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Lack of in-home piped water and reported consumption of sugar-sweetened beverages among adults in rural Alaska

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Abstract

Objective: To assess whether community water service is associated with the frequency of sugar-sweetened beverage (SSB) consumption, obesity, or perceived health status in rural Alaska.

Design: We examined the cross sectional associations between community water access and frequency of SSB consumption, body mass index categories, and perceived health status using data from the 2013 and 2015 Alaska Behavioral Risk Factor Surveillance System (BRFSS). Participants were categorized by zip code to “in-home piped water service” or “no in-home piped water service” based on water utility data. We evaluated the univariable and multivariable (adjusting for age, household income and education) associations between water service and outcomes using log-linear survey-weighted generalized linear models.

Setting: Rural Alaska, USA

Subjects: 887 adults, aged 25 years and older

Results: In unadjusted models, participants without in-home water reported consuming SSBs more often than participants with in-home water (1.46, 95% CI 1.06, 2.00). After adjustment for potential confounders, the effect decreased but remained borderline significant (1.29, 95% CI 1.00, 1.67). Obesity was not significantly associated with water service but self-reported poor health was higher in those communities without in-home water (1.63, 95% CI 1.05-2.54)

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Authorship: EM, SS, AF, KF, LE, PH, TT, MB, and TH conceptualized the study. SS, AF, and KF managed the study data. EM, SS, and PH conducted the analysis and wrote the manuscript. SS, AF, KF, LE, PH, TT, MB, and TH reviewed and contributed to the manuscript.

Conflicts of interest: None

Ethical Standards Disclosure: Not applicable

Conclusions: Not having access to in-home piped water could affect behaviors surrounding SSB consumption and general perception of health in rural Alaska.

Keywords

Sugar-sweetened beverage; water; rural health; Arctic

Introduction:

According to the World Health Organization, 29% of people in the world did not have access to safely managed drinking water in 2015.[1] In low- and middle- income countries, lack of access to improved water sources and sanitation has been associated with infectious disease and poor child growth.[2, 3] Even in the United States, some areas do not have full coverage of in-home piped water. In 2017, at least 15% of occupied housing units in rural Alaska lacked in-home plumbing. [4] The lack of access to piped water service is a particular problem in remote communities that are reachable only by airplane or boat. In these communities, not having piped water has been associated with added risk of numerous infectious diseases, including respiratory hospitalizations in children, skin infections, gastrointestinal infections, and invasive pneumococcal disease.[5-7] In addition to infectious diseases, there may be additional unknown health risks associated with not having access to in-home drinking water. Studies in other regions have found associations between inadequate water supply and stress,[8] musculoskeletal injuries,[9] and gastric cancer risk.[10]

Qualitative research has shown that individuals experiencing water scarcity may conserve water by consuming sugar-sweetened beverages (SSBs).[11] SSBs are defined as any beverage with added caloric sweetener, including regular soda, sweetened juices (eg. Tang® or Kool-Aid®), sweet tea and sports/energy drinks. [12, 13] In the United States, 30.1% of respondents report consuming at least one SSB per day, with the prevalence ranging from under 20% in some states in the northeast to over 40% in the southeast. [14] In several large and repeated studies, frequent consumption of SSBs has been associated with obesity, cardiovascular disease, metabolic disorders, dental decay, and other chronic conditions.[15-18]

In rural Alaska, studies have found that over 50% of adults consume sugar sweetened beverages at least once per week.[19] However, to our knowledge, the association between lack of water access and SSB consumption has not been studied quantitatively. In this analysis of Behavioral Risk Factor Surveillance System (BRFSS) and water utility data, we evaluated whether rural Alaska residents in communities without in-home piped water service reported different frequencies of SSB consumption than residents of communities with in-home service. We also assessed if residents without in-home piped water service had a different prevalence of health outcomes that could be related to SSB consumption, including obesity or self-reported poor health.

Methods:

Study population:

Rural Alaska spans a large geographic area with a population of approximately 240,000 people. Communities are often geographically isolated and can only be reached by boat, airplane, or snowmobile. Food and other supplies can be gathered through subsistence activities (such as hunting) or through air or boat cargo. Larger communities (called “hub towns”) serve as transportation and administrative centers for surrounding smaller communities. For this analysis, data were restricted to those participants who lived in communities that were not externally accessible by the statewide road system or the Alaska Marine Highway ferry system and were not hub towns.

