriginal individuals (Aboriginal Institute of Health and Welfare [AIHW], 2011). There is a growing impetus to identify and address the determining factors of this health disparity, with the overall aim of "closing the gap" and improving the health of Aboriginal Australians (Council of Australian Governments [COAG] 2007). However, the focus thus far has mainly been on lifestyle-based factors such as smoking and alcohol consumption (Vos, Barker, Stanley, & Lopez, 2007) at the expense of environmental health factors like drinking water quality.

A crucial objective of the Australian Governments' Closing the Gap program is to improve Aboriginal health to achieve morbidity and mortality rates similar to those for non-Indigenous Australians. Low perceptions of drinking water safety can lead to other social issues for Indigenous people's health such as obesity and diabetes and can contribute to economic impoverishment with high costs of bottled water and soft drinks. Reducing public health risks due to the drinking water of unknown quality will help to close the gap. This study aimed to gain a deeper understanding of how Aboriginal communities are socially and historically connected to drinking water, their perceptions of drinking water quality, and the degree of satisfaction with drinking water management.

Australian Aboriginal and Torres Strait Islander Population

The Indigenous populations of Australia are referred to as Aboriginal and Torres Strait Islanders. The term Aboriginal is used in the state New South Wales (NSW) to reflect that the First Nations Peoples in this state are Aboriginal (Australian Museum, 2015).

The population of Aboriginal and Torres Strait Islander peoples in 2014 was 713,600 (3% of the Australian population), of which 220,902 (31%) lived in NSW (AIHW, 2015). Twenty-eight percent (60,862) of the Aboriginal population in NSW live in the Hunter New England region, of which 21% live in remote areas compared to 2% of the non-Aboriginal population (Primary Health Network [PHN], 2016).

The current health status and challenges can be seen in the estimated gaps in life expectancy. Currently, life expectancy for Aboriginal and Torres Strait Islander people is 69.1 years for males—10.6 years lower than that of non-Aboriginal males (79.7 years)—and 73.7 years for females—9.5 years lower than that of non-Aboriginal females (83.1 years; Australian Bureau of Statistics [ABS], 2013).

Policy Context: NSW Drinking Water Policy and Regulation

It is recognised that policy frameworks involving Aboriginal peoples should recognise Aboriginal knowledge, as well as the right to self-determination and participation in decision-making (Black & McBean, 2016). This recognition must also include drinking water. Good water management requires an understanding of Aboriginal peoples' values and interests in water, and acting to support and protect those interests (Barber, 2013). In Australia, research has shown that Aboriginal and Torres Strait Islander peoples are keen to contribute their knowledge and to see their values recognised in water allocation decisions (Jackson, Tan, Mooney, Hoverman, & White, 2012).

In the state of NSW, government policy directs that the responsibility to provide safe drinking water rests with each water supplier (Byleveld et al., 2016; New South Wales Public Health Act, 2010). NSW Health is the public health regulator of drinking water in NSW. The NSW Public Health Act (2010) and the NSW Public Health Regulation (2012) require water suppliers to develop, implement, and adhere to drinking water quality assurance programs that address the Framework for Management of Drinking Water Quality in the *Australian Drinking Water Guidelines* (ADWG; National Health and Medical Research Council [NHMRC] & National Resource Management Ministerial Council [NRMMC], 2011). A quality assurance program describes the water supply, identifies risks, critical control points, and details the actions to be taken to protect the quality of water provided to consumers.

As part of the NSW Health Drinking Water Monitoring Program (NSW Health, 2005), NSW Health works with Aboriginal communities and local water utilities to monitor drinking water safety. The program provides free routine testing of drinking water for microbial indicators and physical and inorganic chemical characteristics (Byleveld et al., 2016), as well as protocols for responding to contamination incidences or test results that do not comply with the ADWG targets (NHMRC & NRMMC, 2011).

Since 2008, the water supply and sewerage systems in 61 discrete Aboriginal communities have been improved by the implementation of the Aboriginal Communities Water and Sewage Program (ACWSP). A discrete Aboriginal community in NSW is one parcel of privately owned Aboriginal land that is predominantly inhabited and managed by Aboriginal people (AIHW, n.d.; Henderson, Byleveld, Standen, & Leask, 2016). The ACWSP is a partnership between Aboriginal communities, the NSW government, and the NSW Aboriginal Land Council. The ACWSP aims to improve health and well-being by providing services equivalent to the standard expected in the wider community (Byleveld et al., 2016).

Under the ACWSP, drinking water quality assurance programs were implemented in many discrete Aboriginal communities well before the 2010 NSW Public Health Act requirement. Experienced service providers (generally local councils) are contracted under formal service agreements to provide water and sewage support services (Henderson et al., 2016). Specialist contractors review critical control point performance, risk assessment findings, and improvements. Aboriginal community water management plans were integrated into utility drinking water management systems (Byleveld et al., 2016).

The Importance of Water to Aboriginal Communities

There is a strong and lasting connection between Aboriginal and Torres Strait Islander Australians and water. The strength of this connection can be seen in various ways. The Gamaraigal people, of what is now known as Sydney, resisted European invaders and objected to them clearing the ground around water holes, casting nets without permission, and interfering in cultural and community practices (Broome, 2002). This strong connection is also evident in how people's behaviours and choices are in part shaped by how communities socially and historically connect to drinking water, perceptions of water quality, and the degree of satisfaction with water management (Doria, 2010; Dupont, Adamowicz, & Krupnick, 2010). The strong connection and the value given to natural sources of water in Aboriginal communities have implications when providing treated drinking water.

