

Drinking Water Preferences in Hauled Households in Rural Alaska

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ABSTRACT

In unique environments where piped water service is not feasible or available, such as rural Alaska, some communities rely on hauled water services—i.e., water delivered to a tank at each household by truck or all-terrain vehicle. In these systems, unique challenges can arise around end-user perceptions of the safety and reliability of drinking water. For instance, households must consider the limited water volume available to them between deliveries and the possibility of delayed or missed deliveries due to inclement weather or limited workforce capacity. Another challenge related to the system operations is the potential contamination points at hose and tank connections when distributing water, or concerns regarding the water age in the tank and the corresponding water quality. Oftentimes, arising from such challenges, end-users alter their water consumption behaviors, such as seeking additional drinking water sources or altering their water received through methods like point of use filtration. Here, we analyze 30 interviews with hauled system users to explore water consumption behaviors in hauled households, including additional filtration choices, primary and additional drinking water sources, and reasons for making such choices. Results indicate that perceived negative aesthetic properties and safety concerns of unfiltered tap water are often convoluted with individuals perceiving water to have poor smell and taste to be indicators of unsafe drinking

water. As a result, most participants prefer to drink filtered tap water or store-bought water, despite the notable increased costs and labor associated with these choices. Results also show that service disruptions and water volume are not the primary motivators for alternative drinking water sources. Based on these findings, we recommend that hauled service providers invest in community education on drinking water safety and in-home tank maintenance, as well as encouraging in-home filters, such as Brita and Berkey Filters to build public trust and confidence in utility providers.

INTRODUCTION

In municipal water systems across the United States, water treatment plants, operators, and engineers maintain drinking water treatment and distribution infrastructure to deliver clean drinking water to households, or end-users. In the contiguous United States, these systems are typically subterranean piped networks that connect households to central water mains. Due to geographic remoteness (Hickel et al. 2018), restricted supply chains, and the extreme Arctic landscape (e.g., permafrost) (Cozzetto et al. 2013), some municipal service providers that operate in rural Alaska use a hauled water distribution service to deliver essential water service in spite of the substantial contextual challenges. In a hauled water distribution system, a city employee—or, in some cases, the residents themselves—transports water from a water treatment plant to a household via a water truck or all-terrain vehicle (ATV) (Woodlee 1999). The delivered treated water is stored inside a metal or plastic tank at the home for a few days or even up to a month or longer (Seifert 2004). Some municipal service providers will remove wastewater for further storage and treatment, as well.

Studies have shown that Alaskan households in hauled systems typically consume drinking water from a variety of sources in addition to the treated and hauled drinking water (Spearing et al. 2022). For instance, Alaska Native communities, may practice traditional water collection, such as rainwater and ice melting. Similarly, as hauled systems can experience service delays from logistical challenges, scheduling issues, and weather, residents may choose to supplement their access to drinking water from other sources, such as store-bought water, or bottled water. However, there is not a lot of information available regarding end-user experiences in hauled systems, such as drinking water preferences, drinking water behaviors (e.g., additional in-home filtration), and motivations for such preferences. In general, secondary drinking water standards are often based upon end-user experiences and perceptions of safety, such as concerns with taste and smell of the drinking water (U.S. Environmental Protection Agency 2023). However, there has been very little attention to end-user experience in this specific and unique context. This lack of understanding of household drinking water preferences is problematic as it can impact public health and system reliability. For instance, while municipal water utilities must adhere to specific water quality regulations, and ensure that the water is safe for consumption (U.S. Environmental Protection Agency 2023), some households

may not choose not to drink that water likely because they either do not trust that the utility has met water quality regulations, or the household does not trust the water quality regulations. Individuals who do not drink tap water will sometimes choose to drink water from natural sources instead, which can be dangerous if not treated properly (Centers for Disease Control and Prevention 2023), or households might practice extreme water conservation, which can also lead to significant health concerns (Spearing et al. 2022; Thomas, Hickel, and Heavener 2016). Understanding the motivator for this preference could enable the water utility to provide appropriate community education to prevent health concerns. Similarly, end-uses are often utilized as system sensors for the water utility (Tariq et al. 2024). For instance, a household's report to the water utility that they experienced a water service interruption might be the utility's only indicator of an operational issue. If households are choosing not to drink tap water due to service interruptions, this information could be useful for utility decision-makers utility.

To gain a better understanding of how hauled users choose to consume drinking water and why these choices are made, we conducted interviews with residents of hauled water households in a rural Alaska community. Interview questions focused on households' trust of the water utility, consumption and collection practices of drinking water, and motivations for such choices. Then, we performed a qualitative content analysis of 30 household interviews to reveal and summarize drinking water preferences and motivations for such choices. Practical recommendations include community education, which can be adapted for many different communities. Policy recommendations emphasize the value and importance of local perspectives in regulatory decisions.

