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"It’s Just Another Thing”: Perceptions of Well Water Quality and Barriers in an Arsenic Hot Spot

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ABSTRACT

Privately owned water is the primary source of drinking water for 43 million Americans. Although residential or private wells are susceptible to a variety of contaminants, the Safe Drinking Water Act of 1974 positions individuals as responsible for the testing, remediation, and management of this water. Despite the elevated presence of arsenic in Maine, which is linked to various cancers, cardiovascular disease, and neurological damage, little is known about how private well owners perceive the safety and quality of their own water. This study takes a qualitative approach to understanding concerns and opinions by conducting semi-structured interviews with private well users in the Blue Hill Peninsula, a known arsenic hot spot in Hancock County. We examined water testing and remediation behaviors, contamination concerns, opinions on government intervention, and well owners' barriers to accessing clean drinking water. Results show that health concerns, new home ownership, and fear of ongoing contamination motivate water testing. Perceptions of water safety are largely motivated by sense of place and social-cognitive factors. The largest barrier to accessing clean water is cost, but those who never tested previously are more likely to mention personal barriers, such as lack of time or capacity to test their water. The biggest sources of arsenic awareness include social networks, rather than government campaigns or media outlets. Participants overwhelmingly support greater government intervention. Ensuring clean drinking water, even within private wells, is widely regarded as a collective responsibility.

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INTRODUCTION

The right to clean drinking water and sanitation was recognized as a universal human right by the United Nations General Assembly in 2010, but it is still far from guaranteed (UNGA, 2010). Even in the 21st century, clean and safe drinking water is inaccessible to more than 60 million Americans (Rosinger, 2021). In addition, awareness of heavy metals and chemicals lurking in water and pipes has skyrocketed since the 2014 lead crisis in Flint, Michigan rocked the nation (Maher, 2021). Following a switch to the Flint River for water for cost-savings, the corrosive water eroded pipes, revealing lead and releasing it into hundreds of homes in Flint (Denchak, 2018). Government officials at the town, state, and federal level disputed and downplayed residents' concerns and health effects, such as skin lesions and neurological issues, for months, igniting citizen activists and captivating viewers nationwide (Denchak, 2018). Many scientists and physicians raised concerns regarding these health reports, which sparked subsequent studies. Researchers from the Flint Hurley Medical Center analyzed blood lead levels taken from 736 Flint children under five years old in 2013 before the water change and among 737 children in 2015, the period following the change in water supply. They found that the incidence of elevated blood lead levels of children living in the affected communities nearly doubled after the change in the water source (Hanna-Attisha et al., 2016). Aside from the individual families and community members in Flint, the outcome and the publicization of the water crisis had impacts far beyond the city.

A 2018 study from Pennsylvania State University found that an avoidance of tap water increased by 40% nationwide in the few years following the Flint disaster (Maher, 2021). The case of federal and state regulatory failures sparked activists, community leaders, researchers, and elected officials across the nation to sound the alarm on their own water systems— and uncover countless other "Flints" from New York to West Virginia (Maher, 2021). The common threads between these communities often include failed government oversight and remediation when legal mandates had required it. But what about the water that is not regulated at all?

43 million Americans— comprising 15% of the nation's population—rely on private or residential wells every day for drinking, cooking, and bathing (U.S. Geological

Survey, 2019). Their water, however, is entirely unregulated by federal bodies and even state officials in most cases. For these communities, found in every region of the country, water safety and opportunities for recourse following contamination take on a whole new meaning.

Drinking Water in America

While millions of Americans have avoided their tap water in recent years, many do not even have that option. Approximately two million Americans still live without access to running water, indoor plumbing, or wastewater services at the present day. This is part of a worldwide problem (U.S. Water Alliance, 2020). According to the latest study of drinking water access conducted by the World Health Organization and the United Nations Children's Fund, more than 785 million people did not have access to at least basic water services and more than 884 million people did not have safe water to drink in 2017 (U.S. CDC, 2021). Basic water services are defined as water that is supplied through an "improved water source", such as a household connection, a protected wells and springs, and rainwater collection, and can be collected within a 30-minute timeframe.

In recent years, the stark inequalities related to sanitation in the present day United States have been gaining more traction within the general public. Catherine Coleman Flowers is the founder of the Center for Rural Enterprise and Environmental Justice and a prominent voice for domestic water safety. In 2020, she released her debut book W*aste: One Woman's Fight Against America's Dirty Secret* that exposes, for the first time, the prevalence of failing septic tanks and tainted drinking water in Lowndes County, Alabama (Noble, 2021).

Drinking Water Regulations

To address water contamination issues, Congress passed the Safe Drinking Water Act (SDWA) in 1974. The SDWA authorized the Environmental Protection Agency (U.S. EPA, n.d.) to set maximum standards for specific contaminants that reflect allowable "safe" limits in regulated public water sources. These are referred to as Maximum Contaminant Levels (MCLs), which are legally enforceable standards for various contaminants (such as lead and arsenic) and National Secondary Drinking Water Regulations (NSDWRs) that are non-enforceable guidelines for contaminants (such as iron and chloride) that may cause cosmetic effects, including skin or tooth discoloration, or aesthetic effects, such as taste, odor, or color, in water (U.S. EPA, n.d.). These secondary standards are recommended to water systems but not legally enforced by the U.S. EPA. Hence, public water providers are required to comply with NPDWRs. Under the SDWA, individual states do have the authority to tighten but not loosen NPDWRs and may also choose to legally enforce NSDWRs (U.S. EPA, n.d.) .

