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Jonathan M. Bressler & Thomas W. Hennessy

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RESEARCH ARTICLE



Results of an Arctic Council survey on water and sanitation services in the Arctic

Jonathan M. Bressler^{a,b} and Thomas W. Hennessy^{c,d}

^aAlaska Division of Public Health, Section of Epidemiology, Anchorage, AK, USA; ^bApplied Epidemiology Fellowship, Council of State and Territorial Epidemiologists, Atlanta, GA, USA; ^cArctic Investigations Program, National Center for Emerging and Zoonotic Infectious Diseases, CDC, Anchorage, AK, USA; ^dArctic Human Health Experts Group, Sustainable Development Working Group, Arctic Council, Ottawa, Canada

ABSTRACT

As part of a project endorsed by the Arctic Council's Sustainable Development Working Group (SDWG), a survey was conducted to describe the current status of water, sanitation and hygiene (WASH) services in the Arctic region. The English language internet-based survey was open from April to September, 2016 and drew 142 respondents from seven Arctic nations. Respondents provided information on access to WASH services, notification requirements for water-related infectious diseases, and examples of environmental- or climate-change related events that impact the provision of WASH services. Many remote Arctic and sub-Arctic residents lack WASH services, and these disparities are often not reflected in national summary data. Environmental changes impacting WASH services were reported by respondents in every Arctic nation. Participants at an international conference co-sponsored by SDWG reviewed these results and provided suggestions for next steps to improve health of Arctic residents through improved access to water and sanitation services. Suggestions included ongoing reporting on WASH service availability in underserved populations to measure progress towards UN Sustainable Development Goal #6; evaluations of the health and economic consequences of disparities in WASH services; and Arctic-specific forums to share innovations in WASH technology, improved management and operations, and adaptation strategies for environmental or climate change.

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Arctic; water; sanitation; hygiene; infectious; disease; development; infrastructure; climate; environment

Introduction

The United Nations General Assembly has recognised that safe, clean drinking water and sanitation is a basic human right [1]. The 2015 UN Goals for Sustainable Development (SDGs) include providing access to safe and affordable drinking water and adequate sanitation and hygiene for all by 2030 [2]. The indicators for this goal include measuring the proportion of the population using safely managed and treated drinking water (indicator 6.1.1) – either piped to the home or accessed from a central facility – and the proportion using safely managed sanitation services including a hand-washing facility with soap and water (indicator 6.2.1).

In the Arctic region, inadequate water and sanitation services are associated with poorer health status, and this burden is higher among rural and indigenous populations [3]. While access to safe water prevents waterborne infections which mainly cause gastrointestinal illness, access to adequate quantity of water for hand, face, and body washing prevents water-washed infections that are spread from person to person, such

as respiratory tract infections and skin infections. The issue of water scarcity is addressed in SDG Target 6.4 and measured by freshwater withdrawal (indicator 6.4.2), but does not take into account seasonal scarcity issues posed by freshwater freezing in the arctic or threats to water access posed by environmental change. For Arctic nations, providing and maintaining water and sanitation services presents unique challenges including emerging threats related to the climate and environment [4].

SDG Target 6.A also calls for international cooperation to develop water and sanitation activities and infrastructure. In 2016, as an endorsed project of the Arctic Council's Sustainable Development Work Group (SDWG), a survey was conducted of professionals, government authorities and Arctic and sub-Arctic residents to describe the current state of water and sanitation services. This survey also ascertained which water-related diseases are monitored by public health and identified environmental and climate-related threats affecting water and sanitation in northern circumpolar populations.

