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Water security risks in small, remote, indigenous communities in Canada: A critical review on challenges and opportunities

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Review

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Abstract

Indigenous communities in Canada are disproportionately affected by issues related to water security, especially access to clean water to meet human needs. The issues these communities face are diverse and widespread across Canada, with many causes and consequences. This review summarizes the types and magnitudes of risks associated with the water security of these communities, the consequences considering health and social perspectives, and the means of responding to these issues. Risks are broadly divided into quantitative risks (e.g., water quality and availability) and qualitative risks (e.g., lack of funding and jurisdictional conflicts). These risks lead to unique consequences, resulting in challenges in developing generalized risk response frameworks. Management of these risks includes a mix of techniques relying on legislative and technical approaches. Nevertheless, the affected communities should be included in the decision-making process that should be holistic, incorporating indigenous knowledge. Good governance, cooperation between communities, policy improvement and the development of an institutional mechanism for clean water supply will provide a pathway and guidelines to address the water security challenges among indigenous communities.

Impact statement

This review focuses on assessing the key risks to water security faced by small, remote, indigenous communities throughout Canada. This assessment includes a discussion of these risks from a quantitative perspective, which are well-established risks to water quality, and a qualitative perspective, overviewing the risks from organizational or legislative standpoints that are often neglected or overlooked in studies of these communities. The outline of these factors provides important background to the types and severity of risks to the water security of these communities, with special attention paid to their potential impacts. This review also provides a framework for mitigating these risks and investigating reactive, proactive and governance-based response strategies. A policy of respectful cooperation and collaboration between communities, researchers and the government is identified as the most successful strategy in implementing risk mitigation strategies, providing a path to address these water security concerns in Canada and other colonial states.

Introduction

The concept of water security, describing the accessibility of an adequate amount of water of acceptable quality to ensure human health, is vital to the survival of Small, Remote, Indigenous (SRI) communities (Longboat, 2015). However, a lack of access to water to fulfill these needs is a persistent problem in many of these SRI communities throughout North America, stemming from various complex risks. The issues in Canada alone are diverse and widespread, with communities facing issues stemming from pollution, inadequate resources, aging infrastructure and a lack of training in water systems personnel (Hanrahan, 2017). Drinking water advisories, regulatory warnings that drinking water is unsafe to consume, are also common, with indigenous communities in Canada being 2.5 times more likely to face these issues than other communities of similar sizes and 70% of indigenous communities experiencing an advisory between 2004 and 2013 (Patrick, 2011; Lucier et al., 2020). Further disparities also exist within SRI communities, with older residents having higher difficulties accessing clean water and younger women, especially those with children, having higher difficulties accessing enough water (Duignan et al., 2022). Operators of the water treatment systems within these communities often cite a lack of funding and support as crucial factors, resulting in an inability to adequately meet the demand for water within the communities (Murphy et al., 2015). Many of these communities' water treatment

systems cannot meet the demand and face additional strains caused by nearby industries, development or tourism (Arsenault, 2021). In some parts of Canada, as high as 19% of residents in some communities will go longer than 24 h without consuming water due to issues relating to taste and availability (Ratelle and Yakeleya, 2022). These issues are commonly encountered in other colonial states, with upwards of 194,000 citizens in communities in Australia with populations less than 1,000 reporting unhealthy water based on local guidelines (Wyrwoll et al., 2022), while Indigenous households in the United States are 19 times more likely to lack sufficient indoor plumbing compared to White households (Wilson et al., 2021).

Regulatory failures to achieve water security for these communities have been widespread and longstanding. These issues include the inability to provide adequate infrastructure, regulatory frameworks and prioritization of communities most in need, despite a now 45-year-old pledge by the Canadian federal government to provide sufficient drinking water to SRI communities (Boyd, 2011). Protocols developed by the federal government in response to the failure of water systems in 2000 in the community of Walkerton and subsequent deaths have been demonstrated to have failed a related community that has faced over 17 years of similar water issues (Chambers, 2017). Federal drinking water evaluation methods have also been challenged, with studies noting a narrow scope and a lack of consideration for socioeconomic factors that significantly impact the capacity of these communities to treat water effectively (Brown et al., 2016). Media portrayals of water security issues within these communities are also often delayed compared to other crises within the country, with minimal coverage of Inuit and Metis communities. This coverage often focuses only on responses rather than attempts at mitigation (Lam et al., 2017). Despite this, new federal legislation still presents the opportunity to provide self-governance, improved capacity for addressing emergencies, uniform standards and increased accountability. Recent achievements include lifting over 80% of long-term drinking water advisories (Willms and Shier, 2006; Indigenous Services Canada, 2023).