Although robust federal regulations for public water have been established under the SDWA, enforcement is still lagging. Given that there are approximately 50,000 regulated drinking water systems nationwide, referred to as Community Water Systems (CWSs), lack of compliance in public water systems is a serious issue (U.S. EPA, 2021). In 2018, the U.S. EPA found that 40% of the nation's CWSs violated at least one drinking water standard under the SDWA (U.S. EPA, 2021). More than 30% of CWSs also violated monitoring and reporting requirements (U.S. EPA, 2021). The lead levels in Newark, New Jersey, for instance, measure 57 parts per billion, nearly four times the federal action level triggering corrective measures. Newark has exceeded the federal action level for over two years (NRDC, n.d.). Enforcing proper oversight and corrective measures is often time-consuming, requires citizen suits (when private citizens bring upon lawsuits to enforce statutes), and puts countless households in jeopardy, left to consume water that exceeds MCLs— sometimes without any public awareness.

Yet, government oversight and legal recourse if water contamination occurs are unavailable to the 13 million households that use private well water (U.S. EPA, n.d.). Private well water was excluded from the SDWA, meaning it is not regulated at the federal level or by most states. This lack of regulation has contributed to widespread health issues. For example, in North Carolina, one study found that between 2007 and 2013, 99% of emergency department visits for acute gastrointestinal illness caused by contaminated drinking water were associated with private wells (DeFelice et al., 2016). Additionally, a 2013 survey of nearly 4,000 private wells in rural Wisconsin revealed that 47% exceeded at least one federal MCL (Knobeloch et al., 2013). The issue of excess contaminants in well water is highly documented in Maine, the state with the greatest proportion of well users in the country (Johnson et al., 2019).

Drinking Water in Maine

While over 51% of Maine residents rely on private wells for drinking water and daily functions, it is estimated that 10% to 15% of the state's wells exceed the federal MCL for arsenic (Maine CDC, 2016; Collins, 2020). This puts roughly 100,000 of Maine's 1.3 million residents at risk (Collins, 2020).

Maine Tracking Network (MTN) compiles information on a wide range of public health concerns, such as asthma rates, cancer cases, and well water contamination, among many other measures. MTN data includes water quality test results from more than 51,347 private wells in 340 towns. Water quality samples included in the database were analyzed at the state of Maine Health and Environmental Testing Laboratory (HETL) from the years 1999 to 2013 (MTN, 2017). At the county level, the greatest percentage of wells that test above the federal limit of arsenic for public water, 10 parts per billion (ppb), are found in Kennebec (27.9%), York (22.6%), and Hancock (21.4%) counties (MTN, 2021). The counties with the lowest rates of excess arsenic in well water include Oxford (4.9%), Lincoln (4.4%), and Aroostook (3.5%) counties (MTN, 2021).

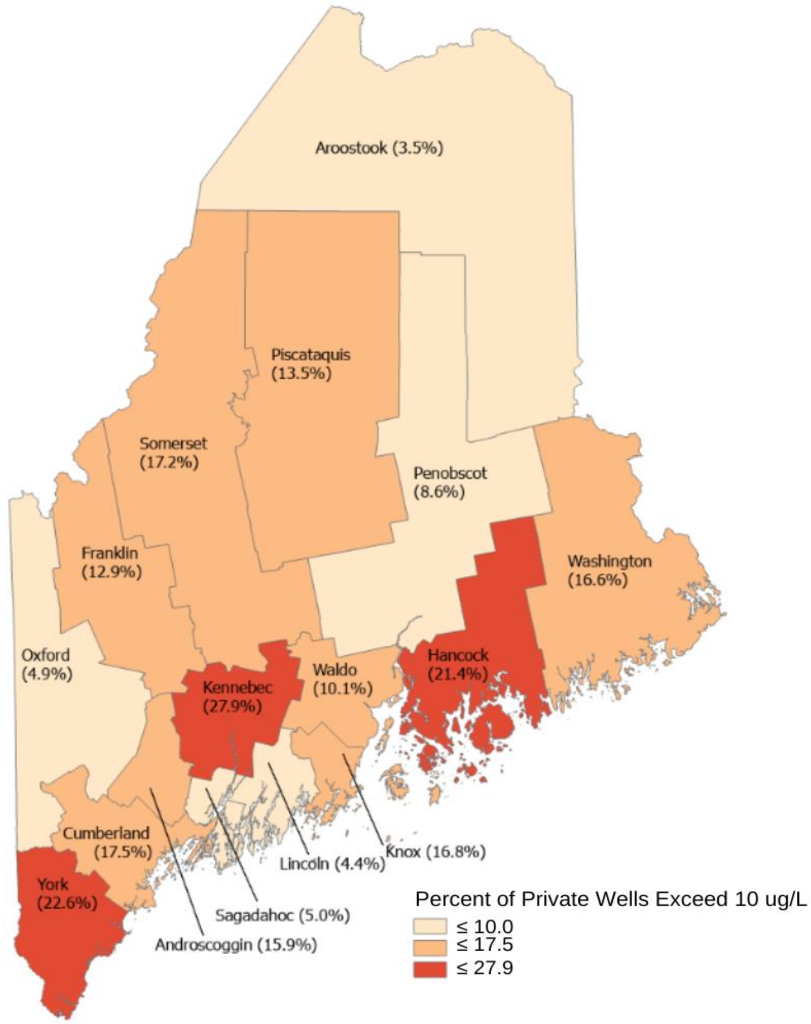

Figure 1. Percent of private wells per Maine county that exceed MCL for arsenic. The state of Maine Health and Environmental Testing Laboratory provided these data. Dana contains water test results from 51,347 private wells tested by the state of Maine Health and Environmental Testing Laboratory between the years 1999 and 2013.

