

Research Paper

Challenges of WASH in remote Australian Indigenous communities

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ABSTRACT

Health and well-being are influenced by access and quality to safe drinking water, wastewater treatment, and hygiene practices and settings. This is recognised in the United Nations' Sustainable Development Goals for water and health. As a signatory to the UN Goals, Australia has a commitment to ensure the access and quality of these resources is attained for all, including Indigenous Australians living in remote communities. This research sought to identify the status of water, sanitation and hygiene services within remote communities on mainland Australia. Interviews were conducted with representatives of organisations providing water, sanitation and/or hygiene to communities. The quality and access of WASH services in remote Indigenous communities were revealed in this research as lacking at times in many communities. The qualitative results indicate that drinking water supplies can be contaminated by microbes or naturally occurring chemicals, wastewater treatment can be poorly maintained with irregular monitoring, and the health of residents is negatively impacted by crowding in houses, which affects residents' ability to maintain healthy hygiene levels of people, clothing, bedding and infrastructure. Effective responses require a collaborative and systemic approach by the respective government agencies responsible that effectively partner with – and adequately fund – Indigenous communities to provide options that are 'fit for purpose, place and people'.

Key words | Australia, development, drinking water, Indigenous health, remote, WASH

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INTRODUCTION

Personal and public health levels are influenced by the quality and access to drinking water, wastewater treatment and waste removal (sanitation), and hygiene practices and settings. Populations that lack safe, clean drinking water services and rely on untreated surface water risk infection by waterborne diseases (WHO 2017). Contamination of food and soil from untreated wastewater also pose a health risk, and there is increasing recognition of the importance of hygiene and its links with sanitation (WHO 2017). Water, sanitation and hygiene are referred to collectively as WASH. The global burden of disease from poor WASH

access and services can be measured in part by the impact of diarrhoea, which constituted 2.9% of the global burden of disease (considered as disability-adjusted life years) in 2015 (IHME 2015), yet can be significantly prevented through safe drinking water and adequate sanitation and hygiene (WHO 2017).

Globally, many remote Indigenous communities in developed countries have poorer quality and access to WASH services than the national population. In Canada, First Nations communities live with high-risk drinking water systems with water quality below that of the general

population, and have higher rates of waterborne infections compared to the national average (Bradford *et al.* 2016). In the USA, Native American and Alaskan communities have been disproportionately impacted by environmental pollution and contamination, including contamination of drinking and recreational water (McOliver *et al.* 2015). In Australia, there are ongoing health, housing and social challenges faced by remote Torres Strait Islanders and Aboriginal people (Bailie *et al.* 2010). Challenges include lower-quality drinking water, poorly maintained sanitation infrastructure, and hygiene-related health concerns not found at the same levels elsewhere in the Australian community (McDonald *et al.* 2009; AG WA 2015; Hall *et al.* 2016).

The access and quality of WASH services are contextualised within the United Nation's Sustainable Development Agenda, which contains 17 Sustainable Development Goals (SDGs) (UN 2015). Of particular relevance to WASH and health are SDG 6, to 'ensure access to water and sanitation for all', and SDG 3, to 'ensure healthy lives and promote wellbeing for all at all ages' (UN 2015). The Australian Government is one of the 196 signatory countries to the UN Agenda, and is committed to progress the SDGs within and beyond its own borders by 2030 (UN 2015). This builds on the UN's Resolution on the human right to water and sanitation (2010), managed by a Special Rapporteur who has noted that Indigenous Peoples often experience 'disproportionate violations of their rights to safe drinking water and sanitation' (UN ESC 2011). When considering the issues of water, sanitation and hygiene for Australian citizens, evidence indicates that many remote Indigenous communities have reduced access – which differs considerably from rural and urban settings (AG WA 2015; Hall *et al.* 2016). Within this context, this research focused on the status (and need) for WASH action in remote, discrete Indigenous communities on mainland Australia. The findings are likely to be relevant to Indigenous and remote communities beyond Australia.