Water vulnerability within these communities is affected by various factors and can vary significantly between communities. As of 2011, roughly 1.5% of homes in Canadian indigenous communities had no direct water service, with 26.5% relying on individual wells or truck delivery, with 39% of these systems experiencing high risk of failure and 34% experiencing medium risk (Neegan Burnside Ltd., 2011). Recent progress has brought the current number of affected communities to 28 across Canada, with 32 long-term advisories in effect; however, this does not consider individual homes or communities of less than five houses (Indigenous Services Canada, 2023). Though many SRI communities have appropriate equipment and infrastructure for treating sufficient amounts of water, this equipment must be properly maintained and operated (Smith et al., 2005; Lucier et al., 2022). Though economic factors are prevalent drivers of water vulnerability, other factors such as availability, existing water quality, types of contaminants, community demographics and social engagement can vary from one community to the next, making the development of generalized approaches challenging (Plummer et al., 2013). While source water planning has been proposed to address water quality concerns for some of these communities, for many of them, it is infeasible or does not address the actual issues at play, which are often tied to a lack of funding (Collins et al., 2017). Within these communities, those citizens without access to running water and proper wastewater systems are 63% more likely to experience illness resulting in missed work or school, with an economic cost of over $100 million as a result of physician care, drug costs and the cost of lost production (O'Gorman and Penner, 2018). Given the complex nature of the state of SRI water security, this review seeks to summarize the critical risks to these communities from the standpoint of both quantitative and qualitative risks. The expected consequences of these risks are summarized, considering individual health impacts, societal costs and environmental impacts, and the current methods of addressing these risks are summarized. Findings of the most successful approaches are discussed. A collaborative stance between researchers, regulators and SRI community members is explored in depth as the path forward for managing these water security risks.

Risks to indigenous communities

Overview of risks

Though the risks facing indigenous communities are diverse and governed by a complex series of factors, they can broadly be categorized as either quantitative risks, those directly quantifiable, or qualitative risks, reflecting issues related to governance and management.

Quantitative risks

In water security, quantitative risks describe those risks to the systems that can be directly quantified and described, such as bacterial or chemical contaminant levels, quantities of clean water and the effects of distribution systems. The variety of potential risks from one community to another presents difficulties in generalizing studies of these issues; however, there are many commonalities in the quantitative risks these SRI communities face. Table 1 provides a summary of these common risk factors. A national analysis of Indigenous reserves in Canada has found that 43% of boil water advisories in affected communities result from unacceptable microbiological quality (Fernando et al., 2016). The high presence of bacteria in these waters increases vulnerability to the growth of antibiotic-resistant strains. Analysis of source water in one community found the presence of coliforms in many stages of the water distribution system, with 46 different bacterial phylae also present and antibiotic-resistant genes found in all source waters and several treatment stages (Fernando et al., 2016). A study of source water contamination within an Indigenous fly-in community found significant levels of fecal bacteria contamination, with water samples from homes serviced by cisterns, distribution trucks, and the community standpipe having unacceptable levels of *E. coli* contamination (Farenhorst et al., 2017). Though there have been many quantitative studies investigating the impacts of biological contaminants on the health of residents, there is a gap in the coordination of these studies and their consideration of health impacts (Bradford et al., 2016; Lane et al., 2020; Hu et al., 2022; Khan et al., 2022). The most common health issue assessed from these quantitative studies of water contamination was gastrointestinal issues, with these studies generally limited to single communities (Bradford et al., 2016).