According to the most recent data on well testing from 2017, 53.2% of all wells in the state have been tested for arsenic (MTN, 2017). The highest testing rate is found in Kennebec County, where approximately 64.8% of well owners have tested and 55.5% of the county uses private wells. Oxford County, in contrast, has the lowest testing average, with roughly 40% of well owners reporting having tested their water, despite 54.7% of the county's residents relying on them.

Arsenic Background

Naturally occurring in the Earth's crust, arsenic is the 20th most abundant element. It is a metalloid that is widely dispersed all over the planet (Dartmouth Toxic Metals, n.d.). As an element, arsenic cannot be broken down in the environment but is able to combine with other elements and form new compounds readily. Since elemental arsenic is not soluble in water, it is very rare ("Arsenic - an Overview", n.d.). As such, there are two classifications of arsenic: organic and inorganic. This paper is focused on inorganic arsenic because arsenic, in this form, is known to be more toxic relative to organic arsenic and is the dominant form of in drinking water (Schwarcz, 2018).

While organic arsenic has more complicated structures and is bonded with carbon, it is considered harmless. It is naturally found in a variety of foods and beverages, such as meats, grains, and fruit juices ("Arsenic - an Overview", n.d.). Additionally, crustaceans and other fish are other known sources of organic arsenic. However, organic arsenic has not been shown to pose health risks (Kuivenhoven & Mason, 2021). In contrast, inorganic arsenic's simpler structures, such as arsenic trioxide, are responsible for the numerous poisons and insecticides that have been used widely throughout history. For these reasons, inorganic arsenic has been dubbed "the king of poisons" and "poison of kings" (Gupta et al., 2017). Inorganic arsenic, which is most commonly found in groundwater, exists in two ionic forms: arsenite (III) and arsenate (V) ((Kuivenhoven & Mason, 2021). Knowing the number of valence electrons and the form of arsenic are necessary to properly assess health risks and toxicity (Kuivenhoven & Mason, 2021).

To prevent this confusion, laboratory test results that report on arsenic, which some of our study participants submitted for this paper, either distinguish between inorganic or organic arsenic in the report or only submit data on inorganic arsenic levels, which are pertinent to public health and regulated by the federal government in food products and drinking water. Henceforth, throughout this paper, unless otherwise noted, "arsenic" will refer to the inorganic form. "Elevated" or "high" levels will also refer to levels of arsenic above 10 ppb. In order to regulate arsenic, it is critical to understand the most common means of exposure.

Arsenic Exposure Mechanisms

The greatest mechanism of exposure to toxic arsenic is through digestion, not through inhalation or dermal contact. Dermal penetration through the skin has not been shown to pose imminent health risks due to poor absorption by the integumentary system. If in contact with known arsenic contaminants, such as exposure to arsenic-based pesticides or chemicals, research has shown that simply washing the area with soap and water is adequate in order to mitigate dermal exposure (Kuivenhoven & Mason, 2021). Additionally, a 2016 study by the Maine CDC and the U.S. CDC found that showering and taking a bath in well water high in arsenic were not significant arsenic exposure sources for children and adults, even in households with arsenic levels as high as 640 µg/L (Smith et al., 2016). Exposure to arsenic in groundwater, however, is a growing health concern—and the two types of inorganic arsenic do not behave equally.

While both forms of inorganic arsenic are common in groundwater, arsenite, composed of three valence electrons, is considered more toxic than arsenate. Scientists have hypothesized that this is due to arsenite's slower excretion rate in the body compared to both arsenate and organic arsenic (Kuivenhoven & Mason, 2021). Once inside the body through the digestive tract, excretion occurs in the renal system. Inorganic arsenic is eliminated slowly from the renal system with only an estimated 30% eliminated within the first week, and differing rates based on the number of valence electrons (Kuivenhoven & Mason, 2021). Arsenite compounds are also 5-10 times more toxic than arsenates due to higher solubility ("Arsenites", 2018). This may account for why, in addition to its greater toxicity, arsenite is also harder to remove from drinking water than arsenate. In cases of known elevated arsenite levels, filters frequently use oxidizers to convert trivalent arsenic compounds into the pentavalent form (Pure Water Gazette, n.d.).

Global and National Exposure

The problem of excess arsenic in drinking water impacts dozens of nations around the globe, such as Argentina, Bangladesh, Chile, China, Hungary, India, Mexico, Nepal, and Taiwan, in addition to the U.S (WHO, 2018; Bagchi, 2007). The World Health Organization (WHO) reported that at least 140 million people from 50 countries are exposed to high levels of arsenic (above 10 µg/L) through groundwater, most of whom live in India and Bangladesh (WHO, 2018). Bangladesh is perhaps the most prominent arsenic hot spot in the globe (Caldwell et al., 2006; Ahmad et al., 2018; Smith et al., 2000), where 55 million people in the country are estimated to be at risk of unsafe arsenic exposure (Ahmad et al., 2018). The heightened levels of the contaminant were first discovered in 1993 in tubewell water, the common source of drinking water in rural areas of the country (Ahmad et al., 2018).