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Supplying town water to Aboriginal communities without acknowledging and appreciating the unique socioeconomic, cultural, and historical context and values may be futile (Baird et al., 2013; Jaravani, Massey, Judd, Allan, & Allan, 2016). Negative community perceptions and concerns about the safety of supplied drinking water may be a proxy for concerns and experiences of racism and cultural safety (Dupont et al., 2010). There are historical reports of Aboriginal people being killed by poisoned drinking water supplies in the past (Jalata, 2013). These concerns and experiences have reportedly led to higher consumption of substitutes for tap water—such as rainwater, costly bottled water, and soft drinks—in other locations (Deschamps & Prum, 2007), but this set of circumstances has not yet been tested in Australia. For example, in 2006 in the town of Armidale, NSW, bottles of water reportedly cost 400 times the price of town water, which if it were to be used all the time would impact on families' financial resources (Pigram, 2006). The experiences and perceptions of Aboriginal people today towards drinking water are largely unknown.

Walhallow is a small Aboriginal community in northwest NSW that has for many years been concerned with the quality and safety of drinking water. NSW Health has provided bi-weekly monitoring tests of the community water supply (town water) since 2001. The test results indicated that the town water has maintained consistent microbiological quality in accordance with the ADWG (NSW Health, n.d.). In additional, each house is supplied with a rainwater tank and the rainwater supply is pumped to the kitchen sink. The rainwater is not routinely tested.

At Walhallow, the ACWSP program provided an opportunity to implement a risk-based drinking water quality assurance management system. Emergency repair works (such as leak detection and repairs for broken pipe and pumps) and infrastructure works (new bore pump, telemetry, reservoir rehabilitation, and new pressure booster pumps) on the town water supply system have been implemented at a cost of about AUD$238,000 (Bala Thangamany, personal communication). The local public health unit regularly engages with the community and participates with Department of Primary Industries Water (DPI Water) and local government in inspections every 4 months and reviews of the program.

The Problem

From December 2007 to February 2008, the NSW Department of Commerce undertook a survey of the water supply and sewerage services in selected Aboriginal communities including Walhallow (Australian Indigenous HealthInfoNet, n.d.). The survey assessed the existing water and sewage infrastructure, operational procedures, and current levels of servicing and maintenance. The survey found that:

- 10 communities had satisfactory water supply and sewerage services, but required assistance with ongoing management and servicing;
- 31 communities had adequate infrastructure, but needed maintenance and repairs to equipment; and
- 20 communities had inadequate infrastructure and required additional funding (Australian Indigenous HealthInfoNet, n.d.).

In response, the NSW government and NSW Aboriginal Land Council committed AUD$200 million over 25 years, beginning in 2008, to fund the ACWSP to improve the health of Aboriginal communities and help "close the gap" (NSW Department of Water and Energy, 2008).

Observations and informal discussions with the Walhallow community indicated that, despite the investment towards town water that is treated and routinely tested, many community members preferred rainwater. Although they are part of the housing infrastructure, rainwater tanks are not eligible for funding under the ACWSP. The Walhallow Local Aboriginal Land Council (WLALC) is responsible for maintaining the integrity of the houses. It is not clear, however, who is responsible for maintaining rainwater tanks.

We hypothesised that the Walhallow community's drinking water choices were culturally guided by their perceptions of health risk. The study was therefore guided by the following questions:

a. What are the drinking water needs that impact the choice of water source among the Walhallow Aboriginal community?

b. What are the drinking water quality characteristics and differences between rainwater and town water that affect the drinking water choices?

c. Is there a need for change in drinking water policy to include an understanding of community perceptions?

Water supply authorities may have the technology and capacity to supply safe water; however, the acceptability of the town water may not solely be dependent on safety considerations. There may be other factors that need to be identified and understood. Consumers can reveal dominant perceptions and concerns that policy makers need to be informed about to enable effective supply and management decisions (Doria, 2010).

The objective of this study was to explore the experiences of people in the Walhallow Aboriginal community with drinking water, to gain a shared understanding with the community about their concerns about using reticulated water supplies, and then to develop together ways to address these concerns.

Location and History

The study was conducted at Walhallow, which is located at 31°18′S 150°30′E near Caroona in the North West Slopes area of NSW. The community was formally established in the 1870s, although the Gomeroi (Kamilaroi) people lived in this area for thousands of years (Taylor, 1999). Walhallow currently has approximately 100 residents, the Kamilaroi or Gomeroi People, and is estimated to peak at 150 residents during special occasions. Walhallow now consists of 42 brick and tile houses, although in the past people lived in mission-built timber and fibrous cement houses. Since 1998, the village has been served by maintained roads and upgraded water and sewerage systems.

It is generally reported that the Walhallow community did not actively choose their current geographical location and issues of water quality emerged when the community was first displaced and resettled at the reserve. Similar issues have been reported for Indigenous communities in Canada (White, Murphy, & Spence, 2012), USA (Smith, 2005), and New Zealand (Bailie, Carson & McDonald, 2004).

Rainwater storage was connected to the Walhallow community houses when the houses were built in the 1940s (Taylor, 1999). Each house has a 9,000L rainwater tank without filters to strain pollutants, and there is no programmed maintenance of the tanks. Neither the community nor NSW

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Health has any record of rainwater tanks being cleaned or the rainwater tank water being tested for microbial contaminants. The quality of the rainwater is unknown and may be unsafe to drink.

The provision of reticulated[1] town water resulted from a needs assessment survey by the community Aboriginal health education officer in 1998 (Taylor, 1999). The assessment fulfilled the recommendation of the race discrimination commissioner investigation into the provision of water and sanitation to Aboriginal and Torres Strait Islander communities. The commissioner recommended a review of the state of water and sanitation in Aboriginal communities (Race Discrimination Commissioner, 1994). Town water was eventually sourced from a bore located about 3 km from the village in an intensive crop agricultural area.

Method

A mixed method design within a community-based participatory action research (PAR) framework was used. The methods included interviews, focus groups, rating of water quality, and water testing. A key strength of a PAR approach is that participants and researchers work collaboratively bringing together their respective knowledge of real world issues and scientific expertise (Cargo & Mercer, 2008). This research design is recognised as culturally acceptable and has allowed us to build sustainable trust with the community (Massey et al., 2012; Weiner & McDonald, 2013).

The initial point for engagement with the community was the existing relationships between the community and the local public health practitioners through several programmes: immunisation programmes; Housing for Health; the ACWSP; and the Companion Animals Health programme. The chief executive officer of the local land council and two other members of the community participated as co-researchers.