Chemical contamination is another common risk to these systems, with the types of contaminants also varying vastly from community to community (Hu et al., 2020). A study of 47 communities in Atlantic Canada assessed vulnerability to lead, manganese and arsenic contamination from 12 years of sampling data. Elevated concentrations were found of each contaminant in several communities (with some exceeding regulatory guidelines by up to 100%), and many communities also had issues with sampling frequency, leading to some contaminants being underreported

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Table 1. Assessment of common quantitative risks and their levels of severity

Category	Number of affected communities	Description of risk level	Possible health consequences	Source(s)
Antibiotic-resistant bacteria	1 community in Manitoba	11 unique genes in samples from 21 different locations	Gastrointestinal illness, increased community vulnerability	Fernando et al., 2016
Total coliforms	5 communities in Manitoba, 1 in Alberta, 1 in Saskatchewan, 5 communities in British Columbia	Maximum levels range from 14,600 – CFU/100 ml, up to 62% of samples contaminated	Gastrointestinal illness	Fernando et al., 2016; Farenhorst et al., 2017; Bradford et al., 2018; Mah et al., 2018; Amarawansha et al., 2021; Hu et al., 2022
E. coli	5 communities in Manitoba, 1 in Alberta, 1 in Saskatchewan	Maximum levels range from 2,000–10,000 CFU/100 ml, up to 82% of samples contaminated	Gastrointestinal illness	Fernando et al., 2016; Farenhorst et al., 2017; Bradford et al., 2018; Mah et al., 2018; Amarawansha et al., 2021
Campylobacter	2 communities in Manitoba	58–100% of samples from cisterns contaminated with up to 1,900 CFU/100 ml	Gastrointestinal illness	Khan et al., 2022
Proteobacteria	1 community in Manitoba	8 orders appearing in up to 56.5% of samples	Gastrointestinal illness	Farenhorst et al., 2017
Arsenic	47 communities over 12 years, 5 communities in British Columbia	Guidelines exceeded in 5 systems	Cardiovascular issues, lung cancer	Lane et al., 2020; Hu et al., 2022
Manganese	47 communities over 12 years, 91 communities in Canada, 5 communities in British Columbia	Guidelines exceeded in 22 systems, 4.0% of samples above Maximum Acceptable Concentration (MAC)	Neurotoxicity, cognitive and attention deficits in children	Lane et al., 2020; Schwartz et al., 2021b; Hu et al., 2022
Lead	47 communities over 12 years, 91 communities in Canada	Guidelines exceeded in 11 systems, 8.4% of samples above MAC	Behavioral issues, cognitive deficits, cardiovascular disease, renal dysfunction	Lane et al., 2020; Schwartz et al., 2021b
Aluminum	91 communities in Canada	1.3% of samples above MAC	Neurological disorders	Schwartz et al., 2021b
Uranium	91 communities in Canada	1.6% of samples above MAC	Kidney effects, cancer	Schwartz et al., 2021b
Copper	91 communities in Canada	0.2% of samples above MAC	Exacerbation of Wilson's disease	Schwartz et al., 2021b
Pharmaceuticals	95 communities across Canada	35 unique pharmaceuticals were detected in 83% of participating communities	Hormonal imbalances, antibacterial resistance	Schwartz et al., 2021a
Disinfection by-products (DBPs)	22 communities in Quebec	6 different DBPs detected at mean concentrations ranging between 0.05–72.2 μg/L	Unregulated DBPs impacts not fully understood	Mian et al., 2021

(Lane et al., 2020). A study of 91 indigenous communities south of the 60th parallel investigated the presence of metal contaminants, with samples taken from 1,516 households. Exceedances of the maximum acceptable concentration of five metals were discovered, with up to 8.4% of households exceeding the maximum acceptable lead concentration and exceedances of proposed operational guidelines of many other metal contaminants reported (Schwartz et al., 2021a). A similar study investigated the presence of pharmaceutical contaminants in surface water samples from 95 indigenous communities throughout Canada. 83% of the participating communities were found to have quantifiable levels of 35 different pharmaceutical contaminants, with 68% of the chosen surface water sampling locations demonstrating contamination (Schwartz et al., 2021b). Disinfection by-products (DBPs), contaminants introduced by the water treatment process, were discovered in the water systems of 22 communities in Quebec. Six unique DBPs were found, with maximum contamination levels of 635 μg/L (Mian et al., 2021).