In the U.S., elevated concentrations of arsenic have also been identified in the bedrock of several states, such as areas of New Hampshire, Maine, Michigan, and some Southwestern states. A 2017 study by the U.S. CDC and the U.S. Geological Survey (USGS) found that as many as 2.1 million wells across the country may be contaminated with arsenic levels above 10 ppb (Ayotte et al., 2017). Maine, as the focus of this paper, has been identified as part of eastern New England's "arsenic belt" where elevated levels of the contaminant have been observed in groundwater (Ayotte et al., 2017).

Health Risks

According to the U.S. CDC, arsenic contamination alone contributes to approximately 1,000 deaths and $9.7 billion dollars in economic impacts each year nationwide ("CDC's Safe Water Program", n.d.). There are a range of illnesses and conditions related to the chemical which will be discussed following two distinct types of exposure: acute and chronic. Acute exposure refers to incurring a single dose that is large enough to cause an immediate effect, while ingesting a smaller amount of a contaminant over a long period of time that inflicts gradual or delayed effects is called a chronic exposure (ATSDR, n.d.) Chronic exposure is far more common in cases of arsenic exposure in drinking water, but acute incidents do occur from other causes.

Acute Exposure

Acute exposure occurs when high concentrations are consumed in a short period of time, typically the result of intentional or accidental poisoning. This is associated with nausea, vomiting, abdominal pain, and severe diarrhea. Acute exposure is also associated with encephalopathy (Ratnaike, 2003), or damage to the brain that can lead to confusion or behavior changes (Malmo, 2021), and peripheral neuropathy, which is characterized by weakness, pain, and numbness of the hands and feet caused by damage to nerves outside of the brain and spinal cord (Mayo Clinic, n.d.). Death can also occur in extreme cases, as was shown in the popular 1941 play and subsequent film, *Arsenic and Old Lace*, in which two elderly women spike their male suitors' wine (Ratnaike, 2003).

Chronic Arsenicosis

Arsenic can inactivate up to 200 enzymes in the body, especially those involved in cellular energy pathways and DNA synthesis and repair, making it extremely harmful over time (Ahmad, 2018). Chronic exposure, hence, is associated with multisystem disease, including skin lesions, cardiovascular disease, diabetes, and blackfoot disease, along with other conditions.

Chronic arsenic exposure to elevated arsenic levels causes a condition referred to as "arsenicosis" (Ahmad et al., 2018). WHO defines this as a "chronic condition arising from a prolonged ingestion of arsenic above safe dose for at least 6 months, usually manifested by characteristic skin lesions of melanosis and/or keratosis with or without involvement of internal organs" (Ahmad et al., 2018). Skin lesions including melanosis (spotted or rain drop shaped pigmentation), keratosis (rough, dry, and spotted nodules), and leucomelanosis (white or "depigmented" and black or "pigmented" spots) are the prominent physical manifestations of arsenicosis (Saha et al., n.d.). Leucomelanosis is typically considered the later or "advanced" form of arsenicosis (Saha et al., n.d.).

In Bangladesh, these dermatological features are the most common manifestations of arsenicosis, and are most frequent among arsenic-exposed populations with poor socio-economic conditions. Poor nutrition also influences the rate of arsenicosis; individuals consuming less protein are found to be more vulnerable to arsenic toxicity in Bangladesh (Ahmad et al., 2018). In India, over 1.5 million people have been exposed to high levels of arsenic and there have been more than 200,000 reported cases of arsenicosis (Tyler & Allan, 2014).

Blackfoot Disease

Similar to arsenicosis, another ailment associated with chronic exposure that affects physical features is blackfoot disease. This is a unique peripheral vascular disease, causing gangrene of the foot, and thus a black or mummified appearance in severe cases ("Blackfoot Disease", 2015; Ratnaike, 2003). Coldness and numbness in the feet are often the first symptoms, with often sudden onset. Its cases have mainly been restricted to some areas of the southwestern coast of Taiwan where residents consume artesian well water with high levels of arsenic (Ratnaike, 2003).

The peak incidence of the disease was between 1956 and 1960, with prevalence rates as high as 18.85 cases per 1,000 people in different villages (Tseng, 2005). It is highly lethal, with a fatality rate of 66.5% over the course of a 30 year study (Tseng, 1989). After 10 years of onset, the survival rate among 1,300 patients was 59.5%, and the 50% survival point was 13.5 years after the start of the disease (Tseng, 1989). Patients with blackfoot disease were also found to have hypertension at high rates and suffer from other comorbidities. Of the 66.5% of patients that died after 30 years, 44% of these deaths were attributed to cardiovascular issues (Tseng, 1989). Black foot patients, therefore, are at an increased risk of mortality from stroke or cardiovascular disease among these patients (“Blackfoot Disease”, 2015).

Cardiovascular Disease

Besides blackfoot disease patients, cardiovascular disease is commonly associated with chronic arsenic exposure in many regions of the world. There has been an increased risk of cardiovascular disease among smelter workers that are directly exposed to arsenic. In a 1997 study in Millard County, Utah, a significant increase in mortality from hypertensive heart disease was observed in both male and female smelter employees (Ratnaike, 2003). Workers in smelters and in plants that manufactured, packaged, or distributed products containing arsenic were exposed from inhaling arsenic fumes and dust (Ratnaike, 2003). While drinking water is the most common source of contamination in the U.S., inhalation has posed risks to specific occupations.