Focusing on WASH in remote Indigenous communities in Australia

Discrete, remote communities on mainland Australia are those permanently inhabited by a predominantly Aboriginal and Torres Strait Islander population – referred to here as Indigenous Australians. A discrete Indigenous community is formally defined as a geographic location with physical or cadastral boundaries, inhabited predominantly (greater than 50% of usual residents) by Aboriginal and/or Torres Strait Islander peoples, and where housing or infrastructure is managed on a community basis (ABS 2007). Census data from 2014 estimated the total resident population of Aboriginal and Torres Strait Islanders as 3% (approximately 686,800) of the Australian population (ABS 2016). Of this Indigenous population, the total population in remote and very remote Indigenous communities (including those on islands) in 2011 was 116,588 with the majority of these populations located in the Northern Territory (NT), Western Australia (WA), Queensland (Qld) and New South Wales (NSW) (ABS 2012), as displayed in Table 1.

This research regarding WASH access within remote, Indigenous communities was undertaken due to the social and environmental determinants of health between Indigenous and non-Indigenous Australians being documented as particularly challenging in more remote and isolated communities (McDonald *et al.* 2008, 2011; Foster & Dance 2012; Clifford *et al.* 2015). Socio-economic factors contribute to these continuing health disparities, coupled with physical barriers, including failures in 'health hardware' in the home. This refers to the essential aspects of a home required to maintain adequate personal health, such as functioning bathroom, kitchen and laundry facilities (Browett *et al.* 2012). These are predominantly related to water-based hygiene functions, and link to 'healthy living practices', several of which are enabled through water: washing people, washing clothes and bedding, removing waste safely (including sewage), improving nutrition (including through a

Table 1 | Population estimates of discrete, remote Indigenous communities, 2011 (ABS 2012)

Remoteness	NT	Qld	WA	NSW	SA	Vic./Tas.	Australia
Remote and Very remote total	11,436	10,639	11,071	4,855	1,211	61	39,273

functioning kitchen), reducing crowding (and associated pressure on the hot water and septic systems) and reducing dust (Pholeros *et al.* 1993). These are key underlying factors that contribute to an increased risk of infection and disease transmission in remote communities (McDonald *et al.* 2009).

Although investment in, and access to, WASH services have improved in recent years in remote Indigenous communities in Australia, many residents continue to experience challenges with drinking water quality, adequate and continuous sanitation services and associated hygiene issues (Clifford *et al.* 2015). In late 2016, the seventh *Overcoming Indigenous Disadvantage* review and report card identified that health outcomes for Indigenous communities – particularly those in remote and very remote locations – were negatively impacted by a range of environmental health factors within homes and communities (SCRGSP 2016). Concerns were raised regarding the quality of infrastructure and services including whether health hardware in remote communities met equivalent standards in non-Indigenous communities (SCRGSP 2016). The report concluded that improving access to clean water, functional sewerage and electricity services in the home environment were priority areas for action (SCRGSP 2016).

METHODS

Qualitative interviews were conducted with representatives from key organisations providing water, sanitation and/or hygiene services or information to three or more discrete, remote communities in four states and territories of mainland Australia. The sample size of interviews was not intended to be representative, nor were responses sought to a standardised questionnaire. Instead, qualitative interviews provide detailed responses to open-ended interview questions, in order to secure ‘deep’ and detailed accounts and perspectives, and to describe both observed issues and solutions (Fontana & Frey 2000). This approach requires a smaller sample size than quantitative methods due to focused case study approach, applied theory and strong focus on dialogue – all of which provide a smaller sample size while delivering higher ‘information power’ or detail and depth (Malterud *et al.* 2016). The organisations were

identified through the authors’ and partner’s professional networks and contacts. The final sample size was achieved once ‘saturation’ occurred and no further new information was revealed during subsequent interviews (Charmaz 2006).