The causes and subsequent severity of these risks are governed by the community's location and the water distribution system the community employs. Environmental drivers of contamination risk to water wells in an Albertan Indigenous community were investigated, finding that bacterial counts peaked roughly 2–4 months following yearly precipitation and overland flow peaks (Mah et al., 2018). More remote northern Indigenous reserves in Saskatchewan were found to have a drinking water advisory count five times greater than reserves in the south and two times as many advisories as villages in the north (McLeod et al., 2020). Many indigenous communities rely on a water truck-to-water cistern method of water distribution. However, this method is highly susceptible to contamination from bacteria. A study of 142 households in Saskatchewan using this system found that summer months increased coliform contamination risk in cisterns by up to 7 folds (Bradford et al., 2018). In two indigenous communities in Manitoba, *Campylobacter* was detected in 68% of source water samples, with samples taken from homes using fiberglass cisterns or the community standpipe having a 100% detection rate, in comparison to 43% and 20% for piped water and water trucks (Khan et al., 2022). Roughly 31% of the homes in an Indigenous reserve in Manitoba rely on a truck-to-cistern delivery system for supplying water, with

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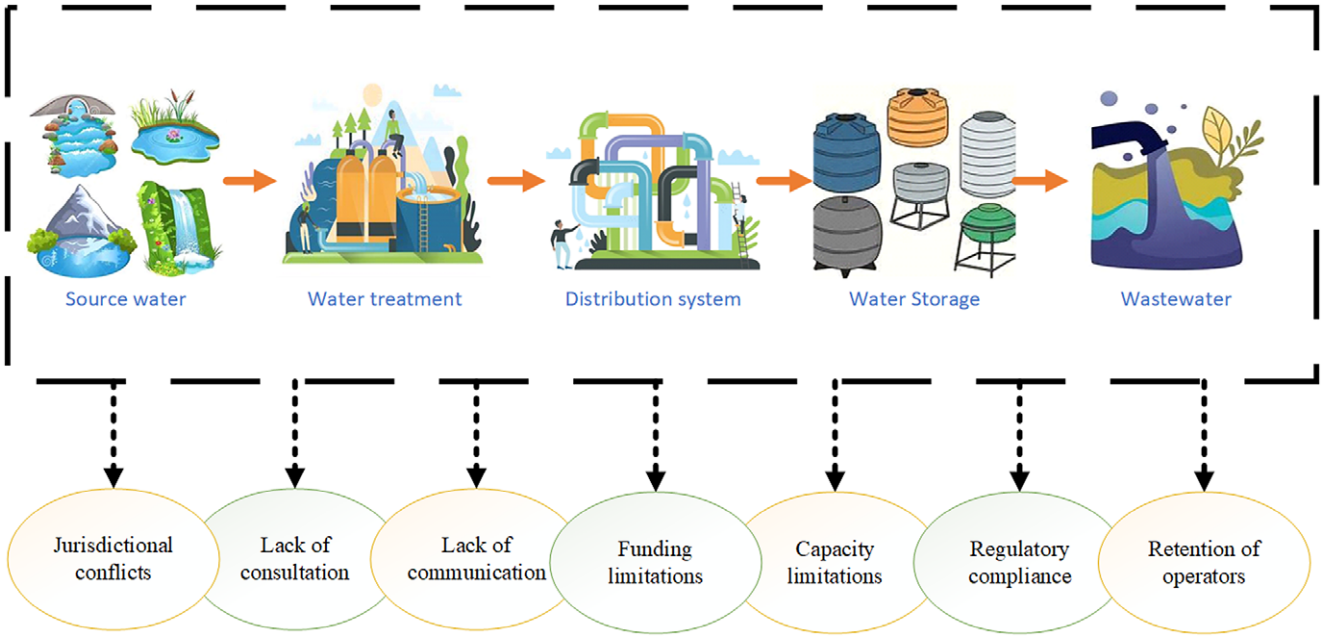

Figure 1. Flow diagram of water treatment with key qualitative risks at each stage.

levels of contamination that are significantly higher and more frequent (Amarawansha et al., 2021). A survey of six Indigenous prairie communities identified household water cisterns as the highest risk (Baijius and Patrick, 2019).