A 1999 study also observed hypertension in a study of nearly 1,500 individuals exposed to arsenic in well water. More recent studies have continued to find evidence that supports this association (Ratnaike, 2003). For instance, cardiovascular issues have also been linked to moderate arsenic exposure in drinking water among Mongolian patients (Wade et al., 2015). The 2015 study found that a 10 μg/L increase in arsenic content in water was associated with a 19% increase in the odds of cardiovascular disease (Wade et al.). Researchers at Dartmouth have found that arsenic may interfere with molecular signals that influence the growth of the cells lining heart and blood vessels (Dartmouth Toxic Metals, n.d). The build-up of these cells can make the passage inside blood vessels more narrow, eventually restricting the flow of blood (Dartmouth Toxic Metals, n.d). This is believed to be a potential mechanism behind the cardiovascular disease and other blood vessel diseases associated with arsenic exposure (Dartmouth Toxic Metals, n.d).

Cancer

Inorganic arsenic is classified as a human carcinogen by the U.S. EPA (American Heart Association, 2019). In the 1980s, it was recognized as carcinogenic by the International Agency for Research on Cancer (IARC) (Hong et al., 2014). After being consumed orally, 90% of arsenic gets absorbed through the gastrointestinal tract, which is greater than most heavy metals, and initial distribution predominantly goes to the liver, kidney, muscle, and skin (Hong et al., 2014. This likely helps to explain why exposure to arsenic over long periods is linked to cancer in these areas of the body. To date, IRAC has confirmed there is a strong association between arsenic in drinking consumption and an increased risk of cancer in the lungs, skin, and bladder, while evidence to support the relationship between arsenic exposure and cancer in the prostate, kidneys, and liver is more limited (Hong et al., 2014. Studies in Chile have found marked increases in both lung and bladder cancers from drinking water exposure (Steinmaus et al., 2014; Steinmaus et al., 2013). A population-based case-control study in northern Chile found that odds of a bladder and lung cancer diagnosis in the city of Antofagasta 38 years after arsenic exposure were about four to seven times higher within individuals with elevated exposure compared to others with only low exposure (Steinmaus et al., 2013).

The association between cancer and arsenic exposure in water or through respiratory inhalation has been well documented around the globe (Mendez et al., 2016; Radosavljević & Jakovljević, 2008; Kurttio et al., 1999; Karagas et al., 2014; Steinmaus et al., 2013). Bladder cancer has been a rising concern in Northern New England, where levels of the disease have been elevated for at least 50 years (Baris et al., 2016). It is believed that arsenic is the only recognized bladder carcinogen known to occur in the well water of this region (Baris et al., 2016. Bladder cancer incidence rates in Maine, New Hampshire, and Vermont are roughly 20% higher than the United States overall (Baris et al., 2016. The first comprehensive study of arsenic exposure and bladder cancer in these three states was published in 2016 and comprised more than 1,200 bladder cancer patients and 1,400 control subjects. The researchers found that bladder cancer rates were associated with greater water intake (over 2.2 liters per day) and were also significantly higher among those drinking from private wells than those on public water (Baris et al., 2016. But this trend was only apparent in those with shallow dug wells, not among those with deeper drilled wells. The age of the well and the timing of its use was also examined.

In the same study, investigators found that if dug wells were used prior to 1960, when arsenical pesticides were still widely used in the region, the heavier water consumers had double the risk of having bladder cancer than light water drinkers (Baris et al., 2016. The authors hypothesize their findings are indicative of the health impacts of arsenical pesticide run-off in these shallow wells. Additionally, there appeared to be a 40 year lag in time of initial arsenic exposure and bladder cancer diagnosis, and this length of time was consistent with the onset of bladder cancer in patients known to have been exposed to arsenic in Chile (Steinmaus et al., 2014; Steinmaus et al., 2013). This suggests a long bladder cancer latency period following arsenic exposure, which can be important knowledge to guide monitoring and targeted health assessments in known arsenic hot spots.

Neurological Damage

Extended exposure to arsenic in drinking water has been shown to pose risks for neurological development. Higher arsenic levels observed in individuals' groundwater or urine correlate with worse performance and lower scores on intelligence examinations, with some studies finding verbal IQ to be most impacted, among other cognitive skills (Tyler & Allen, 2014).

A 2013 meta-analysis found that a 50% increase of arsenic levels in urine would be associated with a 0.4 decrease in IQ points among children aged 5-15 years (Rodríguez-Barranco et al., 2013). Some studies have even been centered around Maine. A five year study of 272 children in grades three through five in Maine found that exposure to legally permissible levels of arsenic (5 ppb) contributed to a decrease in the children's IQ by five to six points (Wasserman et al., 2014). This has raised concerns that the federal standard of arsenic should be lowered and has prompted some states to set stricter limits for public water. At the time of the study's release, a Maine health official said that the state estimated that 20% of all wells in the state exceeded this level of arsenic (Lawlor & McMillan, 2014).

Treatment

In cases of extreme poisoning, chemical compounds known as chelating agents can be used as treatment. A medication known as dimercaprol, also known as British anti-lewisite (BAL) in Oil, is used in the U.S. and other parts of the globe to treat arsenic, gold, and mercury poisoning (Multum, 2022). It is also used in conjunction with another drug called edetate disodium to treat lead poisoning (Multum, 2022). BAL was invented in 1941 as a treatment for lewisite, an arsenic-based chemical warfare agent (Kumar Garg, 2022). These agents work by binding arsenic tightly in complexes and rendering the toxin inactive, helping to remove it from an individual's body and evade death or severe illness (Dartmouth Toxic Metals, n.d.). However, for the greatest chance of success, these drugs are meant to be used within hours of acute exposure. In contrast, for chronic arsenic poisoning, there are virtually no evidence-based treatment options available. Some researchers have advocated for the use of antioxidants, though potential benefits have not been proven by clinical studies (Ratnaike, 2003). There is a marked lack of research devoted to the treatment of chronic arsenic exposure (Ratnaike, 2003).