Individual Interviews

We used individual face-to-face semi-structured interviews to explore participants' lived experiences and perceptions about town and rainwater through criterion sampling (Creswell, 2013). Some of the participants preferred to gather as a group. Group participation was allowed provided that the participants responded individually. Only participants who were at least 18 years of age and living within the community on a permanent basis were asked to volunteer to ensure independent consent. The age limit ensured independent consent and permanency ensured lived experiences with drinking water in the community.

Participants were asked some specific open-ended questions to express perceptions about water and closed-ended questions to give answers about water quality issues (Baird et al., 2013). Participants were allowed to explain their responses to closed-ended questions. The conversations were voice recorded and professionally transcribed verbatim. The transcripts were then thematically analysed by applying line-by-line coding using a deductive approach to interpret participants' quoted experience as qualitative evidence (Kingston, Judd, & Gray, 2014). Descriptive codes were then entered into a Microsoft Excel 2010 spreadsheet and grouped. Similar codes were consecutively

[1] In Australia, reticulated town water supply means a disinfected drinking water supply system delivered to a town (or community) through a network of pumps, pipes, and water storages (water grid) designed to store and distribute water (Local Government & Municipal Knowledge Base, n.d.).

refined into analytical themes (Pfadenhauer & Rehfuess, 2015). Co-researchers participated fully in the analysis and interpretation of the findings.

Focus Group

We selected a purposive sample of three Elders who grew up in the community, although they had since relocated to the nearby city of Tamworth. These three Elders, who had a longstanding experience with the community, were chosen to inform our understanding of the drinking water history in Walhallow (Creswell, 2013). The Aboriginal co-researchers had significant input into the selection of the focus group members, as well as analysing and presenting the findings as part of the PAR process. The semi-structured interviews guide guided the questions and participants consented to voice recorded dialogue. We thematically analysed the transcripts to merge with the themes from the individual interviews.

Participant-Rated Water Quality

The participants were concurrently asked closed-ended questions to rank both town water and rainwater quality, in regards to the following characteristics: taste, smell, hardness, appearance, pressure, reliability, safety, and maintenance (Appendix 1). Group participants ranked these individually on a 7-point Likert scale. The ranks were then collapsed into two categories: ranks 1 to 4 were categorized as *Good*, and ranks 5 to 7 were categorized as *Bad*. The categories were compared between town water and rainwater using Microsoft Excel.

We used the Satterthwaite approximation method assuming unequal variances and standard deviations between the two water sources because it was ideal for the small sample size (degrees of freedom; Ruxton, 2006). The rating of rainwater to town water was then compared using 95% confidence intervals of the standard deviation and the *p*-value. When the confidence intervals did not intercept and the *p*-value was ≤ 0.05 the difference was considered as statistically significant.

Water Testing

Five rainwater tanks were randomly sampled in the community and tested for *E. coli* and total coliforms in accordance with the NSW *Guide for Submitting Water Samples to the Division of Analytical Laboratories for Analysis* (Division of Analytical Laboratories [DAL], 2010). One water sample per tank was collected from the kitchen tap per week for 12 weeks. One house was randomly chosen among the five sample houses for concurrent town water microbiological testing. Town water quality would be expected to be of a constant quality because it is disinfected and is tested fortnightly by the local government. One point of testing only was considered acceptable as a quality control measure. In total, 58 rainwater samples and 12 town water samples were tested for *E. coli* and total coliforms.

Ethics

The Walhallow Aboriginal Corporation as the Local Aboriginal Community Controlled Health Organisation approved the project. Ethics approval was also obtained from the Hunter New England Health Research Ethics Committee (13/10/16/5.06), NSW Health Research Ethics Committee (LNR/13/HNE/418), NSW Aboriginal Health and Medical Research Council's Human Research Ethics Committee (984/13), and James Cook University Human Research Committee (H5531).

Results and Findings

Overall, participants preferred rainwater to town water. Reasons provided by the participants included that rainwater "is more consumable, it is better quality water" and town water is "a bloody big pile of calcium." The main factors that influenced participants' preferences were parental influence, water hardness, and water maintenance. Some participants preferred bottled water to rainwater or town water. Five major themes emerged from the questionnaires about participants' perceptions of drinking water supplies in the community.

Individual Interviews and Focus Group

Fourteen community members, six males and eight females, participated in the individual interviews and responded to all questions. All were above 40 years old and had been residents of Walhallow for many years. The sample size was based on the homogenous makeup of the community and previous qualitative studies that suggested saturation is often reached after 12 interviews (Guest, Bunce, & Johnson, 2006). It has been found that for harmonised communities, like Walhallow, 94% of high frequency codes were identified within the first 6 interviews and 97% within the first 12 interviews (Guest et al., 2006). Francis et al. (2009) similarly found data saturation using retrospective analysis of 10 and 3 additional interviews. Morris (2015) recommends fewer interviews for homogeneous communities and more for studies involving different communities as long as the researchers are satisfied that they have reached saturation.

Five themes emerged from the thematic analysis:

a. Always brought up on rainwater;

b. Rainwater is good . . . but;

c. Town water is good . . . but;

d. If it's maintained then it would be safe; and

e. We buy bottled water.

Always Brought Up on Rainwater

Participants often described how as children they were "always brought up on rainwater" and how "it's been the same for generations." People's knowledge of the source of drinking water has built trust in the rainwater: "Just for drinking, probably rainwater because at least I know where it is coming from." However, another participant noted, "well I think that the rainwater is unsafe, but I think the town water is more unsafe." However, this participant also went on to say, "I think the rainwater would be full of bugs and gunk."

The Elders focus group explained how "it was just drilled in to me that you don't touch the hard water" and "you drink rain water, don't drink that hard water, don't know why, probably a cultural thing." Participants often explained that "it's been the same for generations," but "you never got an explanation why, not to drink it." They explained, "You would get in trouble from your parents, they use to tell us don't drink town water, drink the rainwater."