Water access is variable in these remote areas. Some households have piped water from a centralized treated water source while some have piped water from wells. Communities without piped water from either of these sources may have a closed haul system, where water is hauled to and sewage is hauled away from the house. Other communities have a community clean water access point where individuals haul their own water to their house. In these areas, households usually self-haul limited amounts of water in 5-32 gallon containers by hand or with the assistance of a sled, wheelbarrow, or vehicle. Families often supplement this treated water with water from traditional sources such as springs, tundra ponds, and rainwater. [20, 21]

Measures:

We used self-reported SSB consumption and chronic disease measures from the BRFSS, years 2013 and 2015. The BRFSS is a telephone survey that gathers data about the health behaviors of adults across the United States. [22] In Alaska, rural areas are oversampled to enhance the adequacy of sample size for analysis. BRFSS participants are required to be 18 years of age or older. In this analysis, data were restricted to participants aged 25 years or older, because education level was a confounder of interest and this question is only answered by those who are 25 years or older. Answers to the following questions were used as outcomes:[23]

> “During the past 30 days, how often did you drink regular soda or pop that contains sugar? Do not include diet soda or diet pop.”
>
> “During the past 30 days, how often did you drink sugar-sweetened fruit drinks (such as Kool-aid and lemonade), sweet tea, and sports or energy drinks (such as Gatorade and Red Bull)? Do not include 100% fruit juice, diet drinks, or artificially sweetened drinks.”
>
> “Would you say that in general your health is (Options: Excellent, Very good, Good, Fair, Poor)?”

A weekly estimate of the frequency of SSB consumption was calculated according to the BRFSS data usage recommendations.[24] Participants were assigned weight categories (neither overweight nor obese [body mass index (BMI) < 25 kg/m^2], overweight [25≤BMI<30 kg/m^2], or obese [BMI≥30 kg/m^2]) based on BMI calculated from participant-

reported height and weight. Other variables of interest included reported annual household income (<$25,000, $25,000-$49,000, or ≥$50,000), formal education level (less than high school, high school graduate, or some college or higher), race, and age (in years).

We obtained 2016 water service data from the Alaska Infrastructure Programs, United States Environmental Protection Agency. BRFSS participants were categorized by zip code as having water piped to their home if their community had piped water either from centralized water service or from wells. Participants were considered to *not* have piped water if their community had a closed haul system, a washeteria, or other community watering points where individuals bring their own water to their home.[25] Some zip codes included communities with differing water service status ("mixed" zip codes). For example, one zip code could include two small communities, one with in-home piped water service and one without in-home piped water service. In these instances, the zip code was attributed the water status of the community with the larger population.

All data were publically available.

Statistical analysis:

We described participant demographics according to water service status based on their zip code. Reported percentages were survey-weighted according to the BRFSS weighting formula[26] Weights were provided in the BRFSS dataset. Before analyzing the primary question, we developed a causal model to determine the minimum number of potential confounders in the relationship between residence in a community with piped water and SSB consumption. We used a survey-weighted log-linear generalized linear model (GLM) to compare the frequency of reported SSB consumption between participants in zip codes with and without in-home piped water service. After assessing the univariable associations, we controlled for annual household income, formal education level, American Indian/Alaska Native race, and age. For the binary outcomes of obesity and fair/poor health, we used a survey-weighted log binomial GLM. After assessing univariable associations, we also controlled for age, sex, race, and income in the obesity analysis, and age, race, and income in the self-reported poor health analysis. Model outputs are expressed as exponentiated (exp) β, which we called a frequency ratio. A frequency ratio can be interpreted as the percent higher or lower that one group reported drinking SSBs per week compared to another group. Using α=0.05, ratios were considered to be significant if the 95% confidence interval did not include 1. We conducted a sensitivity analysis by removing participants with mixed zip codes to identify whether these participants affected the model results. Data were analyzed using SUDAAN (RTI International, NC).

Results:

After excluding urban areas, hub communities, and communities on the statewide road or marine highway system, 887 rural Alaskans over age 25 years participated in the 2013 and 2015 BRFSS. Slightly more participants were female (430, 52%) and the mean age was 48 years. Of these participants, 733 (83%) lived in 102 zip codes with piped water and 154 (17%) lived in 28 zip codes without piped water. Among participants with in-home piped water, 43% reported completing some college or higher and 39% reported household annual

income of over $50,000 (Table 1). Among participants without in-home piped water, 27% reported completing some college or higher and 22% reported household annual income of over $50,000 (Table 1).