METHODS AND DATA COLLECTION

We conducted semi-structured interviews with residents of hauled water households in a community in the Yukon-Kuskokwim (YK) Delta of Alaska in July and August 2023. Prior to data collection, the project received approval from the University of Texas at Austin Institutional Review Board (IRB), Carnegie Mellon University IRB, Alaska Area IRB, and the Yukon-Kuskokwim Health Corporation (YKHC) Human Subjects Review Board. Interview participants were recruited through social media posts, flyers, handouts, radio announcements, and word-of-mouth. Interviews were conducted in-person, in participants' homes. Participants were compensated monetarily for their time. The interviews were recorded (with permission), transcribed, and checked for quality (i.e., reviewed for transcription errors).

We selected a subset of 30 interviews for this analysis, all of which were households that received water through the hauled distribution system. Interviews included questions on water affordability, water usage, and system maintenance. In this analysis, we focus on discussions surrounding participants' drinking water preferences. Such questions included "Do you drink the water straight from the tap or have any inline

filtration or use a Brita [or other] filter?”, “For what reasons do you do additional filtering?”, and “Do you collect your own water [from natural source]?”

We performed a qualitative content analysis (cite) to evaluate participants’ drinking water preferences. The coding structure included three main categories: drinking source preference, filtering preference, and motivators, as shown in Table 1. The sub-codes were developed through hybrid inductive-deductive coding process. Inductive coding means that the codes are based on themes predetermined from literature, while deductive coding means that the codes emerged from the analysis. For instance, previous studies have shown that there are three types of drinking sources in this community—natural water, tap water, and store-bought water, and so these codes were produced using inductive coding. The sub-codes on filtering preferences and motivations for drinking emerged in the interview with households, demonstrating a deductive coding process. If a participant indicated that they use any additional filters in their home (in-line or pitcher), that excerpt was assigned to the “filtered” sub-code. Here, a preference refers to the stated behavior. For instance, while someone may prefer to drink bottled water, if they primarily drink tap water, their preference was coded as tap water. The unit of analysis was the participants’ full response to an interview question on the relevant topic, ranging from a phrase to a paragraph. Notably, multiple codes from any category could be assigned to an excerpt if relevant. Two researchers conducted the qualitative coding, and a third researcher verified this work using the coding dictionary in Table 1. The researchers collectively reviewed the coding to resolve any inconsistencies.

Table 1. Starting with the pre-defined categories of water source, filter preference, and motivators, the researchers added and defined sub-codes as they emerged from the interviews.

Categories and Emergent Codes	Definition	Example Excerpt
Drinking Water Source Preference		
Natural Water	Water collected from the natural environment, including packed ice, rainwater, and snowmelt	“We wait till the roof rinses off and use a 32-gallon bucket.”
Tap Water	Water obtained from faucets inside the home	“We only drink water straight out of the tap if it comes from the Brita?”
Store-Bought Water	Water purchased from a store or private service	“For drinking water, we use bottled water”
Drinking Water Filter Preference		
Filtered	Additional filtration mechanisms, including in-line or pitcher filters	“We have a water filtration system ...We used to use [pitcher] filters.”
Unfiltered	No additional filtration measures taken	“No, no other filters or anything like that. We drink the water from the tap”
Stated Motivators for Preferences		
Accessibility	Accessibility and the amount of work required to obtain or filter water	“I change the filter probably once every month. I changed it about three weeks ago, it was black. It's black within a week”

Advice from Others	Impact of other people’s opinions on their preferences	“We were told to not do it. And I don’t remember who told us to. We heard some stories. [...] It’s like one or two people told us, so we don’t drink it.”
Aesthetic Properties	Taste, smell, color, or other appearance of the water	“Very very yellow”
Affordability	Costs associated with obtaining or filtering drinking water	“The pitcher filter was cheaper because I couldn’t afford the [bottled] water.”
Cultural Practices	Indigenous cultural beliefs and practices around water	“Yeah, because my significant other, he grew up with rainwater and is from the village...”
Equipment Maintenance	Impact of water source or filter on the home’s equipment	“Sometimes they would put a filter before the water pump to save life in the water pump. And they put filters before the hot water heater.”
Health Perceptions	A perception that the water is safe or unsafe to consume	“Drinking bad water deteriorates your health. I don’t know, that’s why I got these filters. I hope they’re as good as they say they are.”
Unnecessary	Opinion that other options do not impact the outcome of the drinking water	“You’re going to bring it in and let it melt. [...] Most times it’s okay. We’ll just let it settle and then we use it until it’s near the bottom and dump it.”
Water Volume	Amount of water available for consumption	“I save my water for laundry and dishes.”