One Elder in the group further explained why rainwater was preferred to town water:

> As far as the tank water is concerned the people always chose tank water because it was soft water and the result of using tank water as opposed to town water was people could see it in their tea, with the taste of tea and the hardness of the tea and that sort of thing. You could see it straight away, so it was something that was always in front of you every dinnertime, so tank water was always considered the best because it didn't do that.

Rainwater Is Good . . . But . . .

Participants frequently described the taste of rainwater as: "very good . . . will be [ranked] one out of seven for rainwater [one being best]"; "tastes better"; "it is more consumable"; "it is better quality water"; "because it is softer, it is clearer"; "it hasn't got any smell"; and "tastes fresher." Participants also described how they felt safe with drinking rainwater: "I've been drinking it [rainwater], and it hasn't made me run to the toilet or anything."

However, several participants disliked rainwater because it is: "shocking, very, very poor"; "when you run the tap it is yellow or brown"; and "it is not as good as it used to be, so it is terrible now, it is not as good as it was when we were growing up either." Some participants said, "Mine is nice to drink and that, like I still drink it but I really think that it is contaminated, like frogs and whatever else is in there. Plants, like I've got plants growing out of my tank." "There has always been *E. coli* in water out here," and "It used to give me UTIs [urinary tract infections] constantly."

Town Water Is Good . . . But . . .

Participants frequently described town water as "pretty good and clear"; "looks alright"; "it is drinkable";" better than my rainwater"; "it doesn't smell"; "is 100 times better in terms of smell than those [other] places"; and "I don't mind the taste either." Participants generally liked town water: "Because you use it more. Like everyone uses it more than their rainwater." And if there are no "rains you have got no water anyway so you have got to have some sort of supply, so I reckon the town water. And health wise and all that stuff."

However, participants often referred to town water as the "hard water." Participants asserted that town water caused skin problems such as "itchy and scaly skin" and "very harsh on the skin and you can tell with the shower how it builds up with the calcium." One participant remarked, "You look at the showers and that, what do you think they do to our insides too?" Many participants talked at length about "calcium build-up in the water heaters," and the need to regularly "dig it all out."

Participants also complained about the cost of maintaining hot water systems because of the hardness of the town water. For example, as one participant articulated"

> He [the plumber] is probably out here; probably about, I don't know, 6 times a year doing it. The elements have got like salt; I have got to get the elements replaced all the time. I have had I think it is two hot water systems . . . in nine years.

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If It's Maintained Then It Would Be Safe

Participants said that if the rainwater were properly maintained "then it would be safe." Several participants were aware that town water was being maintained: "They come out every couple of months because you see them. I know, I see them coming out all the time."

Several participants wanted the local government to extend their services to rainwater. For example, one participant said, "It goes in with the general maintenance of it, that program of the councils where they are coming out and checking, that should be extended to the tank system." Another said, "It would be good to have the tanks cleaned out probably get some new water in it." One participant countered that "whoever has got the houses have a responsibility . . . they have to be kept to it."

Lack of information was frequently cited as contributing to residents' rejection of town water. An Elder resident was dismayed: "Ahh, yuck! We don't know what we are drinking." Several participants did not even know "if it is bore water or bloody river water" or "whether it is coming from some unknown source . . . probably from the river." A participant then wanted to know the effects of chlorine: "Chlorine! What will chlorine do to you though? It is a chemical isn't it?"

We Buy Bottled Water

Participants who dislike both rainwater and town water often said, "We buy bottled water" because "you can just tell that bottled water has been filtered because it feels more natural . . ." and "it is supposed to be the best or something."

However, one Elder participant said he "won't buy water. It is too dear." Community members who cannot afford the cost often get bottled water from the local pre-school. The pre-school was said to "always have heaps of water, cold in the fridge and especially in summer time they are all like can we have bottles of water."

Participant-Rated Water Quality

The rating of water quality characteristics helped us to identify which water attributes participants believe are most important in determining the drinkability of each type of water. The ordinal data was collapsed into two categories of *Good* or *Bad* to capture the participants' perceptions of the water. If the participant rated the water characteristic favourably (1-4), their perception for that characteristic would be good. Otherwise, it would be bad, which may ultimately lead to the rejection of the water.

Participants generally rated rainwater taste and hardness as most important in deciding their preferred drinking water source (Table 1). Town water taste was rated *Very Bad* (0 rating it as *Good* and 14 rating it as *Bad*) compared to 9 *Good* and 5 *Bad* for rainwater, which is statistically significant ($t(17.26) = -3.42$, $p = 0.003$). Town water hardness was rated as *Very Bad* (0 rating it as *Good* and 14 rating it as *Bad*) compared to rainwater (14 rating it as *Good* and 0 rating it as *Bad*), which is statistically significant ($t(16.81) = -6.12$, $p = 0.0001$).

Secondly, the participant ratings helped us to compare the water attribute rated as most in need of urgent improvement for each type of water (Table 2). Town water hardness was the higher priority (14 rating it as a *High Priority* and 0 as a *Low Priority*) compared to rainwater (0 rating is as a *High Priority* and 14 rating it as a *Low Priority*) and statistically significant ($t(18.96) = 6.94$, $p = 0.0001$).

Table 1. Participant Rated Water Quality Attributes by Water Source, Walhallow, March 2014

Water Characteristic	Water Source	*Good* *n*	*Bad* *n*	*t* (*df*)	95% CI of *SD*	*p*
Taste	Town	0	14	-3.42 (17.26)	[0.68, 5.31]	0.003**
	Rain	9	5		[1.68, 2.24]	
Smell	Town	10	4	-0.79 (25.57)	[1.29, 2.40]	0.437
	Rain	11	3		[1.48, 1.68]	
Appearance	Town	12	2	0.75 (22.88)	[1.70, 2.15]	0.458
	Rain	10	4		[1.15, 2.01]	
Pressure	Town	14	0	0.85 (22.87)	[0.90, 1.28]	0.406
	Rain	11	3		[1.33, 1.44]	
Reliability	Town	9	5	0.43 (25.94)	[1.62, 2.42]	0.668
	Rain	5	9		[1.54, 2.84]	
Safety	Town	8	6	0.65 (25.12)	[1.34, 2.72]	0.524
	Rain	6	8		[1.62, 2.99]	
Hardness	Town	0	14	-6.12 (16.81)	[0, 0.62]	0.0001***
	Rain	14	0		[1.44, 1.59]	

Note. Participants rated each characteristic on a 7-point Likert scale with 1 being the *best* and 7 being the *worst*. The results are displayed as two categories: *Good* (1-4) and *Bad* (5-7). In order to assess whether differences in the ratings of town water and rainwater were statistically significant, the Satterthwaite unequal variance *t*-test was performed on the ordinal level data for each characteristic. CI = confidence interval. *SD* = standard deviation. $N = 14$.