CONTACT Jonathan M. Bressler  jonathan.bressler@alaska.gov  Alaska Division of Public Health, Section of Epidemiology, Council of State and Territorial Epidemiologists, Anchorage, Alaska, AK, USA; Applied Epidemiology Fellowship, Council of State and Territorial Epidemiologists, Atlanta, GA, USA

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Methods

The survey was conducted from 10 April to 1 October 2016, in English, and used the internet-based survey tool “SurveyMonkey.com”, which allowed respondents to participate using a personal computer. The survey questions may be viewed online [5]. The survey was intended to reach professionals and residents of Arctic nations and was open to all interested persons. The link to the survey was distributed through email lists and direct contacts, including the Arctic Human Health Experts Group. Additional information was solicited from subject matter experts recommended by survey respondents, and presenters and attendees at the Water Innovations for Health Arctic Homes (WIHAH) Conference in Anchorage, Alaska from 18 September to 21 September 2016.

The survey had three sections: Water and Sanitation Services, Disease Surveillance, and Environmental or Climate Changes Affecting Water and Sanitation. It was expected that respondents would likely not be able to provide authoritative answers to all sections. Because some respondents reported data for water and sanitation access that were speculations, only government, tribal, or service authorities were used to describe WASH access in this summary. Survey respondents were contacted to confirm the data they provided. The data provided from some areas on access to water and sanitation services were approximations, so comparisons between areas should be made with caution.

Information obtained about the requirements for reporting human cases of water-related infectious diseases to regional or national public health authorities was supplemented by using online resources and publications from each area [6–9]. Water-borne diseases were defined as those that can cause infection by being present in drinking water (e.g. cholera), and water-washed diseases as those where transmission is primarily from person-to-person for which personal sanitation practices, such as handwashing, can interrupt transmission (e.g. respiratory tract infections).

In the third section, respondents were asked whether or not environmental- or climate-change related events had caused loss of water or sanitation access or damage to water and sanitation infrastructure. They were asked to describe these events and provide supporting information such as news articles or other publications.

Survey results were supplemented by information obtained from direct contacts at the 2016 conference on Water Innovations for Health Arctic Homes (WIHAH), the US Census [10], and the Alaska Department of

Environmental Conservation. Data provided by the World Health Organization (WHO) through the Joint Monitoring Programme (JMP) [11] were compared to the data supplied by respondents. For these comparisons, JMP numbers on improved sanitation (i.e. where human waste is protected from human contact) and shared sanitation facilities were combined since shared facilities are considered sanitary in most places in the Arctic where they are used, such as in Finland, Sweden, and Iceland. JMP data for unimproved (i.e. unsafe) drinking water sources, such as unprotected springs and wells, were combined with surface water sources for this comparison.

Preliminary survey results were presented at the WIHAH conference, and feedback for interpretation and presentation of the results were integrated into the project. Conference proceedings are available online [12], and the suggested next steps from the WIHAH conference are included here in [Box 1](#).

Results

A total of 142 individuals responded to the survey and 51 gave complete responses for at least one section. Five of these were from Canada, three from Finland, three from Greenland, one from Iceland, one from Norway, three from Sweden, and 35 from Alaska; no responses were received from Russia.

All respondents from Finland, Iceland, Norway, and Sweden reported universal availability of improved (i.e. safe) water for the entire population; incomplete service was reported from Canada, Greenland, and Alaska ([Table 1](#)). Respondents from Iceland and Norway reported universal access to improved sanitation; gaps in sanitation service were reported from Canada, Finland, Greenland, Sweden, and Alaska. While no responses were received from Russia, other sources report incomplete coverage of water and sanitation services in much of Arctic Russia [11,13]. Reported access to services differed from the percentages described by the JMP. Most survey respondents reported on smaller geographical areas within countries, whereas the JMP data cover the entire country, so direct comparisons between some responses and the JMP data are not possible. Most respondents who reported 99% access in their areas specified that this was an approximation, and likely closer to 100% of households had access, but they wished to indicate that a gap in access of less than 1% still existed.

Access to improved water and sanitation services is very high in urban areas, whereas gaps in service exist mainly in rural areas. For example, in rural Greenland,

Box 1. Selected “Next Steps” from Participants of the Water Innovations for Healthy Arctic Homes (WIHAH) Conference, September 2016 that relate to the Arctic Council WASH project.*.