Overall, 37% of participants reported drinking SSBs at least once per day, and participants reported drinking SSBs a mean of 8.5 times per week. Participants in communities with in-home piped water reported a mean SSB consumption frequency of 7.8 times per week while participants in communities without in-home piped water reported a mean frequency of 12.5 times per week. Overall, those who reported higher frequency of SSB consumption were younger, had lower household income, and lower formal education (Table 2).

In the unadjusted model, respondents who lived in a community without in-home piped water reported consuming SSBs 46% more often than those who lived in a community with in-home piped water (unadjusted exp β 1.46, 95% CI 1.29, 1.67, p=0.02). After adjustment for age, income, and education, the size of the effect decreased (adjusted exp β 1.29, 95% CI 1.00, 1.67, p=0.05; Table 3).

In an unadjusted overall model, residence in a community without in-home piped water was not associated with obesity (adjusted exp β 1.22, 95% CI 0.81, 1.83, p=0.36; Table 3). This did not change after adjustment for confounders. In unadjusted and adjusted models, participants in communities without in-home piped water were significantly more likely to report fair/poor general health (adjusted exp β 1.63, 95% CI 1.05, 2.54, p=0.04).

Three zip codes with 31 participants were considered to have “mixed” service. All three were coded as having in-home piped water based on the criteria listed above, but included some participants in communities with washeterias or watering points. In sensitivity analyses where we removed these zip codes, no meaningful changes were observed in the models described above (data not shown).

Discussion:

Within the United States, rural Alaskans have the lowest access to in-home piped water service and experience a concordantly high burden of infectious disease.[6] However, the burden of infectious disease might not capture the full picture of the outcomes of lack of water access within rural Alaska or elsewhere. We evaluated whether a lack of water service in rural Alaska was also associated with frequency of SSB consumption and other chronic disease outcomes. We found that rural Alaskans who lived in communities without in-home piped water may consume SSBs more frequently than those who lived in communities with in-home piped water service. Our findings contribute to the growing literature on the non-infectious disease risk factors associated with inadequate access to reliable, clean, water within the home[8,9,27]

The linkage between lack of in-home water service and infectious disease risk in Alaska has been well described.[28] However, the relationship between in-home water service and SSB consumption is not well documented. There are several potential reasons that residents of communities without in-home piped water service might drink SSBs more often than those in communities with in-home piped water. Self-hauling water is time-consuming, and the

amount brought into the home is often directly related to a household's access to a vehicle and the presence of an able-bodied male household member.[29, 30] If water is not easily accessible, people may decrease their water consumption and increase their consumption of other beverages. Recently a quasi-experimental study in schools in New York City showed that providing accessible water jet dispensers led to decreases in student BMI, ostensibly due to the consumption of water rather than other beverages.[31] However, more research is necessary to evaluate the precise reasons that residents of communities without in-home piped water service consumed SSBs more frequently than those in communities with in-home piped water.

In this analysis, frequency of SSB consumption was associated with age, household income, and education level. Other studies of SSBs have found similar patterns, demonstrating that younger people, men, those with lower income, and those with less formal educational attainment are likely to drink SSBs more frequently.[14, 32, 33] In rural Alaska, several factors could also influence the choice to drink SSBs, regardless of water accessibility. For example, prior studies have shown that some residents in these communities distrust the safety of treated water and/or are not satisfied with its quality (including color and taste).[20, 21] Across the United States, trust of water sources has been shown to impact behavior around water consumption, especially among minorities [34-36]. Therefore, rural residents might perceive that consuming beverages from bottles or cans is safer than consuming tap water. The use of sugar-sweetened mixes such as Tang ® could offer a more palatable way to consume treated water. Further, SSBs may be cheaper than bottled water in these communities, possibly contributing to higher consumption.

Not having in-home piped water service was not significantly associated with obesity in this analysis. Although the association between drinking SSBs and obesity has been well-described in other contexts,[15] there could be aspects of living in communities without piped water that are protective against weight gain. For example, in Yupik communities, hauling water is conducted primarily by men and boys and could serve as a form of physical activity.[20] Communities without piped water could also differ from those with piped water by other activities related to exercise and diet, such as the types and frequencies of hunting or other physically-demanding subsistence activities. Unfortunately we were not able to assess these other factors in the current analysis. Further research on obesity in communities without piped water is warranted.

Living in a community without in-home water was associated with a higher proportion of respondents reporting fair or poor general health in this analysis. This association could reflect that residents experienced a variety of poor health outcomes associated with lack of water access, including infectious diseases.