The resulting 17 interviews included representatives from state and territory government (6), Indigenous (4), research (3), utility (2) and non-government (2) organisations. The interviewees worked for organisations located in the Northern Territory (NT) (8), Queensland (Qld) (3), South Australia (SA) (3), New South Wales (NSW) (2) and with a national mandate (1). As this research was seeking input on a wider range of services and not community-specific, Aboriginal and Torres Strait Islander people were only interviewed if they represented the organisation approached for an interview. Indigenous identity was neither sought nor recorded. The project aims and core questions were reviewed for cultural and other sensitivities by researchers with extensive experience in Australian Indigenous research. The project received ethical clearance from the University’s Human Research Ethics Committee (reference #2016001540).

The questions asked to interviewees concerned their perceptions of whether the drinking water, wastewater treatment and hygiene access and services met the needs of the remote community residents. Additional questions were asked based on the interviewees’ responses to the core questions to explore them in further detail – noting this input depended on the interviewee’s areas of specialty, their perceived ‘successes’ of programmes and initiatives, and the priorities of the organisation. The questions were intentionally broad to enable interviewees to share their perceptions from their organisation’s speciality, services and jurisdiction. This open-ended interviewing approach is common for a qualitative approach to data-gathering (Fontana & Frey 2000). Each interview lasted approximately 45 minutes. All interviews except two were conducted by telephone to limit the project costs; one was conducted by email and the other in person at the request of the participants.

The interviews were transcribed, uploaded into NVivo qualitative software, and analysed using qualitative social science methods informed by grounded theory to elicit the emerging themes in a formative approach – a method derived from grounded theory (Hoepfl 1997; Charmaz 2006). Two researchers analysed the transcripts to identify

emerging themes, which were validated by both researchers. Quotes from the interviewees are provided in the Results section to illustrate the key themes raised. Due to the small sample, interview transcripts were analysed as a whole, rather than per sector or organisation type, which may introduce a limitation to this study. The quotes are attributed using an identity code to avoid identification of specific individuals and organisations.

RESULTS

This section provides only the findings from the interviews, which are presented in three subsections regarding water, sanitation and hygiene. Quotes from interviewees are provided to exemplify the issues raised from specific interviewees, although the same topic was often raised by multiple interviewees.

Drinking water

Interviewees described how some water utilities and government programmes have increased funding of new water treatment services and infrastructure over the past decade to ensure safe, reliable supply, including to address microbial health risks. Drinking water is provided through basic chlorine disinfection of bore or reservoir water, ultraviolet secondary disinfection, or advanced treatment systems. Advanced treatments are more expensive, with high-tech micro-filtration and reverse osmosis treatments installed for supplies with high levels of naturally occurring contaminants, such as nitrates and uranium, in the deep bore water supplies. This has necessitated a debate over the guiding principle of 'fit for purpose, fit for place, and fit for people', to ensure that the sophistication of the treatment technology is appropriate for the capacity in the community to maintain the treatment. The challenge was described as:

'A lot of the communities have good quality drinking water, at least initially... we often quickly see a lack of maintenance, meaning that everybody goes back to using their old water source – because the big fancy system doesn't work' (Researcher #1).

Drinking water supplies are at risk of both microbial contamination and chemical contamination by naturally occurring elements in deep artesian (bore) sources. The microbial risk from both unmaintained infrastructure and behaviours were described as being linked to waterborne health issues:

'It's quite chronic in cases... [because] storage tanks [are]... rarely replaced... They're going to rust, they're going to corrode... Water supplies are 100 percent a [health] problem' (Indigenous organisation #1).

The chemical contaminants in water, predominantly arsenic, cadmium, nitrates, uranium and barium, tend to increase towards inland Australia, where monsoonal rains do not replenish supplies. Although these are naturally occurring, their presence can require the installation of advanced water treatment technologies due to the health risks from excess concentration.