Sources of Arsenic in Drinking Water

In the late 1800s, lead arsenate became extensively used across the United States as a pesticide for apple and cherry orchards through the early 1900s. There is a history of lead arsenate usage on apple orchards, blueberry barrens, and potato crops (D'Angelo et al., 1996, taken from Baris et al., 2016). This includes parts of Maine and New England (Robinson & Ayotte, 2006). By 1960, most uses of lead arsenate were phased out due to its observed health impacts on agricultural workers and concerns surrounding ingesting residue on fruits (Frisbie et al., 1936 & Nelson et al., 1973 taken from Hughes et al., 2011). The official United States ban on lead arsenate use did not take place until 1988 (Peryea, 1998, taken from Hughes et al., 2011). Anthropogenic sources of arsenic, including former pesticide use, treated lumber, and manufacturing, may contribute to ongoing groundwater contamination, but findings in most research have been inconclusive (Ayotte et al., 2003).

Geology

While more uncertainty clouds the role of historical lead arsenate in present water quality issues in Maine and nationwide, a wealth of evidence supports the role of bedrock and geological processes as driving forces behind arsenic prevalence around the world. In Maine and other parts of New England, metasedimentary and volcanic bedrock in particular has been linked to greater arsenic concentrations in well water (Ayotte et al., 2003; Ayotte & Zheng, 2015; Parviainen et al., 2015). Metasedimentary bedrock refers to rock that has undergone metamorphosis, or been heated.

Water from wells in metasedimentary bedrock units, primarily in Maine and New Hampshire, has been found to have the greatest arsenic concentration, relative to wells drilled in other forms of bedrock (Ayotte et al., 2003). It is estimated that nearly 30% of wells in metasedimentary bedrock aquifers contain arsenic concentrations greater than the legal limit for public water (Ayotte et al., 2003). Arsenic has also been found at concentrations of 3−40 mg/kg in whole rock samples in these formations, indicating a potential geologic source (Ayotte et al., 2003). A 2012 report from the U.S. Geological Survey provides important insight into the contribution of bedrock to groundwater arsenic.

The report, which was updated in 2018, features analysis of water tests from nearly 5,000 bedrock wells across New England, northern New Jersey and southern New York state — more than 4,700 public-supply wells between 1997 and 2007, as well as 117 private residential wells between 1995 and 2007 (Flanagan et al., 2018). Approximately 2,000 wells tested for arsenic, and 13% were found to have arsenic greater than 10 ppb (Flanagan et al., 2018). Importantly, this study highlighted the "arsenic belt" stretch of calcareous metasedimentary bedrock, impacting the 492 wells tested along this strip. This so-called "arsenic belt" ranges from the coast of Maine to a point in the middle of Massachusetts (Flanagan et al., 2018). Bedrock lithology and redox conditions are other explanatory variables found to be important in predicting arsenic concentrations. In particular, high arsenic concentrations (above 10 ppb) were associated with a lithostratigraphic stretch of calcareous metasedimentary rocks in eastern New England, high pH (7.0–8.5) and low dissolved oxygen concentrations (Flanagan et al., 2018). Other studies reaffirm the presence of arsenic in groundwater with high pH. High pH is related to groundwater age and possibly the presence of calcite in bedrock, which can help to explain why elevated arsenic is widely found in areas with calcareous rock formations (Ayotte et al., 2003).

However, as shown in the 2016 study of bladder cancer cases that examined well type and timing of the well's use in relation to historical lead arsenate spraying, these two factors also affect well water quality (Baris et al., 2016). Moreover, a 1999 report found a correlation between the concentrations of arsenic in ground water and land-use data; significantly higher concentrations are found in areas identified as agricultural land use than in other land use areas (Ayotte et al., 1999). The researchers acknowledged that there is more agricultural land in areas overlying the metasedimentary rocks in such areas, making it hard to determine the contributions of pesticide use and bedrock as it relates to arsenic in groundwater. Their findings suggest that both geology and land use may play a role in present day arsenic contamination (Ayotte et al., 1999). Geology, while integral to the arsenic contamination observed in Maine and across the country, is just one piece of the puzzle.

Well Type

These explanations concur with the repeated finding that drilled well owners are more likely to experience elevated arsenic levels, relative to dug well owners. Drilled bedrock wells, the most common type of well in Maine, directly intersect with water-bearing fractures in the underlying bedrock ("Well Types," n.d.). These wells often range from 100 to 500 feet deep, far deeper than dug wells. While they are coated in a steel casing to protect them from surface water contamination, these deep wells are still susceptible to contamination from geological influences. While shallow, dug wells have been characterized as generally more susceptible to contaminants from anthropogenic or animal activities, such as excess nutrients from fertilizer, chemical spills, or animal excrement, deeper wells are at greater risk of geological sources of contamination, with arsenic serving as a prevalent chemical (Berkey, 2018).

Other Water Contaminants

Besides arsenic, there are other common contaminants of concern among private well owners nationwide. The following provides a brief overview of contaminants most relevant to Maine, though it is not a comprehensive list.