Qualitative risks

Qualitative risks (for instance, funding, regulation and training) are also very common to the water security of SRI communities. However, more attention has often been given to quantitative issues, with qualitative concerns neglected. These risks can impact all aspects of the water treatment systems of these communities, outlined in Figure 1. Indigenous communities' qualitative issues should be examined in more detail to overcome the constant risk of water system failure. Most studies consider individual and typical qualitative issues in specific geographical contexts. The most common qualitative risks faced by indigenous communities are jurisdictional conflicts (Marshall et al., 2020), lack of consultation and participation on the policy level (Latchmore et al., 2018), limitations in funding and capacity (Marshall et al., 2020), absence of regulatory frameworks (Simms et al., 2016) and retention of qualified operators (Reading et al., 2011).

Mascarenhas (2007) researched Six First Nation Communities in southwestern Ontario and highlighted governance factors affecting the health and welfare of communities. The University of Victoria also investigated the water systems of indigenous communities, identifying technical and financial challenges affecting water services. Additionally, conflicting responsibility, new regulations and other operational factors were identified as critical (Reading et al., 2011).

McCullough and Farahbakhsh (2012) interviewed 16 indigenous communities in Ontario to identify the challenges behind the water system failure. Regulatory framework issues, infrastructure gaps and organizational capacities were highlighted, with indigenous communities being burdened by colonial history and facing jurisdictional issues. Bradford et al. (2016) conducted a scoping review and found that uncertain water provision, funding delays and lack of framework further exacerbate management and infrastructural challenges in the water systems of the indigenous communities. BC Ministry of Health (2016) provided an update on the progress made in drinking water protection in BC. They highlighted challenges such as recruiting and retaining qualified staff, lack of public consultation and permission process and economic struggles as factors affecting service delivery. McFarlane and Harris (2018) reviewed the academic literature on the governance of small drinking water systems and identified high levels of non-compliance in operations and slow developments in addressing water system and infrastructure issues.

Marshall et al. (2020) highlighted the issues faced by the indigenous communities with a partnership with an Anishinaabe community in southern Ontario. They identified jurisdictional issues leading to SRI communities being underrepresented as stakeholders with the same rights and considerations as other groups and a lack of funding and capacity impacting the water system of indigenous communities.

Impacts to indigenous communities

The relationships between economies, societies and ecosystems are complex and diverse, especially as they relate to the Sustainable Development Goal of clean water and sanitation (DeWit et al., 2023). The impacts of the aforementioned risks, much like the risks themselves, are also diverse and vary based on various circumstances. These impacts can broadly be divided into health, societal and environmental categories.

Health impacts

The impacts of a lack of good quality running water have been investigated from a physical and mental health standpoint. The availability of running water has been associated with an 80% decrease in the odds of reporting depression while functioning wastewater systems halve the odds of gastrointestinal illness (O'Gorman, 2021). Interviews with communities in Alberta and the Northwest Territories found that ≈ 82% of respondents relied on bottled water rather than locally available tap water as their primary

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water source, with health and ease of access cited as the primary reason for this preference and significant gender discrepancies present in the responses to both queries (Spicer et al., 2020). Likewise, a study in Ontario analyzed perceptions of water safety in five communities, finding that Indigenous community residents were two times as likely to rely on bottled water and four times more likely to report illness from tap water (Dupont et al., 2014). Community surveys with other indigenous communities in Ontario yielded similar insight into perceptions of water safety. Between 8 and 61% of respondents, depending on the community, would follow drinking water advisory guidelines, with access to safe water during advisories being rated as inadequate to very inadequate (Baird et al., 2015). Risk perception was analyzed in two Saskatchewan communities, finding that while drinking water health standards were exceeded for most communities, there was no association between this factor and risk perception (Ford et al., 2019).