All interviewees referenced the Australian Drinking Water Guidelines (NHMRC 2011) as the main guide to develop their water monitoring regimes. However, several raised concerns with the on-ground accuracy and frequency of water monitoring regimes – challenged by the remote locations, minimal staff, infrequent transport for the water samples and a lack of oversight of the staff responsible. These issues were perceived to contribute to unsafe water supplies and ill-health in community residents.

The interviewees all commented on the low community acceptability of the groundwater in terms of taste and colour. Two commented that alternative drinks were preferred by both Indigenous and non-Indigenous residents in remote communities, including:

'The water is quite hard... people don't want to drink it because it doesn't taste very good, so then they start substituting it for other things like soft drink or cordial or something like that... you do find, when you travel bush, all the whitefellas [non-Indigenous] are drinking bottled water' (Indigenous organisation #2).

All services were impacted by the high turnover in staff in remote communities around Australia, which limited the

ability to maintain the water treatment infrastructure *in situ*, described as:

'You get quite a changeover of staff, so no-one gets to manage the treatment plant to the level required to bring suitable quality of water... there was one stage there where [a community] gave up on the treatment for a while because [they] couldn't get anyone appropriately qualified to manage it, and so they had to rely on tank water' (Government #6).

The long-term sustainability of water resources was recognised as a limiting factor for the future of remote communities, especially those with increasing population growth, described as:

'The ultimate sustainability of that [groundwater] source ... is linked to the viability in that community. Due to that strong relationship between the community and the land on which it's situated, relocating [the community] obviously isn't an option for them' (Water utility #2).

Sanitation

Some very remote communities remain serviced by septic tank and absorption drain systems. Interviewees commented on the risks of design faults, irregular monitoring inspections and a lack of maintenance, all of which increased the risk of sewage contamination into the local environment.

In recent years, funding has been provided under the National Aboriginal Health Strategy (NAHS Working Group 1989) to establish community-scale wastewater treatment facilities that are managed by community organisations or a central water utility. As for water, the selection of wastewater treatment options was described by several interviewees as needing to be 'fit for purpose, fit for place', to avoid the challenges described as:

'Some infrastructure... is kind of over-engineered, too technical for a remote community. ... you've got to be realistic with the skillsets that are going to operate it. And with the high-tech stuff, a whole lot of extra cost and risk and things like that' (Government #2).

Population growth in remote communities has led to increased pressure on wastewater treatment facilities, described as:

'Our [Indigenous] towns are growing. ... But water supply, sewerage and sanitation is so very important and we're not keeping up with it in a number of areas ... The infrastructure is starting to get old, it has not been upgraded. ... Currently we have six towns who are absolutely at capacity' (Government #4).

In response, development conditions for new housing require an extension of the capacity of the wastewater treatment facility. Improving the water and wastewater treatment facilities was noted to sometimes attract additional residents to the community.

Similar to drinking water, monitoring of wastewater outputs was identified as critical, but not always conducted regularly or with rigour – due to the challenge of ensuring regular and comprehensive testing. This was linked to comments regarding the lack of regular maintenance in these remote locations. The lack of skilled officers to manage wastewater treatment plants was raised by many interviewees, as well as the high rate of staff turnover, described as:

'The [installed water and wastewater] infrastructure didn't see through its useful life. It didn't get through to what would be expected, because the communities often were not supported with operation maintenance and monitoring. They didn't have the technical knowledge and skills' (Government #1).

An effective response to increase local staffing capacity as well as the sustainability of the wastewater treatment plant was noted to be state government funding for local resident training and their organisations, which are often local councils.

A specific sanitation challenge raised by the majority of the interviewees was the high rate of blockages in the waste pipes from the household toilet to the treatment plant – noted as being more prevalent than in the general community. Pipe blockages were noted to be caused by non-flushable items such as clothing (particularly underwear), items used for menstrual hygiene (both feminine

hygiene products and alternatives, such as rags) and babies' nappies. To manage blockages, the main solution mentioned was the installation of macerators and standby pumps at the 'end of the pipe', prior to the wastewater treatment. Three reasons provided by interviewees to explain this high rate of flushed items were a lack of waste bins in bathrooms and/or regular emptying of bins, cultural aspects of privacy, and a lack of toilet paper (or lack of ability to buy toilet paper).