This analysis has a few limitations. First, these data sources are cross sectional, which affects the interpretability of temporal associations. Second, there may be some misclassification of water service exposure on the individual level. For example, in communities that have a piped water system, some households might still use point water sources. Therefore, the exposure in this analysis only represents a community-wide exposure to water service infrastructure. Additionally, the BRFSS data are self-reported, so responses

are subject to inaccuracies. For example, self-reported height and weight often result in an underestimate of obesity.[37] However, we would not expect this underestimate to be differential between communities with and without piped water. Furthermore, the BRFSS requests information on the frequency of SSB consumption, but does not include an estimate of volume. Similarly, sugar-sweetened coffee drinks are not included in the measure. These issues could lead to a misrepresentation of the amount of SSBs consumed, although we also do not expect this to be differential between communities. Additionally, although rural Alaska was oversampled in the BRFSS, the number of participants who were classified as living in a community without piped water was small. The small sample size likely resulted in insufficient power to detect some significant differences, and possibly the borderline significance in the overall result.

Confounding is an important consideration illuminated by this analysis. Respondents from communities with and without piped water were markedly different according to their reported demographics. Furthermore, the changes to the effect estimates after adjustment demonstrated that confounding by socio-economic status, age, and race existed in the association between piped water and drinking SSBs. There may be residual confounding or additional confounding by other factors that were not measured. Accordingly, the associations seen here warrant further investigation in other datasets and prospective analyses.

Conclusions

Recent studies have shown that disparities exist across the United States in terms of clean tap water access and consumption.[38, 39] Our analysis suggests that residents who lived in communities without in-home piped water may drink SSBs more frequently than those who lived in communities with in-home piped water. Although lacking piped water was not significantly associated with obesity in this analysis, a higher frequency of SSB consumption could lead to a number of other chronic disease outcomes and may have contributed to the association between lack of water and reported poor health. Access to in-home clean water is a key component to maintain optimal health in rural Alaska.

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Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry. Use of trade names is for identification only and does not imply endorsement by the Public Health Service or by the U.S. Department of Health and Human Services.

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Table 1:

Characteristics of adult participants by in-home piped water access, rural Alaska [b], 2013 and 2015

	Residence in zip code with			
	Piped water		No piped water	
Characteristic	**Sample N**	**Survey-weighted % (95% CI)**	**Sample N**	**Survey-weighted % (95% CI)**
Sex				
Male	355	62% (57%-67%)	75	53% (41%-64%)
Female	378	38% (33%-43%)	79	47% (36%-59%)
Age (years)				
25-34	113	20% (16%-25%)	37	44% (32%-56%)
35-49	213	31% (27%-37%)	41	18% (12%-26%)
50-64	278	36% (30%-41%)	46	21% (14%-30%)
65+	129	13% (10%-16%)	30	17% (11%-27%)
American Indian/Alaska Native				
Yes	442	52% (47%-58%)	125	74% (59%-85%)
No	291	48% (42%-53%)	29	26% (15%-41%)
Education				
Less than high school	82	18% (13%-23%)	34	31% (22%-43%)
High school graduate or GED	300	39% (34%-45%)	65	42% (31%-54%)
Some college or higher	345	43% (38%-49%)	55	27% (18%-38%)
Household Income				
<$25,000	260	33% (29%-39%)	67	52% (40%-64%)
$25,000-$49,999	160	28% (23%-33%)	35	26% (17%-37%)
≥$50,000	257	39% (33%-44%)	31	22% (13%-35%)
Self-reported health				
Excellent	104	14% (10%-18%)	20	10% (6%-16%)
Very good	200	27% (22%-31%)	30	23% (14%-36%)
Good	288	41% (36%-47%)	61	39% (28%-52%)
Fair or poor	138	18% (14%-22%)	42	27% (19%-28%)
Overweight or Obese	504	73% (68%-78%)	90	66% (54%-76%)
Obese	231	51% (44%-58%)	43	47% (33%-61%)
≥1 SSB[a] per day	214	34% (28%-39%)	67	55% (43%-66%)
Total	733	83% (79%-86%)	154	17% (13%-21%)

[a] SSB= Sugar-sweetened beverage

[b] Data were restricted to those participants who lived in communities that were not externally accessible by the statewide road system or the Alaska Marine Highway ferry system and were not hub towns.

Sum of data may not equal total due to missing values.