Societal impacts

The aforementioned drinking water advisories are one of the most common means of reacting to the discovery of low or inadequate water quality, with boil water or do-not-consume advisories being widespread across the country. Though these can be effective in the short term, they carry their own impacts on SRI communities. A series of surveys and interviews were conducted to investigate the effectiveness of drinking water advisories in Ontario. There was a high degree of uncertainty regarding the proper protective actions to be undertaken during the advisories, with 79% of male respondents and 46% of female respondents indicating adherence to advisory guidelines (Lucier et al., 2020). An analysis of the trends in drinking water advisories in Ontario during the 10 years from 2004 to 2013 found that the advisories are becoming more common and longer. These advisories most commonly occurred in summer months and were linked to equipment malfunctions, which could be mitigated through additional operator training (Galway, 2016). These advisories have also been found to result in significant disparities in the availability of "good" drinking water generationally and by gender. A study of the Six Nations of the Grand River in Ontario found that the younger generations were more dissatisfied with water quality. Women within the communities often had challenges obtaining adequate clean water (Duignan et al., 2022).

Environmental impacts

Detailed linkages have also been drawn between the declining health of nearby waterways due to misuse and pollution and the strain on the water treatment systems within many communities, revealing distinct impacts on food sources, community health and community activity (Lucier et al., 2022). Federal policies and programs addressing water health have been noted for their inflexibility and gaps in execution. Often, these policies are too generalized, resulting in low engagement and a lack of consideration for community heterogeneity (McCullough and Farahbakhsh, 2012; Spicer et al., 2020). Simplistic and overgeneralized approaches to framing water issues were also cited as a concern in managing water security for indigenous communities in an analysis of the 2001 Aboriginal Peoples Survey (Spence and Walters, 2012).

Risk response and mitigation roadmap

A framework for responding to water security risks can be divided into three categories: reactive responses addressing existing risks, proactive responses addressing recurrence and governance and management strategies to prevent risks.

Phase 1: Risk response strategies

Reactive strategies to water security risks are widespread, with the application of drinking water advisories to SRI communities being widespread. A probabilistic analysis identified the key drivers of drinking water advisories considering data sourced from 1,167 historical advisories across Canada. Occurrence and frequency were influenced by water source type and location, duration was influenced by system age and operator training, and the cause was primarily influenced by system age (Post et al., 2018). A database of drinking water advisories throughout Ontario was also used as the basis of a decision tree classifier to predict the drivers of these advisories. It was found that insufficient or no training of operators was an indicator in over 50% of the advisories considered, and the usage of groundwater wells and the age and number of people served by the system increased the likelihood of advisories (Harvey et al., 2015).

Short-term responses to these risks include risk assessments, with many well-established techniques allowing risks to water treatment and distribution to be identified (Mpindou et al., 2022). The available water system services methods for assessing biotic and abiotic elements of a drinking water source were compiled, showing how these services can be assessed for risks and subsequently improved (Gartner et al., 2022). Direct consultation with indigenous communities was used as the basis of a risk assessment tool outlining the most common risks present to the water delivery system in six communities in Atlantic Canada. This tool produces intuitive results to prioritize the most significant risks to the systems and suggests means to address them while demonstrating the value of direct consultation with indigenous communities (Lane et al., 2022). Similar techniques were used to assess hazards within Indigenous wastewater systems, developing a sanitation safety plan as an alternative to current regulatory approaches to wastewater hazards (Lane et al., 2021). Responses from 54 communities were used to evaluate the effectiveness of new risk-level guidelines in Ontario indigenous communities. It was found that based on these guidelines, all of the communities were considered low risk, even though there was variable capacity for drinking water in each, indicating a need to explore other potential underlying factors of these risks (Walters et al., 2012).

Phase 2: Proactive risk mitigation strategies

Prevention of the conditions leading to water insecurity is a practical next step, with source water protection, water safety plans and water sharing agreements providing more reliable water sources for communities; however, limits exist to the effectiveness of these techniques. Source water protection programs in Canada and the United States have been reviewed, focusing on previously published literature. It was found that many of these studies fail to recognize the indigenous communities as anything more than stakeholder groups, as opposed to rightsholders, relying little on their traditional knowledge and management and having minimal involvement from local elders and knowledge keepers (Marshall et al., 2018). A water protection program was implemented with direct consultation with an Indigenous community, using the concept of the Medicine Wheel in combination with qualitative data analysis techniques. The resulting source water protection framework identified apparent issues of concern with policy and funding and indicated a need for better risk assessment tools implementable by the communities (Marshall et al., 2020). Following a detailed consultation between community members and researchers, traditional knowledge has also been implemented to protect source

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water. Community members' assessments of risks to the water system components were used to identify management actions to mitigate risks throughout the water treatment process, identifying key bodies responsible for management while reclaiming indigenous planning methods (Patrick et al., 2019).