Per-and Polyfluoroalkyl Substances, a class of thousands of chemicals, known as "PFAS", are a rising contaminant of concern, dubbed the "forever chemicals" for their ultra-strong carbon-fluorine bonds that prevent degradation (Hogue, 2021). PFAS are linked to a range of long-term health effects, such as cancer, kidney failure, birth defects, high cholesterol, infertility, and thyroid issues, among many other conditions (ATSDR, n.d.; Blake & Fenton, 2020). Like PFAS, pesticides and herbicides are other anthropogenic organic chemical pollutants in water, soil, and food. Pesticides and herbicides of varying types pose a variety of risks to human health if ingested or inhaled in great amounts or low amounts over time, including fertility issues, cancer, birth defects, and neurological damage, especially among infants and children (Syafrudin et al., 2021). Other naturally occurring contaminants beside arsenic are also common throughout Maine. Radon, for instance, is estimated to kill 165 Mainers annually (Ousfar, 2020). While most exposure from radon is related to gas build up in basements, the toxin can be dissolved in groundwater from underlying bedrock and can also be released in the air and subsequently inhaled when obtaining water from a tap, showering, or doing dishes and laundry ("Radon and Drinking," n.d.). Similarly, uranium is a naturally occurring radioactive gas that is linked to kidney damage, various cancers, as well as developmental and reproductive harm (Eggers et al., 2015). Finally, another concern among well owners is the presence of naturally occurring disease-causing bacteria, pathogens, parasites, or microorganisms.

Regulations for Arsenic and Private Well Water

The current federal standard for arsenic allowance in public water—which some activists are seeking to lower in Maine— is 10 micrograms per liter (10µg/L) or ppb ("Arsenic", n.d.). The allowable arsenic levels actually used to be much higher. In 2001, the U.S. EPA lowered the maximum limit of arsenic to 10 ppb, replacing the old standard of 50 ppb ("Drinking Water Arsenic," n.d.). Still, this did virtually nothing to improve the quality of unregulated well water. New Hampshire and New Jersey are the only two states, as of April 2022, to have lowered their state-wide MCLs for arsenic to 5 ppb (Dolan, 2021). In Maine, there are four key policies in place to regulate private well water and limit exposure to arsenic and other common contaminants. These include funding free tests, remediation, and awareness campaigns.

In January of 2004, Maine started to require the seller of residential property to provide the purchaser with informational flyers on arsenic in private water supplies and in treated wood ("Title 33",, 2007). Two other flyers that include a list of labs to contact for well tests and tips for what to do if elevated results occur were also developed by the Maine Department of Health and Human Services (DHHS) and are available online but are not required to be disseminated (Maine CDC, n.d.). This statute also requires the sellers to provide a property disclosure statement that includes the date of the most recent water test if any, and report any problems experienced, such as an "unsatisfactory" water test. However, it does *not* require sellers to test before property transactions— only to provide any information the seller may possess.

In June of 2017, the Maine House and Senate overrode then-Governor Paul LePage's veto by 113-33 and 35-0, respectively to approve LD 454, "An Act to Ensure Safe Drinking Water for Maine Families." The law helped to create and allocate funding for the Private Well Safe Drinking Water Fund, which allowed the Maine CDC to carry out more outreach campaigns across the state, and directed the Maine CDC to establish the recommendation for a water test every three to five years, simplifying their messaging ("An Act to Ensure Safe Drinking Water for Maine Families", 2017). The Legislature allocated $63,992 for these outreach efforts through 2017-2019 and additional funding was required to come directly from the fees collected from well water tests conducted by the HETL ("An Act to Ensure Safe Drinking Water for Maine Families", 2017). Water test fees could be waived for low-income well owners that could show proof of enrollment in a food stamp program or other financial need, but DHHS also required a letter of justification for a free test from a physician, specialist from the Department of Environmental Protection, or a geologist. This requirement for a letter of justification in addition to a showing of indigency was established by DHHS, not the Legislature.

Please make check or money order payable to: TREASURER OF STATE.
Send to: HEALTH AND ENVIRONMENTAL TESTING LABORATORY
221 STATE ST., STATION #12, AUGUSTA, ME. 04333.
Do not send cash

For your convenience, payment may be made by VISA OR MASTERCARD.

Visa MC Card Number Expiration Date (MMYY)

££ ££££-££££-££££-££££ ££££

Signature of Card Holder_______________________________________ **Am** $

NAME ______________________________________

STREET______________________________ TOWN______________________________

ZIP ____ TELEPHONE (______)______ _-
____

FEE WAIVERS: Free water testing may be available if you meet both (1.) and (2.) below:

1. Food Stamp Eligible (Please provide Food Stamp ID) or demonstrate other proof of financial need or if you have already spent $150.00 on water testing at a state certified lab.
2. There is written professional justification to support the need to test this Private Water Supply.

Examples are: Doctor’s letter, Department of Environmental Protection (DEP) Recommendation, geologist.

Figure 2. Test kit order form from 2020.