- Develop a database of water and sanitation infrastructure, source water or treatment systems at risk from environmental or climate change.
- Quantify the economic consequences of inadequate access to in-home water and wastewater services, including direct health care costs (morbidity and mortality, health care expenses) and indirect costs, such as lower educational attainment due to illness, decreased subsistence and employment activities. Such analyses should include methods that account for the unique cultural context of the Arctic, including individual and cultural values.
- Conduct an assessment of how much water is needed per person per-day to provide the best benefit for health in Arctic communities. In doing this, consider newer technologies not available in prior World Health Organization (WHO) water quantity standards. These could include low-flow faucets, separating or dry toilets, and water reuse methods that could conserve water and reduce cost for a similar gain in health. Also, consider the water related needs that can be centralised (e.g. laundry) versus those that must be available in the house (e.g. handwashing)
- Through the Arctic Council Sustainable Development Working Group and its Arctic Human Health Expert Group (AHHEG), Arctic states should cooperate to share data about water and sanitation access in their Arctic communities, as well as progress towards the Sustainable Development Goal #6.
- Through AHHEG, and through non-Council bodies such as the International Circumpolar Surveillance network, Arctic states should cooperate to track water-related infectious diseases (both water-borne and water-washed) in the Arctic region over time, and to study how changes in water and sanitation access affect these rates.
- The Arctic Council should continue to create forums for Arctic communities to share innovations in water and sanitation technology, cost management methods, and climate change adaptation strategies.
- Arctic states should cooperate with one another to assess the quantity of water needed for good health in the Arctic, and to consider adopting standards for providing adequate water quantity and engineering methods for achieving these standards.

* Full report can be found at <http://www.sdwg.org/project/sdwg-achievements-2015-2017/>

(The findings and conclusions in this report are from the conference proceedings and do not necessarily represent the official position of the US Centres for Disease Control and Prevention.)

approximately 25% of households have no access to improved water, and approximately 65% of households have no access to improved sanitation. In Greenland, unimproved sanitation services refer to bucket toilets that use plastic bags, also known as honey buckets. However, JMP data for Greenland suggest that 100% of both urban and rural populations have access to improved water and sanitation. While JMP data for Finland also suggest universal improved sanitation access, a response from the Lapland region suggested that about 5% of residents in the urban areas of Inari and Utsjoki lack improved sanitation services. In the northern provinces and

territories of Canada, numbers are similar to the JMP data. Of the areas described in Table 1 in Alaska, none have complete access to improved water and sanitation. Respondents noted that in some cases, lack of access is a choice made by residents rather than an inability to obtain access.

Some community members from very isolated areas reported that few or no households in their community have access to improved water. Many small, isolated communities in Alaska and Greenland have only self-haul systems which provide treated water but no plumbing, and many rely on unimproved bucket toilets as the sole means of waste sanitation. The JMP data from Russia suggest that gaps in water and sanitation service exist, with approximately 9% of rural Russians lacking improved water and 30% lacking improved sanitation. Even urban populations in Russia appear to lack improved water (1%) and sanitation (8%). However, comprehensive surveys of water and sanitation access have not been conducted in the Russian Arctic [14].

Reported water quality and quantity standards varied by geography (Table 2). Respondents described the existence of water quantity standards (the amount of water that is recommended to be provided per capita) in Canada (Northwest Territories, Nunavut, and Yukon), Finland, and Norway. Respondents and contacts from Greenland, Iceland, Russia, Sweden, and Alaska reported no water quantity standards. The water quantity standard ranged from 90 to 200 litres per person per day. Respondents reported that the standard was generally met where applicable.

National wastewater treatment standards were reported to exist for Canada, Finland, Norway, and Alaska. Respondents and contacts reported no wastewater treatment standards in Greenland, Iceland, or Russia. While a national standard exists in Canada, respondents reported that it does not apply north of the 60th parallel where Yukon, Nunavut, and the Northwest Territories are located. In these areas, treatment standards are site-specific and were reported as usually met. Responses from Finland, Norway, Sweden, and Alaska report that treatment standards are usually met (Table 2).