* $p < .05$. ** $p < .01$. *** $p < .001$.

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Table 2. Participant Rated Water Attribute Most in Need of Improvement by Water Source, Walhallow, March 2014

Water Characteristic	Water Source	High Priority *n*	Low Priority *n*	*N*	*t* (*df*)	95% CI of *SD*	*p*
Taste	Town	10	2	12	-1.09 (25.99)	[1.37, 2.70]	0.285
	Rain	8	4	12		[1.39, 1.89]	
Smell	Town	5	6	11	-1.24 (23.25)	[1.32, 3.19]	0.223
	Rain	9	3	12		[1.09, 2.63]	
Appearance	Town	1	10	11	-1.97 (24.95)	[1.22, 4.28]	0.061
	Rain	6	6	12		[1.27, 2.99]	
Pressure	Town	3	8	11	-0.69 (20.00)	[1.82, 3.39]	0.113
	Rain	5	7	12		[1.15, 3.43]	
Reliability	Town	3	8	11	0.81 (25.82)	[1.62, 4.02]	0.423
	Rain	3	9	12		[1.76, 3.33]	
Safety	Town	8	3	11	-0.11 (24.67)	[1.51, 2.11]	0.913
	Rain	8	4	12		[1.81, 1.85]	
Hardness	Town	10	2	12	6.94 (18.96)	[0.69, 1.55]	0.0001***
	Rain	1	12	12		[1.01, 6.4]	

Note. Participants rated each characteristic on a 7-point Likert scale with 1 being the *highest priority* and 7 being the *lowest priority*. The results are displayed as two categories: *High Priority* (1-4) and *Low Priority* (5-7). In order to assess whether differences in the ratings of town water and rainwater were statistically significant, the Satterthwaite unequal variance t-test was performed on the ordinal level data for each characteristic. CI = confidence interval. *SD* = standard deviation.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Water Testing

Rainwater tests at Walhallow indicated that half of the rainwater tested had *E. coli*. Of the samples tested, 30/58 (52 %) had *E. coli* with a mean of 18 colony-forming units per sample (Table 3). Overall, 3/5 rainwater tanks had more than 50% *E. coli* detection rate[2] over the sampling period. The ADWG recommends no *E. coli* in every 100ml of a drinking water sample. There is no guideline value for total coliforms as they are not recommended for use as an indicator of faecal contamination. Total coliforms are an indicator of disinfection efficiency. Rainwater at Walhallow is not disinfected.

Discussion

Parental influence, town water hardness, and rainwater maintenance were the main factors influencing participants' choice of drinking water. Participants rated town water hardness significantly different from rainwater. The difference between the other water characteristics was not statistically significant. About half of rainwater samples had *E. coli* while town water samples did not detect any *E. coli*. Participants also suggested that if rainwater were properly maintained then it would be safer.

Early engagement and social interactions developed trusting relationships, fostered cultural appropriateness, and provided opportunities to learn community protocols, and to use appropriate language and avoid sensitive behaviours. The active participation of community members as co-researchers developed legitimacy and goodwill with the community.

Parental Influence

The significance of interpersonal relationships, parental influence, and community culture was a strong and recurring message from participants although water safety, smell, and taste were also discussed often. Consequently, the rejection of treated town water in favour of untreated rainwater at Walhallow has been passed on from generation to generation, placing the community, particularly children, at risk of waterborne enteric diseases through consuming possibly unsafe rainwater.

Influence, or habit, that is passed from generation to generation becomes a tradition and consequently a culture. Culture is defined as the shared patterns of behaviours and interactions, cognitive constructs, and affective understanding that are learned through a process of socialization (Centre for Advanced Research on Language Acquisition [CARLA], n.d.). Aboriginal culture and kinship are strong and act as protective forces for children and families (Secretariat of National Aboriginal and Islander Child Care [SNAICC] & Innovative Resources, 2009). A participant described how hard it is to get out of a habit instilled by one's parents: "I was always brought up, like it is hard to get out of your [habit], when you are used to rainwater."

[2] The *E. coli* detection rate is the number of *E. coli* detections divided by the number of samples multiplied by 100 to create a percentage (i.e., the proportion of samples with *E. coli* to the total number of samples tested per house).

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Table 3. Rainwater and Town Water Testing Results, Walhallow, November 2014 to January 2015

House Number	Water Source	Number of Samples	*E. Coli* Detections	Total Coliforms Detections
1	Rain	12	9	10
2	Rain	12	9	11
3	Rain	10	4	7
4	Rain	12	7	11
5	Rain	12	1	8
2	Town	12	0	1

Cultural influence is not unique to the Walhallow community. Culture and law are used interchangeably among Aboriginal and Torres Strait Islander Australians, illustrating that community connections, activities, and knowledge govern people's behaviour (Barber & Jackson, 2011). Throughout Australia, Aboriginal peoples have a strong association with country, culture, kinship, and self-determination; these are characteristics that have been reported to safeguard communities against transgenerational trauma (Australian Indigenous HealthInfoNet 2016; Colquhoun & Dockery, 2012).