Given the growing scarcity of water resources in many remote indigenous communities in Canada, the United States and Australia, the application of water sharing in a "just" manner has been posited to ensure equal access to these resources (GCEW, 2023). Using water systems data from 804 indigenous communities, two probit models were developed to find that an Indigenous community's participation in a water-sharing agreement will reduce the likelihood of boil water advisories (Lipka and Deaton, 2015). Though water-sharing agreements have successfully alleviated some water security concerns, they are unreliable. Similarly, significant shortcomings were present in funding security, rate negotiations and the presence of clauses allowing unilateral discontinuation of service to indigenous communities by the source municipality (Huo et al., 2022). An analysis of 419 communities in Ontario, including 118 indigenous communities, investigated the effectiveness of water-sharing agreements between remote communities. The results indicated a distinct lack of participation of indigenous communities in water-sharing agreements (Deaton and Lipka, 2021).

Phase 3: Water governance and management frameworks

Oxford's REACH program highlights assessment, reporting and management, including community acceptance and applicability, as key elements of risk-based approaches to water safety issues (Charles et al., 2023). Water management strategies combining legislative or management frameworks and self-governance can be a practical regulatory step in achieving water security. These management frameworks can incorporate proactive and reactive risk management, monitoring and assessing qualitative and quantitative risks (Wilson, 2019). Some indigenous communities in Saskatchewan were asked to self-report the health effects of tap water to promote awareness and participation. Adverse effects were reported in 28% of these households, with concerns about environmental factors affecting water quality, insufficient access to drinking water and water avoidance or dissatisfaction being common (Waldner et al., 2017). These management frameworks can be implemented in terms of community-based research labs, collective and traditional knowledge in developing water policy research, and reciprocal learning methods to encourage the decolonization of water (Arsenault et al., 2017). Establishing generalized management frameworks by combining scientific knowledge, available practices and traditional knowledge will ensure equitable contributions from community members, effective operations of SRI water systems and low human health and environmental risks (Alcantara et al., 2020). Thus, they can assist in developing pathways toward a holistic water management approach for indigenous communities (McGregor, 2014). Furthermore, developed management frameworks can be adaptive to local water safety plans with an emphasis on the success of the bottom-up approach (Black and McBean, 2017).

Management frameworks can integrate different index and footprint-based approaches to bring a lens of quantitative risk and evaluate the performance of SRI water systems. These approaches facilitate summarizing and communicating complex water quality data to the broad community (Lumb et al., 2006; Mian et al., 2021). Continuous application and testing of proposed management frameworks will facilitate the decision-maker in collecting comprehensive data on qualitative and quantitative risks (Morrison et al., 2015). This enables the establishment of robust ethical and legal frameworks to strengthen ties between water security, biodiversity and social and cross-cultural factors (Matsui, 2012). The proposed management frameworks can be generalized to address water security issues among indigenous communities through the application of Indigenous water relations for a more holistic approach, understanding of colonial politics as a root cause of insecurity, and applications of a "two-eyed seeing" approach against more common integration of Western and Indigenous approaches. (Wilson et al., 2019). Also referred to as "braiding," the application of these principles can ensure equity, accessibility and usability for Indigenous community members while centering their voices in the collaboration (Mehltretter et al., 2023).

Conclusions

The risks to water security within SRI communities are diverse and widespread. Though they can be sorted into categories of qualitative and quantitative risks, it is difficult to generalize these risks due to the variety of issues these communities face that are unique to factors such as location, climate, remoteness, proximity to developments and governance. Because of this, attempts at creating blanket solutions through regulation or technical research are often unsuccessful as they fail to address the unique needs of the communities and rely on a unilateral approach. The solution to these issues lies in respectful collaboration with SRI communities, including implementing facets of traditional Indigenous knowledge in research and involving communities in the regulatory process, ensuring true collaboration. The "braiding" of these differing approaches to knowledge provides insight to practitioners while offering a means for decolonization efforts. Through this, a pathway to water security for SRI communities in North America can be charted, ensuring that the needs of these communities now and in the future are satisfied.

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