RESULTS AND DISCUSSION

The analysis revealed several trends in participants’ preferences for drinking water sources and filtration. Most participants prefer to drink filtered tap water (53%), while others prefer store-bought (bottled) water (27%), as shown in Table 2. Store-bought water can be costly, as one respondent expressed that a five-gallon bottle of drinking water can cost \$40. Five participants drank water from more than one water source (e.g., filtered tap water and store-bought water). No participants indicated that they drink exclusively unfiltered water, and only two participants indicated that they sometimes drink unfiltered water (i.e., water straight from their tap). This preference for filtered water indicates that participants are willing to put forth additional effort to retrieve their preferred drinking water, whether by purchasing from a store, installing in-line filters in their homes, or passing water through a pitcher filter before drinking. Many residents expressed frustration with the frequency with which they must change their filters in the in-line filtration system and the pitcher filters. Some residents expressed that the filters had to be changed once per month to avoid unsightly build-up.

Table 2. Participants indicated their preferences for drinking water source and filtration, with most participants preferring to drink filtered tap water.

Water Source Preferences	Filtered Only	Filtered & Unfiltered
Natural Water Only	1 (3%)	0 (0%)
Tap Water Only	16 (53%)	0 (0%)
Store-Bought Water Only	8 (27%)	0 (0%)
Natural & Tap Water	0 (0%)	1 (3%)
Natural & Store-Bought Water	1 (3%)	0 (0%)
Tap & Store-Bought Water	2 (7%)	1 (3%)

Household water preferences can have various economic and cultural impacts on communities (Fuente et al. 2022). Residents who choose store-bought water incur additional costs, which may be significant in rural Alaska where the cost of goods is very high (Whitney and Robinson 2023). Residents who use additional in-home filters must pay for replacement filters regularly, which can be expensive and logistically challenging in regions with limited supply chains (George 2022). Out of the 30 participants in this study, 12 households purchase water from a store, and 21 households purchase in-home filters. In fact, several households purchase both. This economic burden may be relieved if the households' concerns about the unfiltered tap water could be addressed. If not addressed, residents might eventually decide that the cost burden is more than they can tolerate, and they may relocate away from the region. Other community members might move elsewhere due to other concerns about the water, choosing to live in areas where they feel more comfortable drinking unfiltered tap water. These population changes can have both cultural and economic impacts on the community, especially if those moving away identify as Alaska Native. Out-migration is a growing concern for Indigenous communities, where cultural traditions are not being preserved by younger generations (Driscoll et al. 2010; Martin 2009; Robinson et al. 2020). The local economy can further suffer, as water utilities rely on customer revenues in order to maintain operations (Thomas, Hickel, and Heavener 2016).

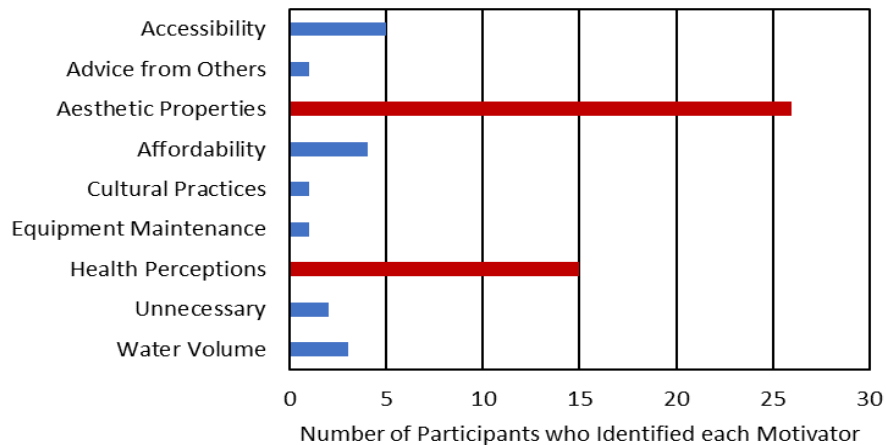


Figure 1. Participants discussed the motivators for their water source and filtering preferences. Note that the total count exceeds 30 because most participants could indicate more than one motivator for their preferences.

Understanding household motivators in selecting drinking water sources or choosing to filter their water can help to better understand how these impacts may be mitigated. The analysis revealed nine motivators regarding drinking water source and filtering preferences, as shown in Figure 1. Across all water sources, most participants indicated concerns about aesthetic properties (26 participants, 87%) or health perceptions (15 participants, 50%). Aesthetic properties describe the sensory attributes of the water, including the taste, color, and smell (Sarkar 2022). The health perception is distinct from aesthetic

properties, describing concerns that the water may be unsafe to drink and lead to health issues. Interestingly, only five or fewer participants discussed each of the other motivators. Because this study uses a small sample size of only 30 interviews, future research should still explore the other motivators, as they range in frequency from 3% to 17% and could vary more if applied to a larger sample size. Table 3 includes a detailed breakdown of the aesthetic and health motivators, with details about the participants' drinking water preferences. For instance, all participants who prefer natural water sources for drinking water (3) indicated concern for the aesthetic and health properties of treated tap water, often citing a "slight yellow tinge" and a "chlorine" taste to the tap water. Of the participants who prefer tap water (20), almost all of them are concerned with aesthetic properties (19), and about half of them are also concerned with health implications (9). The motivators for the households who prefer to drink store-bought water were somewhat more varied, with eight respondents concerned about aesthetic properties and six concerned about health. In fact, some respondents pondered if the hauled water led to streptococcus infections and increased COVID rates in the community.