Parental influence over drinking water has also been demonstrated in rural Kenya (Makutsa et al., 2001) and India (Firth et al., 2010), where low cost drinking water contamination interventions were hindered by cultural practices that caused low acceptance and sustained the use of untreated water. In Camarines Sur, Philippines, in 2012, it was found that villagers who had access to chlorinated water chose to drink from untreated wells because parents were resistant to change, despite deaths due to a cholera outbreak (De Guzman, Carr de los Reyes, Sucaldito, & Tayag, 2015). Drinking water suppliers should therefore be aware of parental influences on water choices and be prepared to address public health problems associated with drinking water in a social context in addition to scientific knowledge (Gorelick et al., 2011).

Rainwater Safety

The participants' perceptions were that the taste and smell of rainwater were good. Other studies (see for example Wright, Yang, Rivett, & Gundry, 2012) have highlighted the importance of taste and smell in determining people's choices in drinking water. In the current study, although participants knew that rainwater's microbiological quality was poorer than town water, they still preferred rainwater. A participant who had her rainwater tested and found it to be contaminated did "a bit of research . . . and stopped drinking it." Instead of switching to town water, she preferred to "go to the old girls [house over the road] and use their [rain] water." While the drinking of rainwater is not unique to Walhallow, NSW Health does not endorse this practice when reticulated town water is available (NSW Health, 2007; enHealth 2010). According to NSW Health (2007), where treated water is provided, rainwater may be used for low risk uses such as hot water services, laundry, toilet flushing, or gardening. In 2013, the Australian Bureau of Statistics (ABS) reported that 19.3% of rural NSW households had rainwater as the main source of drinking water compared to 76% for rural South Australia and 23% of other rural Australian households (ABS, 2013).

Frequent detection of *E. coli* in the rainwater test results is not surprising, given that roof catchments and guttering are subject to contamination by bird and small animal droppings, which are known to harbour potential pathogens. A study in South Australia found that 59% of rainwater tanks in Aboriginal communities had either faecal coliforms or Streptococci (Plazinska, 2003). Other studies of rainwater tanks in southeast Queensland detected *Salmonella, Giardia lamblia, Legionella pneumophila, Campylobacter jejuni*, and *Cryptosporidium parvum* (Ahmed, Hodgers, Sidhu, & Toze, 2012; Ahmed, Vieritz, Goonetilleke, & Gardner, 2010), which were tracked back to possum and bird faecal samples.

The presence of faecal coliforms such as *E. coli* in rainwater does not necessarily mean that the community will get ill from drinking the water. There are no records of waterborne disease outbreaks at Walhallow, although sporadic and unreported cases cannot be discounted. Continuous contact with a risk often results in the normalisation of the risk, where the individuals become familiar and desensitised to its presence (Halpern-Fisher et al., 2001).

Epidemiological investigations undertaken in South Australia have failed to identify links between rainwater tanks and gastrointestinal illness despite global underreporting contributing to a lack of evidence (Heyworth, 2001; Heyworth, Glonek, & Maynard, 1999; Rodrigo, Sinclair, Forbes, Cunliffe, & Leder, 2010). A study by Heyworth, Glonek, Maynard, Baghurst & Finlay-Jones (2006) found that there was no difference in the incidence of gastroenteritis in children who drank rainwater and those who drank treated town water. In our study, participants who drank rainwater often said they have not had diarrhoea or other symptoms from the water; hence, they assumed that it was safe for drinking: "I don't have any issues with it." "It [*E. coli*] has always been mainly in the drinking water, they did surveys ages ago, with *E. coli* in them. I reckon because the insects and frogs get in the rainwater."

Town Water Hardness

During the period 2006 to 2015, routine town water monitoring data for Walhallow showed that the mean total hardness measured as calcium carbonate ($CaCO_3$) was 268 mg/L compared to the ADWG value of 200 mg/L (NSW Health, n.d.). Participants often referred to town water as "hard water" that caused "itchy and scaly" skin after bathing. Consequently, the community disliked the town water and this may lead to perceived water insecurity. When hard water is heated, the calcium hydrogen carbonate ($Ca(HCO_3)_2$ that causes the hardness is converted into $CaCO_3$, which is deposited as a whitish scale. Hence "hard water" is the qualitative description that people use for the scaling actions of water, while water hardness is a quantitative measure of metal ions that are dissolved in the water usually measured as CaCO3 (McMellon, 2010).

Hard water scale accumulation causes the elements of hot water systems, kettles, and appliances to overheat and burn out, resulting in higher energy bills that become a burden on low-income Indigenous families (Browett, Pearce, & Willis, 2012). Hard water also causes malfunctioning of health hardware by clogging internal plumbing and water appliances, increasing the frequency of fixture repair and maintenance costs. For example, replacing a solar hot water system in Central Australia costs AUD$5,000 and the replacement of tapware cost AUD$100 per tap (Browett et al., 2012; Downing, 2000). Additionally, households must purchase large volumes of expensive soaps, softeners, and other cleaning materials that are capable of lathering in hard water (Pearce, Willis, McCarthy, Ryan, & Wadham, 2008). Therefore, water related expenses may be undertaken at the expense of other pressing household issues.

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Water hardness is not unique to Walhallow. Even mainstream towns around Walhallow such as Quirindi, Gunnedah, Narrabri, and Moree that use similar groundwater do not treat for water hardness due to the prohibitive cost. However, larger regional towns and cities can soften their water supply by treating it to remove calcium and magnesium. However, any potential public health risks would depend on the local concentration of minerals, other than those contributing to hardness, in the respective aquifer (NHMRC & NRMMC, 2011).

Water Quality Maintenance

Participants indicated that if the water sources were properly maintained then the water would be safer. Considering the health risks of drinking untreated rainwater instead of treated and routinely tested town water, responsibility for drinking water safety at Walhallow requires interagency negotiation for improvements at the service level. The regional public health unit could help with educating the community on the advantages of choosing town water over rainwater to promote the use of safer town water. Community members who choose to continue drinking rainwater would need to boil the water before drinking it.