Health-related hygiene

Interviewees were asked to describe health-related hygiene issues they had observed of concern in remote Indigenous communities. All predominantly focused on the health impacts of crowding, with the majority describing three-bedroom houses with one bathroom as regularly housing ten to twenty people per house.

Maintaining clean facilities as well as personal hygiene of all residents in crowded houses was noted as major difficulties by interviewees. This included the cost of washing supplies, when used by a large number of the house's residents. This can be a challenge in addition to the cultural expectations of sharing assets among family members:

'When you've got 20 people in your house ... am I going to put my \$5 bottle of shampoo in the shower recess when there's 20 other people and in the first day it's gone? ... Indigenous culture of course is kinship and it's sharing. So, to lock your goods away ... they're running the risk of their culture and their society saying, 'Hey, our kinship structure is 'what's yours is mine and what's mine is yours'. So, you've got all those dynamics playing a part as well' (Indigenous organisation #1).

Such high populations per house can affect the ability of the health hardware to function where overused. The interviewees reflected their understanding of direct link between functioning health hardware and the hygiene and health of the community residents, described as:

'A female Aboriginal elder on one of the communities said to me ... 'How can we wash hands when we don't have hand basins that work and we don't have showers that

work and we don't have the infrastructure?' ... You can have all these great programs and all these great ads on TV, but if you don't have the basic infrastructure enabling those people to wash their hands, then all you're doing is just basically offending them' (Indigenous organisation #1).

The interviewees described health hardware in the houses of remote communities as being absent or insufficient (such as a lack of washing machines), damaged by bore water (through calcification of taps), or of low quality materials. Much of this hardware was noted to be ageing and poorly maintained by the government housing owners, where many remote communities wait significant lengths of time for repairs to their health hardware – described as:

'With some communities, there's very little on-ground capacity for some of the maintenance that's required. So very often, small problems just get left, and left, and left ... It's not until it's completely broken and you've got a catastrophic problem that it's fixed' (Indigenous organisation #4).

Repairs were identified as being the responsibility of specific agencies that owned and managed the houses, as the housing stock in communities is predominantly government-owned. Despite this identified responsibility, interviewees considered that residents perceived they had minimal agency to request maintenance, described as:

'White people kind of know how to get the toilet fixed, ... how to access somebody to fix it, or that they have a right for it to be fixed. ... I think with Indigenous housing, it's probably more difficult for people to complain [about broken health hardware] ... It's about understanding how the systems work – about knowing who to contact and who to harangue to get stuff done' (Researcher #1).

A further comment was provided on the (often lack of) government agency collaboration to ensure a more holistic response:

'hygiene promotion [is] ... fragmented across the Health Department, ... [Department of] Housing ... [we need to] strategically bring these different groups together with

what [the] community needs are – to roll out aspects of hygiene and hygiene promotion. ... [Otherwise,] we just seem to not gain traction on that issue from just one agency's perspective' (Government representative #3).

DISCUSSION

The results can be most effectively considered as a 'system', with each aspect representing concentric layers within a system. [Figure 1](#) identifies that healthy behaviours in the home are influenced overwhelmingly by the layer regarding the effects of crowding. In turn, the functionality of the health hardware influences whether the house's residents can routinely perform these desirable health behaviours. Surrounding these inner layers is the availability of water and wastewater services to the community.