Table 2:

Characteristics of adult participants by sugar-sweetened beverage consumption, rural Alaska[a], 2013 and 2015

	<1 Sugar-sweetened beverage/day		≥1 Sugar-sweetened beverage/day	
Characteristic	**Sample N**	**Survey-weighted % (95% CI)**	**Sample N**	**Survey-weighted % (95% CI)**
Sex				
Male	287	60% (54%-65%)	143	63% (54%-70%)
Female	319	40% (35%-46%)	138	37% (30%-46%)
Age (years)				
25-34	81	19% (15%-25%)	69	32% (25%-41%)
35-49	161	27% (23%-33%)	93	32% (25%-40%)
50-64	234	36% (30%-41%)	90	29% (21%-38%)
65+	130	18% (14%-22%)	29	7% (4%-11%)
American Indian/Alaska Native				
Yes	336	47% (41%-52%)	231	72% (62%-80%)
No	270	53% (48%-59%)	50	28% (20%-38%)
Formal education				
Less than high school	73	17% (13%-23%)	43	24% (17%-33%)
High school graduate or GED	213	34% (29%-40%)	152	49% (40%-57%)
Some college or higher	315	49% (43%-54%)	85	27% (20%-35%)
Household Income				
<$25,000	197	30% (25%-36%)	130	46% (37%-55%)
$25,000-$49,999	133	29% (23%-35%)	62	25% (18%-33%)
≥$50,000	222	41% (35%-47%)	66	29% (21%-39%)
Self-reported health				
Excellent	86	13% (7%-17%)	38	13% (9%-20%)
Very good	167	30% (25%-36%)	63	20% (14%-27%)
Good	229	39% (33%-45%)	120	45% (36%-54%)
Fair or poor	120	18% (14%-23%)	60	22% (16%-30%)
Overweight or obese	409	73% (67%-78%)	185	71% (63%-78%)
Obese	183	50% (42%-58%)	91	51% (41%-61%)
Total	606	63% (58%-68%)	281	37% (32%-42%)

[a]Data were restricted to those participants who lived in communities that were not externally accessible by the statewide road system or the Alaska Marine Highway ferry system and were not hub towns.

Sum of data may not equal total due to missing values.

Table 3:

Generalized linear models of health outcomes and piped water service, rural Alaska[b], 2013 and 2015

Characteristic	Unadjusted ratio (95% CI)	Adjusted ratio (95% CI)
SSB frequency[a]	**(n[c]=783)**	**(n[c]=719)**
No piped water	1.46 (1.06-2.00)	1.29 (1.00-1.67)
Age group (years)		
25-34		Ref
35-49		0.82 (0.58-1.15)
50-64		0.80 (0.46-1.39)
65+		0.37 (0.21-0.63)
Annual household income level		
<$25,000		Ref
$25,000-$49,999		0.75 (0.52-1.09)
≥$50,000		0.80 (0.44-1.43)
Formal education level		
Less than high school		Ref
High school graduate or GED		0.76 (0.41-1.42)
Some college or higher		0.63 (0.24-1.65)
American Indian/Alaska Native		1.62 (1.05-2.50)
Obesity	**(n[c]=846)**	**(n[c]=784)**
No piped water	1.08 (0.73-1.61)	1.22 (0.81-1.83)
Age group (years)		
25-34		Ref
35-49		1.60 (0.97-2.65)
50-64		1.49 (0.89-2.50)
65+		1.50 (0.86-2.61)
Female		1.25 (0.92-1.69)
Annual household income level		
<$25,000		Ref
$25,000-$49,999		0.76 (0.48-1.20)
≥$50,000		1.13 (0.72-1.78)
American Indian/Alaska Native		1.04 (0.68-1.57)
Fair/poor health	**(n[c]=883)**	**(n[c]=807)**
No piped water	1.50 (0.98-2.30)	1.63 (1.05-2.54)
Age group (years)		
25-34		Ref
35-49		2.96 (1.34-6.54)
50-64		4.55 (2.20-9.43)
65+		3.96 (1.82-8.61)
Annual household income level		
<$25,000		Ref

Characteristic	Unadjusted ratio (95% CI)	Adjusted ratio (95% CI)
SSB frequency[a]	(n[c]=783)	(n[c]=719)
$25,000-$49,999		0.58 (0.36-0.92)
≥$50,000		0.22 (0.12-0.39)
American Indian/Alaska Native		0.90 (0.54-1.50)

[a] SSB= Sugar-sweetened beverage

[b] Data were restricted to those participants who lived in communities that were not externally accessible by the statewide road system or the Alaska Marine Highway ferry system and were not hub towns

[c] Unweighted model sample size used in analysis.