Bartram (1996) suggested that a drinking water service level is conditioned by continuity and quality (safety), such that service quality = service level × continuity × safety (see also Kayser, Moriarty, Fonseca, & Bartram, 2013). Although town water continuity and service level are guaranteed at Walhallow, safety is diminished because people do not drink it due to its hardness. Thus, the service quality is compromised by a diminished perception of safety. Reduced service quality undermines the value of the service and associated public health benefits. In Canada, for instance, it was found that the degree of concern about the health risk of town water was inversely proportional to town water consumption and to aesthetic concerns raising the consumption of bottled water (Dupont et al., 2010).

The World Health Organization (WHO, 2011) *Guidelines for Drinking-Water Quality* define domestic water as water used for all usual domestic purposes including consumption, bathing, and food preparation. To promote health, an individual needs a basic water supply of 20L per day for of which only 2 litres (10%) is for direct consumption (drinking and food preparation). However, considering that the Walhallow community is provided with an optimal service water supply (100L/day; Howard & Bartram, 2003) direct consumption is only 2%. The bulk of the service (98%) goes to other health or household needs such as food preparation, bathing, and laundry. Therefore, treating the safe town water for hardness would be essential for general health promotion in the community.

The introduction of the NSW Aboriginal Communities Water and Sewerage Program has created interdepartmental alignment in the provision of safe drinking water to Walhallow and other NSW Aboriginal communities. The WLALC, NSW Office of Water, Hunter New England Population Health Unit, and local government all work across disciplines to deliver safe town water to Walhallow.

The NSW *Guideline on Rainwater Tanks Where a Public Water Supply is Available—Use of* (NSW Health, 2007) spells out the best methods for maintaining rainwater tanks. These include tank design and maintenance, catchment management, tank desludging, and maintenance. Rainwater quality can be improved by the use of first flush devices and filters that are properly maintained and meet an appropriate standard such as AS/NZS 4348 or ANSI/NSF 53 (NSW Health, 2007). Properly maintained rainwater tanks can "provide good quality drinking water. Rainwater tanks are

widely used as a source of drinking water throughout rural Australia. Occasionally there are cases of illness from contaminated rainwater" (NSW Health, 2007, p. i). People who decide to use rainwater for potable uses should be aware of potential risks associated with microbiological and chemical contamination. The WLALC may have to consult again with the community about who is responsible for and how rainwater maintenance occurs.

Buying Bottled Water

The preference for bottled water among some of the participants was due to perceived safety and aesthetic considerations of the current supplies. One participant said, "[Bottled water is] supposed to be the best." Low perceptions of town water have been associated with higher consumption of costly bottled water and sugary beverages, resulting in high incidence of related diseases such as diabetes, gastritis, and obesity in Indigenous communities elsewhere (see for example Sarkar, Hanrahan, & Hudson, 2015). Water insecurity and poverty also caused a high intake of sugary beverages in Canada's Inuit Indigenous community resulting in high levels of related diseases such as diabetes and obesity (Sarkar et al., 2015). Where water supplies are fluoridated, drinking bottled water may also reduce the fluoride intake among children leading to poorer oral health (Gorelick et al., 2011).

Generally, Australians choose bottled water because of concerns about microbiological quality of town water, avoidance of chlorine, preferred taste, and the perception that bottled water is healthier (Cochrane, Saranathan, Morgan, & Dashper, 2006). Studies in the United States (Gorelick et al., 2011) and rural Canada (McLeod, Bharadwaj, & Waldner, 2014) found health risks and aesthetic complaints about town water to be the most frequently cited factors influencing the consumption of bottled water. However, studies in England (Ward et al., 2009) and Portugal (Doria, 2006) found that taste was the most important consideration in choosing bottled water.

Policy Implications

The diseconomies of scale experienced by small Aboriginal communities present difficulties for policy makers. The cost of financing water supply treatment, especially to treat water hardness, can be exorbitant on a per service basis. The current policy regime may not be sufficiently flexible to deal with the diversity of consumer preferences and different cost-benefit trade-offs between communities. However, it is difficult to precisely identify and measure the health effects of improved water supply. Governments, water suppliers, and consumers would need to make practical decisions on the most rational solutions and compromises. This decision-making requires a balanced consideration of the health risks, the cost of treatment, and community aspirations for enhanced water quality.

Water hardness, taste, and smell are primary determinants of aesthetic acceptability of drinking water at Walhallow, and indeed other communities, but cannot be disassociated from health considerations. Community acceptance of a water supply is determined by cultural conditioning, perceptions of safety, and level of consumer education on water safety among other issues (Doria, 2010). It is not adequate to conclude, on the basis of technical comparison of physical characteristics of water among communities, that consumers will obtain equal benefits from the introduction of the same level of service (Race Discrimination Commissioner & Australia, 1994). It is important to promote equality as a measure of outcomes of actions, instead of the input of similar resources in different situations (Race Discrimination Commissioner, 1994).

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There is no specified rainwater strategy for the Walhallow community and there are no technical standards that apply to rainwater because it does not form part of the authorised supply system. Rainwater tanks are the property of the housing provider. The role of the housing provider or occupier in maintaining the tanks is not clear. The ACWSP only extends to the housing block boundary. Should the ACWSP be extended to include the houses? Would the funds be adequate? What are the policy implications in other communities? Furthermore, would the community be able to afford the higher water rates due to water softening? These are some of the policy issues that need further discussion and consideration.

The ACWSP is currently undergoing a planned review. In response to this study, the feasibility of installing a water softener at Walhallow is under consideration. The WLALC is also considering the feasibility of regular rainwater tank maintenance. We contend that if the town water is softened, the community is adequately consulted and educated, and children are allowed to choose with time there may be generational change and the uptake of safer town water will increase.

Strengths and Limitations

A major strength of this study is that a PAR approach allows a high degree of community involvement and empowerment, which resulted in the findings being context appropriate. PAR methodology is a culturally appropriate approach for working with Aboriginal communities for a joint research outcome and can be applied in and with other Aboriginal communities in NSW and Australia. The community co-researchers gained valuable skills in research methods and water testing. The researchers and the community are working together to improve rainwater maintenance and to advocate for ways to soften the town water to meet the ADWG 2011 value, for the benefit the community.