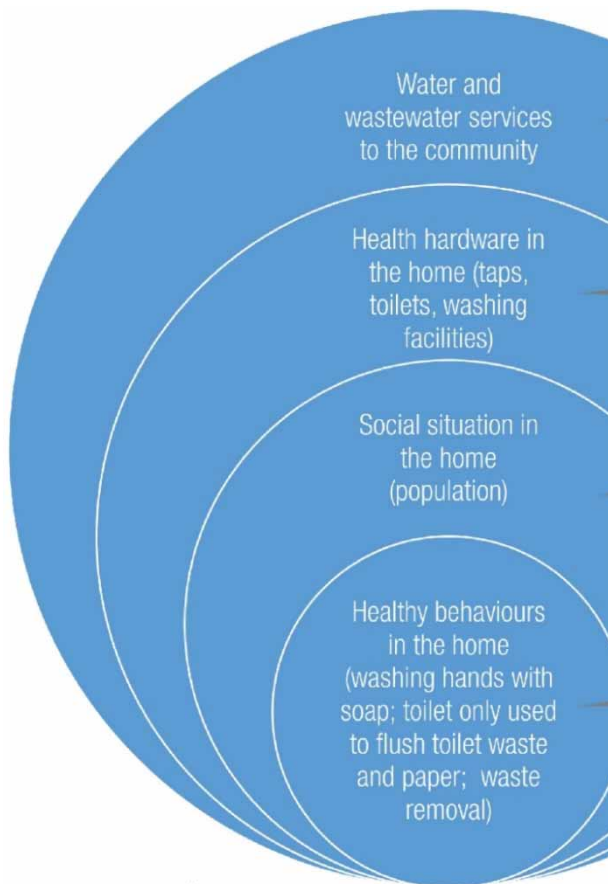


Figure 1 | Proposed approach to consider the integrated system of water, sanitation and hygiene in remote Indigenous communities.

Given these interlinked influences between the layers, a systems approach to this environmental health issue can provide a holistic approach to action, and bring together the range of agencies providing these services at each layer. This was articulated by an interviewee who stated:

'[It's about] being respectful and having some knowledge about what the issues are that people face ... being gentle around why it's hard to have toilet paper in your house all the time and have soap in your house all the time. It's not about blaming people, it's about finding a way and prioritising what's the most important thing to do and again helping with access to that' (Indigenous organisation representative #3).

Managing such a system requires collaboration by the respective agencies responsible. As noted by [Bartram & Platt \(2010\)](#), water-related disease burden can be attributed to lack of coordination between responsible agencies. Their recommended response is to create a framework that identifies the roles of agencies related to WASH and health to work in a more comprehensive health system and therefore maximise health gains ([Bartram & Platt 2010](#)). Further and consultative research among the relevant government agencies in each state would be required to explore this further.

This need for a systems approach is also relevant for the delivery of WASH services for Indigenous communities in other developed countries. In Canada, the Government's Indigenous and Northern Affairs Canada proposed a 'new approach' in 2016 with First Nations Peoples working in partnership with Government to deliver WASH projects as key decision-makers and collaborators ([Leclair 2016](#)). They proposed new funding of CAD\$4.6 billion for WASH and other community infrastructure. However, this was criticised by Human Rights Watch (HRW) for lacking a systems approach; HRW noted that infrastructure investments also required parallel changes in water quality regulation, funding for operation and maintenance, support for staff operating water treatment, and protection of source water. Similarly in the USA, many homes on Native American reservations lack access to clean water or sanitation, and government funding is limited for this infrastructure and maintenance ([Risen 2016](#)). Unequal access to clean drinking water is increasingly being recognised as a contributor health disparities and environmental injustice for vulnerable

US communities, including on Native American reservations (Doyle *et al.* 2018). Effective responses have been led by Native American communities in a comprehensive, community-engaged systemic approach that simultaneously addresses legal and regulatory, community capacity, and financial challenges (Doyle *et al.* 2018).

This study was limited by a small sample, and this limited the ability to draw conclusive findings. Therefore, future research and capacity-building could progress these findings to policy responses and actions for WASH access and services in remote Indigenous communities in Australia. It could consider seeking quantitative findings to measure the emergent findings presented here.