Table 3 shows which water-related infectious diseases (water-borne and water-washed) are reportable to public health authorities according to survey respondents. Diseases that are reportable differ by area, but in most cases water-borne diseases are reported while few water-washed diseases are.

Environmental and climate-related events impacting water and sanitation access were described by survey respondents throughout the Arctic. Decreases in water quantity and quality, damage to water and sanitation infrastructure, maintenance and treatment issues, and

Table 1. Comparison of reported access to water and sanitation services by survey respondents with WHO Joint Monitoring Program (JMP) data, 2016.^a

			Water access		Sanitation access	
			Improved	Unimproved/surface water	Improved/shared	Unimproved
Canada	Survey	Northwest territories	99% ^b	1%	99% ^b	1%
		Nunavut	100%	0%	100%	0%
		Yukon	99% ^b	1%	99% ^b	1%
	JMP	Urban	100%	0%	100%	0%
		Rural	99%	1%	99%	1%
Total		100%	0%	100%	0%	
Finland	Survey	Total	100%	0%	100%	0%
		Lapland	100%	0%	100%	0%
		Inari and Utsjoki	100%	0%	95%	5%
	JMP	Urban	100%	0%	100%	0%
		Rural	100%	0%	100%	0%
Total		100%	0%	100%	0%	
Greenland	Survey	Total	92%	8%	75%	25%
		Urban	99% ^b	1%	95%	5%
		Rural	75%	25%	35%	65%
	JMP	Urban	100%	0%	100%	0%
		Rural	100%	0%	100%	0%
Total		100%	0%	100%	0%	
Iceland	Survey: Total		100%	0%	100%	0%
	JMP	Urban	100%	0%	100%	0%
		Rural	100%	0%	100%	0%
		Total	100%	0%	100%	0%
Norway	Survey: total		100%	0%	100%	0%
	JMP	Urban	100%	0%	100%	0%
		Rural	100%	0%	100%	0%
		Total	100%	0%	100%	0%
Sweden	Survey	Total	100%	0%	100%	0%
		Ålvsbyn	100%	0%	99% ^b	1%
		Lycksele	100%	0%	100%	0%
		Umeå	100%	0%	100%	0%
	JMP	Urban	100%	0%	100%	0%
Rural		100%	0%	100%	0%	
Total		100%	0%	100%	0%	
Russia	JMP	Urban	99%	1%	92%	8%
		Rural	91%	9%	70%	30%
		Total	97%	3%	86%	14%
Alaska	Survey	Kotzebue	90%	10%	95%	5%
		Shishmaref	30%	70%	30%	70%
		North Slope Borough	99%	1%	99% ^b	1%
		Northwest Arctic Borough	89%	11%	89%	11%
		Total (US Census)	96%	4%	– Not available –	
		Urban (AK DEC ^c)	99%	1%	99%	1%
		Rural (AK DEC ^c)	84%	16%	84%	16%
USA	JMP	US Urban	99%	1%	100%	0%
		US Rural	98%	2%	100%	0%
		US Total	99%	1%	100%	0%

^aSurvey responses are approximate and not necessarily comparable.

^bSurvey responses of 99% were specified as approximations, closer to 100%, where respondents wished to indicate a gap of <1%.

^cAlaska Department of Environmental Conservation.

changes in planning due to environmental and climate-related events were reported from Nunavut, Greenland, Norway, Sweden and Alaska. The only respondents from Finland and Iceland reported being unaware of such events impacting water and sanitation in those countries.

The responses related to environmental changes affecting water and sanitation services are shown in Table 4. Respondents described that receding glaciers, reduced snow pack, warmer temperatures, and loss of groundwater aquifers affected source water quantity.

Additional responses indicated that gradual changes in water colour and greater turbidity following stream-bank erosion due to permafrost thaw has affected water quality. Other reported infrastructure damage included permafrost thawing that has led to loss of reservoirs and flooding that raises the risk of sewage lagoon overflow. The high cost of operating and building water and sewage treatment systems in small communities was said to prevent the construction of adequate systems. Other noted water treatment issues included the flooding and infiltration of storm water

Table 2. Water quantity and wastewater quality standards in the Arctic, as reported by survey respondents, 2016.