The sample size has made the effects of gender and age on water preferences difficult to interpret. The study was carried out in a particular context and a particular community, we are therefore unable to generalise these results to all Aboriginal communities in NSW or Australia. However, this study may give some good foundations for further studies in other communities. Every Aboriginal community has unique physical, cultural, economic, and social environments, which may cause communities to have different attitudes towards their drinking water supplies (Anadu & Harding, 2000; Hu, Morton, & Mahler, 2011). The timing of the water testing also made it hard to predict the impacts of seasonality and drought.

Our study was unable to relate health outcomes to water quality data and identified preferences; further research is required to address this data gap. A major research priority is the assessment of the uptake and acceptance of town water supplies in multiple rural NSW Aboriginal communities. A cost-benefit study could develop better understandings about whether the resources expended in maintaining the town water supplies are worthwhile and cost effective. This may also contribute to the improvement of the quality of the community-preferred sources.

Conclusion

In this study, we found that the perception of town water hardness and parental influence were key factors associated with participants' decisions to drink rainwater. Perceptions of town water and rainwater quality and safety were also associated with decisions by some to drink bottled water. Considering the potential costs of repairing and replacing malfunctioning scaled health hardware,

the cost of soap and detergents, the cost of drinking water substitutes like bottled water and fizzy drinks, and the health impacts of untreated rainwater, the need for softer town water is compelling.

This study presents important insights that water supply authorities need to consider when assessing health risks: choosing appropriate mitigation measures and building business cases for water quality improvement programs at Walhallow. The findings can inform potential interventions to improve drinking water quality in Aboriginal communities by involving communities in the process and by addressing community social concerns about town water supplies. Tangible improvements in the quality of town water will not be fully recognised if the community is distrustful about the supply. Understanding this paradigm can improve future programs and policies for the supply of adequate and acceptable drinking water to Aboriginal communities. Programmed interventions are unlikely to fully achieve the intended benefits without a good understanding of the social factors influencing drinking water choices by incorporating appropriate and adequate responses in partnership with communities to mitigate such factors.

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Appendix 1

Interview Questionnaire

My name is . . . from Hunter New England Population Health. I hope you have heard about the community project on drinking water from the previous consultation meetings or from the Local Aboriginal Land Council.

The Walhallow Aboriginal Land Council, on behalf of the community, and the Hunter New England Population Health Unit are currently working together to conduct an assessment of the community's drinking water needs. The results of the assessment will help the community to map the required activities to improve the health of the Walhallow community through drinking water of known quality. The assessment will also provide Hunter New England Population Health with opportunities to learn about what issues about drinking water are most important to Walhallow community and what can be done to address those issues.

As a member of the Walhallow Community over the age of 18 years and living in the community, we would like to know what you think about the quality of drinking water in the community. We are therefore inviting you to participate in this assessment.

It is important that you should know that your participation in this assessment is voluntary. Should you agree to participate, you are free to withdraw at any time. Your name or address will not be recorded. The answers will be recorded in a voice recorder and on the printed questionnaire.

All information collected will be owned by the Walhallow Aboriginal Land Council.

Do you agree to participate?

A. Participant Information

Participant = any community member over 18 years old

Gender- male/ female

Age group

16-18	19-24	25-40	41-50	51-65	65-75	76-85	>85

B. Water Preferences

1. Can you describe what you use rainwater for?
2. Can you explain what you use town water for?
3. How would you describe the rainwater quality?
4. How would you describe the town water?

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5. How would you rank the water quality between 1 and 7 with 1 being *the best* and 7 *the worst*?

Water Source	Water Characteristic						
	Taste	Smell	Appearance	Pressure	Reliability	Safety	Hardness
Rainwater							
Town water							

6. Which water characteristic do you consider the most important? Rank between 1 and 7 with 1 being *the best* and 7 *the least*.

Water Source	Water Characteristic						
	Taste	Smell	Appearance	Pressure	Reliability	Safety	Hardness
Rainwater							
Town water							

7. Which water source do you trust most? Why?
8. Which supply do you recommend to your children? Why?
9. Which supply do you recommend to your visitors? Why?
10. If rainwater were to run dry, would you drink town water? Yes/No
11. If your answer is "No," can you explain why?
12. If town water were to run dry, would you drink rainwater? Yes/No
13. If your answer is "No," can you explain why?
14. When you visit town do you drink town water? Yes always/Yes sometimes/Never
15. If never, what do you drink if you become thirsty?
16. Can you explain why you do this?
17. Can you tell me about a time when you went away from Walhallow and what you did about drinking water?
18. When your children go to school, do they carry drinking water with them? Yes/No
19. If your answer is "Yes," which water?
20. Can you explain why the children carry the water to school?

C. Water Management

1. How would you describe drinking water maintenance in Walhallow?

1 = *Very Good*; 2 = *Good*; 3 = *Bad*; 4 = *Very Bad*

Rainwater	
Town water	

2. If any improvements were to be made which issues would you prefer to be addressed first? Rank them 1-7 (1 for the *highest priority* and 7 for *lowest priority*).

Water Source	Water Characteristic						
	Taste	Smell	Appearance	Pressure	Reliability	Safety	Hardness
Rainwater							
Town water							

3. If only one water source were to be improved, which water would you prefer? Why?
4. Who do you think should best be responsible for the water maintenance? Why?

D. Culture

1. Do you use the water for any cultural purposes? Yes/No
2. If yes, which water supply? Town/Rainwater
3. Can you describe what type of cultural purposes?
4. Does the source of the water have any influence on your choice of water? Yes/No
5. Can you describe what the influence is?
6. Does the quality of the water have any influence on the choice of water? Yes/No
7. Can you describe what the influence is?
8. Which water quality criteria do you consider most when using the water for cultural purposes?
9. Can you explain why?

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E. History

In relation to the history of Walhallow, from a long time ago to more recently, what are some of the issues that relate to the safety of drinking water?

Do you have any other issues pertaining to drinking water in Walhallow that you would want to be addressed?