CONCLUSIONS

The quality and access of WASH services in remote Indigenous communities were revealed in this research as lacking at times in a range of communities. The most effective approach identified was a systems approach within the household and community level of WASH service delivery, and with technology that is adapted specifically for each place (community), people (and associated skills and support) and purpose (for the stage of water and wastewater treatment).

Potential responses to consider a systems approach differs for each stakeholder group. For Australian federal, state and territory governments, financial investment could increase the range of innovative, interlinked options to improve the status of WASH. For researchers, quantitative research and ongoing monitoring can continue to quantify problems, identify tested solutions and further inform policy and programme development to reduce hygiene-related health concerns, including from crowding. Non-governmental organisations (NGOs) specialising in WASH could consider collaborating with Indigenous organisations to more effectively address WASH challenges – especially regarding hygiene-related behavioural health responses.

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REFERENCES

- ABS 2007 *Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities, Australia, 2006*. Australian Bureau of Statistics, Canberra, Australia.
- ABS 2012 *Census of Population and Housing: Characteristics of Aboriginal and Torres Strait Islander Australians, 2011*. Australian Bureau of Statistics, Canberra, Australia.
- ABS 2016 *National Aboriginal and Torres Strait Islander Social Survey, 2014–15*. Australian Bureau of Statistics, Canberra, Australia.
- AG WA 2015 *Delivering Essential Services to Remote Aboriginal Communities*. Western Australian Auditor General, Perth, Australia.
- Baillie, R., Stevens, M., McDonald, E., Brewster, D. & Guthridge, S. 2010 [Exploring cross-sectional associations between common childhood illness, housing and social conditions in remote Australian Aboriginal communities](#). *BMC Public Health* **10**, 147.
- Bartram, J. & Platt, J. 2010 [How health professionals can leverage health gains from improved water, sanitation and hygiene practices](#). *Perspectives in Public Health* **130** (5), 215–221.
- Bradford, L., Bharadwaj, L., Okpalauwaekwe, U. & Waldner, C. 2016 [Drinking water quality in Indigenous communities in Canada and health outcomes: a scoping review](#). *International Journal of Circumpolar Health* **75**, 1–16.
- Browett, H., Pearce, M. & Willis, E. 2012 [Cost implications of hard water on health hardware in remote Indigenous communities in the central desert region of Australia](#). *International Indigenous Policy Journal* **3** (3). doi:10.18584/iipj.2012.3.3.6.
- Charmaz, K. 2006 *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. Sage, Thousand Oaks, CA, USA.
- Clifford, H., Pearson, G., Franklin, P., Walker, R. & Zosky, G. 2015 [Environmental health challenges in remote Aboriginal Australian communities: clean air, clean water and safe housing](#). *Australian Indigenous Health Bulletin* **15** (2), 1–13.
- Doyle, J., Kindness, L., Realbird, J., Eggers, M. & Camper, A. 2018 [Communication challenges and opportunities for tribal waters: addressing disparities in safe public drinking water on the Crow Reservation in Montana, USA](#). *International Journal of Environmental Research and Public Health* **15** (4).
- Fontana, A. & Frey, J. 2000 [The interview: From structured questions to negotiated text](#). In: *Handbook of Qualitative Research* (N. Denzin & Y. Lincoln, eds). Sage, Thousand Oaks, CA, USA, pp. 645–672.