	Water quantity standard in place?	Standard	Is standard usually met?	Wastewater treatment standard in place?	Is standard usually met?
Canada: Northwest territories	Yes	90 L/person/day (trucked service) 225 L/person/day (piped)	Yes	Yes	Yes ^a
Canada: Nunavut	Yes	90 L/person/day	Yes	Yes	Yes ^a
Canada: Yukon	Yes	Site-specific	Yes	Yes	Yes ^a
Finland: Lapland	Yes	120 L/person/day	Yes	Yes	Yes
Greenland	No	No standard	Not applicable	No	Not applicable
Iceland	No	No standard	Not applicable	No	Not applicable
Norway	Yes	200 L/person/day	Yes	Yes	Yes
Sweden	No	No standard	Not applicable	Yes	Yes
Russia	No	No standard	Not applicable	No	Not applicable
USA: Alaska	No	No standard	Not applicable	Yes	Yes

^aNational Canadian wastewater treatment standards do not apply north of the 60th parallel. In Nunavut, Northwest Territories, and Yukon, standards are site-specific and generally met.

Table 3. Water-related infectious diseases reported to public health authorities in the Arctic, as reported by survey respondents, 2016.

	Canada: Northwest territories	Canada: Nunavut	Canada: Yukon	Greenland	Finland	Iceland	Norway	Russia ^c	Sweden	USA: Alaska
Water-washed diseases ^b	Skin infection hospitalisations (impetigo, furunculosis)									
	Lower respiratory tract hospitalisations in children		X							
	Influenza, all ages	X	X	X		X			X	X
	Influenza, children	X	X	X		X			X	X
	Invasive <i>Streptococcus pneumoniae</i> infections	X	X	X	X	X	X		X	X
	Invasive <i>Staphylococcus aureus</i> infection		X							
	Methicillin-resistant <i>S. aureus</i> infection	X	X	X	X	X	X		X	
Water-borne diseases ^a	Hepatitis A	X	X	X	X	X	X	X	X	X
	Enterohemorrhagic <i>E. coli</i> (EHEC) infection	X	X	X	X	X	X	X	X	X
	Typhoid fever	X	X	X	X	X	X	X	X	X
	Cholera	X	X	X	X		X	X	X	X
	Bacillary dysentery (Shigellosis)	X	X	X	X	X	X	X	X	X
	<i>Campylobacter sp.</i> infection	X	X	X	X	X	X	X	X	X
	<i>Salmonella sp.</i> infection	X	X	X	X	X	X	X	X	X
	<i>Giardia sp.</i> infection	X	X	X	X	X	X	X	X	X
	<i>Legionella pneumophila</i> infection	X	X	X	X	X	X	X	X	X
	<i>Cryptosporidia</i> infection	X	X	X		X	X	X	X	X
	<i>Vibrio</i> species infection		X				X	X	X	X
	<i>Naegleria fowleri</i> (amoeba) infection							X		
	Gastroenteritis hospitalisations		X	X				X		
Norovirus infection		X	X		X		X	X		

^aWater-borne diseases are those that can cause infection by being present in drinking water.

^bWater-washed diseases are those for which personal sanitation practices involving water can interrupt transmission.

^cReportable diseases in Russia vary by region, and are not necessarily reportable nationwide.

into wells and sewage treatment plants – which reduces treatment effectiveness – and the need to replace filters more frequently and use excessive amounts of disinfectants. Respondents noted that infrastructure planning has been affected in several ways, including alteration of water treatment plants to prevent flooding and to treat flood water that infiltrates plants and contaminates treated water. Installations of flexible piping systems are planned, and buried systems

have been replaced with temporary on-site tanks to mitigate the impact of permafrost thaw that causes uneven building settling. Some respondents noted that governments have been hesitant to fund infrastructure projects in communities that might need to be relocated due to rising sea levels or other environmental and climate-related events, and some incomplete projects have remained unfinished due to lack of funding, leaving residents with only unimproved water

and sanitation options. Finally, both survey respondents and experts at the WIHAH conference highlighted research being conducted to identify solutions for communities coping with environmental and climate-related events impacting water and sanitation service.