Table 3. Aesthetic properties and health perceptions emerged as the most common motivators. Some participants indicated a concern for just one issue, and others indicated concern for both. The frequencies vary according to drinking water source preference.

Most Common Motivators	Natural Water (3)		Tap Water (20)		Store-Bought Water (12)		Total (30)	
Aesthetic Only	0	0%	10	50%	4	33%	13	43%
Aesthetic & Health	3	100%	9	45%	4	33%	13	43%
Health Only	0	0%	0	0%	2	17%	2	7%
Total	3	100%	19	95%	10	83%	28	93%

The households' concerns about their drinking water's aesthetic and health properties are especially interesting here because of the mode in which these households receive water. All households in this study receive water through the municipal hauled water distribution system. Water is treated to drinking water standards at a water treatment plant, transported via truck, pumped into a holding tank in their home, then used throughout their cycle for household needs, which could be a few days or up to a month or more in this community. Residents' awareness of their system is likely heightened in these hauled households due to the visual reminders of a water holding tank and regular water truck deliveries. In some homes with plastic tanks, residents can even see inside the tank and observe the aesthetics of their water, mentioning "rusty water" or "white mineral deposits" inside of their water tanks. Such reminders may encourage residents to think more critically about the treatment process, leading them to consider filtration methods. Interestingly, while many of the participants indicated concern about the health impacts of drinking the tap water, the region in which this community is located actually reports higher levels of water wash disease - a result of extreme water conservation - than it does gastrointestinal diseases caused by unsafe drinking water (Hennessy et al. 2008; Thomas, Hickel, and Heavener 2016).

PRACTICAL RECOMMENDATIONS

The findings from this study can inform practical recommendations for community members, utility leaders, and regulators. Specifically, results show that residents often perceive negative aesthetic properties as indicators of health concerns. In turn, residents may turn to more expensive options, such as bottled water, or other options, such as natural drinking water sources. These results show an opportunity for local utilities can educate residents on interpreting water characteristics such as smell, taste, and color, which might change without indicating a health risk. While not directly impacting health, this change could foster trust and acceptance, encouraging community members to drink more water. Furthermore, these results show that improper tank maintenance and infrequent filter changes may contribute to these negative aesthetic properties of tap water. Utility leaders can implement community education initiatives to improve experiences for community members who use the hauled water system. One such initiative might include education on properly cleaning and maintaining home water tanks and ensuring that filters are installed and replaced regularly. Programs could subsidize filtration materials, including in-line and pitcher filters, promoting equitable access to clean, safe, and affordable water in unique contexts. These results showed that water delivery schedules and service interruptions were not common motivators for the consumption of alternative drinking water sources, showing that improvements in logistics may not impact water consumption behavior.

CONCLUSION

In this study, we evaluated the drinking water preferences of residents in a rural Alaska hub community who lived in households on the hauled water system. A qualitative content analysis revealed that most participants prefer to drink filtered tap water or store-bought water over unfiltered tap water, with no participants exclusively drinking unfiltered water. The findings suggest that while participants mention a variety of motivators for these preferences, water aesthetics—such as taste, color, and smell—and health perceptions are the primary motivators driving the drinking water preferences. These drinking water preferences present economic and cultural implications for the community. The financial burden of purchasing bottled water or maintaining in-home filtration systems can strain household budgets, particularly in remote areas with limited access to supplies. To address such challenges, we provide practical recommendations for community members, utility providers, and policymakers. Through targeted community education initiatives, local utility providers can help to improve residents' understanding of the differences between water aesthetic properties and water quality properties that may impact health. They can further provide education on proper maintenance practices of in-home hauled water systems. Programs

could also provide support to communities by subsidizing filtration materials. These strategies could enhance public health outcomes, ensure the sustainability of rural water infrastructure systems, and support the resilience of remote Alaska communities. Future studies may include a similar analysis on a larger set of interviews within this same community or in other unique contexts, such as private or village-hauled systems. They may further explore other considerations, including effective community engagement strategies, costs of operating hauled water systems, costs of living in a hauled household, and policy strategies for improving system operations.

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