- Foster, T. & Dance, B. 2012 Water-washed diseases and access to infrastructure in remote indigenous communities in the northern territory. *Water* **39** (4), 72–77.
- Hall, N., Shannon, C. & Jagals, P. 2016 It's a fallacy that all Australians have access to clean water, sanitation and hygiene. *The Conversation.com* (7 September).
- Hoepfl, M. 1997 Choosing qualitative research: a primer for technology education researchers. *Journal of Technology Education* **9** (1), 47–63.
- IHME 2015 *Global Burden of Disease: Viz Hub*. Institute for Health Metrics and Evaluation, Seattle, WA, USA. <https://vizhub.healthdata.org/gbd-compare> (accessed 20 July 2017).
- Leclair, D. 2016 *Delivering First Nations Infrastructure Together*. Indigenous and Northern Affairs Canada, Gatineau, Quebec, Canada. http://www.rpic-ibic.ca/documents/Breakfast_Series_PPT/NCR-8476943-v5-RPIC-PPT-2016-03-08_V4.pdf (accessed 21 May 2018).
- Malterud, K., Siersma, V. & Guassora, A. 2016 Sample size in qualitative interview studies: guided by information power. *Qualitative Health Research* **26** (13), 1753–1760.
- McDonald, E., Bailie, R., Brewster, D. & Morris, P. 2008 Are hygiene and public health interventions likely to improve outcomes for Australian aboriginal children living in remote communities? A systematic review of the literature. *BMC Public Health* **8** (1), 1.
- McDonald, E., Bailie, R., Grace, J. & Brewster, D. 2009 A case study of physical and social barriers to hygiene and child growth in remote Australian aboriginal communities. *BMC Public Health* **9**, 346.
- McDonald, E., Slavin, N., Bailie, R. & Schobben, X. 2011 No germs on me: a social marketing campaign to promote hand-washing with soap in remote Australian aboriginal communities. *Global Health Promotion* **18** (1), 62–65.
- McOliver, C., Camper, A., Doyle, J., Eggers, M., Ford, T., Lila, M., Berner, J., Campbell, L. & Donatuto, J. 2015 Community-based research as a mechanism to reduce environmental health disparities in American Indian and Alaska Native communities. *International Journal of Environmental Research and Public Health* **12** (4), 4076–4100.
- NAHS Working Group 1989 *National Aboriginal Health Strategy*. National Aboriginal Health Strategy Working Group, Canberra, Australia.
- NHMRC 2011 *Australian Drinking Water Guidelines*. National Health and Medical Research Council, Canberra, Australia. <https://www.nhmrc.gov.au/guidelines-publications/eh52> (accessed 28 July 2017).
- Pholeros, P., Rainow, S. & Torzillo, P. 1993 *Housing for Health: Towards A Health Living Environment for Aboriginal Australia*. Healthabitat, Sydney, Australia. <http://www.healthabitat.com/the-healthy-living-practices> (accessed 8 May 2017).
- Risen, T. 2016 Left Behind: For some Native American communities facing water problems, hope circles the drain. *US News* (16 June). <https://www.usnews.com/news/articles/2016-06-16/some-native-americans-lack-access-to-safe-clean-water> (accessed 21 May 2018).
- SCRGSP 2016 *Overcoming Indigenous Disadvantage: Key Indicators 2016*. P. Commission, Canberra, Australia.
- UN 2015 *Transforming our World: The 2030 Agenda for Sustainable Development*. United Nations, New York, USA.
- UN ESC 2011 As with So Many Other Human Rights, Indigenous Peoples Suffer Disproportionate Violations of Right to Safe Water, Sanitation, Permanent Forum Told. In: *Permanent Forum on Indigenous Issues (Tenth Session, 11th Meeting)*. United Nations Economic and Social Council, New York, USA. <https://www.un.org/press/en/2011/hr5061.doc.htm> (accessed 18 May 2018).
- United Nations Resolution 2010 *The Human Right to Water and Sanitation*. Resolution 64/292, July 28. United Nations General Assembly, New York, USA.
- WHO 2017 *Diarrhoeal Disease: Fact Sheet*. World Health Organization, Geneva, Switzerland. <http://www.who.int/mediacentre/factsheets/fs330/en/> (accessed 27 July 2017).
- WHO 2017 *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*. World Health Organization, Geneva, Switzerland. <http://www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf?ua=1> (accessed 27 July 2017).

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