Discussion

While the data for access to water and sanitation from the JMP are used to track progress towards SDG #6, the situation in many rural Arctic regions is not reflected in the national reports for those nations since large population centres with water and sewer services dominate national statistics. For example, the JMP report for the USA indicates 99% access to improved water and sanitation, but these data cannot be generalised to Alaska. Thus, the SDG indicators for water and sanitation development in Arctic nations should not be applied without appropriate caveats and are best augmented by local data, such as provided in this report. This is particularly important for understanding the situation in remote communities in Alaska, Russia, Greenland, and subarctic Canada.

In some places, a national standard for volume of water per-person per-day has been set, and in these places respondents reported that the standard was usually met. However, according to survey respondents, water quantity can vary considerably throughout the year: late-summer drought or inadequate winter snowpack can reduce water quantity and lead to water rationing, especially in winter months when water stores can be depleted. Respondents indicated that wastewater treatment standards were usually met, where applicable. When standards were not met, action was taken to rectify treatment issues.

Access to an adequate quantity of running water is associated with better health [3,15–20]. This survey indicates that although waterborne diseases are reported to public health authorities in most places throughout the Arctic, few water-washed diseases are. If these diseases are not monitored, the health threats of inadequate access to water of sufficient quantity could go unrecognised and unmeasured.

The mandated reporting of waterborne disease, but not water-washed disease is a decision made by local or public health authorities. One explanation for this might be that the health threats of unsafe water – waterborne infections – are easily eliminated through water treatment, while eliminating water-washed infections requires behaviour change such as hand and body washing in addition to providing sufficient water. Infection by waterborne disease implies flawed treatment, which public authorities are obligated and

prepared to address, while infection by water-washed disease could result from unhygienic practice even with adequate water provision. Governments and public authorities are less capable of inducing behaviour change than they are of enforcing water treatment. However, making water-washed diseases reportable and setting and enforcing national standards for water volume provision might help to mitigate water-washed disease threats.

Unprecedented environmental and climate-related events are threatening water security and access to sanitation in the Arctic in ways that are unique [4]. According to survey respondents, loss of water supply, reduction of water quality and damage to infrastructure add to existing challenges of system maintenance and water treatment, and the high costs of delivering safe water and wastewater service are common in remote Arctic communities. The responses to this survey also indicate that changes in the environment and climate threaten water and sanitation infrastructure in traditionally well-served and developed urban areas like those in Arctic Europe. Respondents from communities near the ocean have reported increased salt content of drinking water from sources drawn close to shore and increased shoreline erosion, which threatens infrastructure that was initially installed a safe distance from shore. Further, respondents indicated that thawing permafrost has caused infrastructure damage and leads to the loss of surface water sources, decreased snowpack has resulted in reduced water supplies, and more intense storms have caused damage and contamination from flooding.

Next steps

The issue of water and sanitation access in the Arctic is a global challenge. The UN Sustainable Development Goals have focused on the less developed, highly populated regions of the world where billions of people still lack basic water or sanitation services. However, since progress on the SDGs are reported at the national level, the apparent high service coverage in the Arctic regions of nations – such as Alaska in the USA, Greenland, and arctic Russia – is most representative of well-served urban areas and does not adequately describe the situation in remote or rural communities lacking water and sanitation services. Fortunately, innovative solutions are being developed throughout the Arctic to deal with these issues, but more could be done to promote development and dissemination of these adaptations. **Box 1** shows measures suggested by WIHAH conference attendees to promote access to and reduce the disparity of water and sanitation services in the Arctic, which were described by

respondents to this survey and presented at the conference. These suggestions do not represent official recommendations of the conference supporters or national government agencies, including CDC. Other suggested next steps are available in the WIHAH conference proceedings [12].

Disclosure statement

No potential conflict of interest was reported by the authors.

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