Later in 2017, state legislators in Maine also overrode Governor LePage’s veto in order to pass LD 1263, “An Act To Increase the Affordability of Safe Drinking Water for Maine Families,” into law. This law allocated $500,000 to help low-income families afford filtration systems when they have elevated arsenic. This initiative, called the “Arsenic Abatement Program”, is operated by the Maine Housing Authority (MHA), and allows for residents and landlords to apply for funding assistance for filtration systems. For qualifying households and landlords, the Program offers up to $15,000 to install a point of access filtration system and a maximum of $3,000 for point of use systems (Maine Housing, n.d.). To qualify, the well must first test above 10 ppb. Additionally, the household or landlord must earn 120% of the county median income or lower to be considered (Maine Housing, 2021). There are also asset restrictions. Individuals seeking assistance may not have liquid assets, such as cash or bonds, over $5,000. Applicants 60 years or older may have liquid assets up to $50,000 (Maine Housing, 2021). For landlords whose wells test above 10 ppb, they must own property that has four or fewer units to qualify for the program.

More regulations have been passed in recent years. “An Act To Protect Drinking Water for Maine Residents” (LD 1570) was signed by Governor Janet Mills in the summer of 2021. Under this law, beginning on January 1, 2022 and every five years thereafter, landlords are required to test all private wells on their property for arsenic and provide the results to tenants within ten days of notification (“An Act To Protect Drinking Water for Maine Residents”, 2021). The landlord must also notify any new tenant of the most recent results of a test. The law also expanded free water testing and made free tests easier to access by creating a new program operated by DHHS through HETL and Maine CDC to provide free testing for arsenic for low-income residents. A qualifying individual is defined as a person who receives assistance under the MaineCare program or a food supplement program. The previous requirement set by DHHS to present a letter of justification from a doctor or a geologist to access a free test—in addition to a showing of indigency—was explicitly removed in the legislation. The bill allocated $51,484 annually for free testing for the years 2021-2022 and 2022-2023. Lastly, the law also required DHHS to review recent research regarding arsenic toxicity and subsequently revise the MCL for arsenic in line with levels suitable for consumption. Therefore, it is possible that Maine will join New Jersey and New Hampshire in the future by lowering the acceptable standard for arsenic in drinking water.

Currently, a new measure in the Maine legislature, “An Act To Continue Supporting Safe Drinking Water for Maine Families” (LD 1891) would allocate $500,000 to the MHA to provide one-time grants for water remediation or treatment to low-income residents with private wells (“An Act To Continue Supporting Safe Drinking Water for Maine Families”, 2022). This would essentially replenish funding for the Arsenic Abatement Program, as well as allocate funding to treat wells with other contaminants. In February of 2022, Sarah Woodbury of Defend Our Health testified on behalf of the bill, stating that according to the MHA, 662 households have benefited from the Arsenic Abatement Program since the implementation of LD 1263 in 2017, necessitating more funding (Woodbury, 2022). As of April 2022, LD 1891 had been passed by the Maine Legislature and was awaiting signature from Governor Mills. In summary, key policies to protect private well water have been passed in Maine to help address federal regulatory gaps**.**

Research Aims

Given the vast health concerns surrounding water quality for federally unregulated water, this paper focuses on private well owners in order to understand their perceptions of water contamination and knowledge of existing resources for clean drinking water in Maine. Through qualitative research, we capture the lived experiences of individuals residing in a known arsenic hot spot in the Blue Hill Peninsula and Deer Isle, a rural region of coastal Downeast Maine that relies heavily on residential wells. With a qualitative analysis of the perspectives from 18 community members, this paper seeks to highlight narratives that may better inform policy solutions to drinking water contamination problems and explore critical perspectives on the human experience of contamination.

Blue Hill Background

A part of coastal Downeast Maine, the Blue Hill Peninsula is a small community of close-knit towns in Hancock County. This area includes the seven towns of Blue Hill, Surry, Castine, Brooklin, Penobscot, Sedgwick, and Brooksville. The Blue Hill area is well known as the "gateway" to Deer Isle, Maine's second-largest island (Blue Hill Peninsula Chamber of Commerce, n.d.). Blue Hill, the largest town in the Peninsula, is home to roughly 2,792 residents, according to the 2020 U.S. Census—many of whom rely on private well water (U.S. Census Bureau, 2020). According to MTN, while roughly 53% of Maine's population reported using a private well at home in 2017, 76.1% of Hancock County residents relied on private wells (MTN, 2017). But the story of Blue Hill involves far more than well water. The following photographs were taken during a visit to the Blue Hill area in November of 2021.

While characterized as quiet year round, tourists flock to these rural communities every summer for the rocky coastal views, fresh seafood, and blueberries (Inns Along the Coast, n.d.). Summer ventures to the area date back to 1881, when Captain Oscar Crockett started a steamboat service from the railhead at Rockland to Blue Hill, allowing a "Summer Colony" to be formed on Parker Point (Blue Hill Peninsula Chamber of Commerce, n.d.). Institutions still frequented today, such as the Blue Hill Inn, flourished with tourists from the Northeast (Blue Hill Peninsula Chamber of Commerce, n.d.). Other common attractions in the present day include a visit to the Blue Hill Co-op, the Blue Hill Public Library, and the Blue Hill Community Bookstore.

The Callahan Superfund Site in Brooksville is a source of sulfide deposits. Mining in the Blue Hill Peninsula dates back to the 1870s, in which copper mines sprouted up along the coast, particularly in Brooksville (Blue Hill Historical Society, n.d.). Mining and steamship building were central to the area's economy in the 19th century. Some of the earliest mining companies in the area included Blue Hill Copper and The Douglass (Blue Hill Historical Society, n.d.). Yet by 1881, only six of thirty-nine companies continued to operate (Blue Hill Historical Society, n.d.). A similar fate emerged for the Callahan Mine, whose lifespan was just a few years.

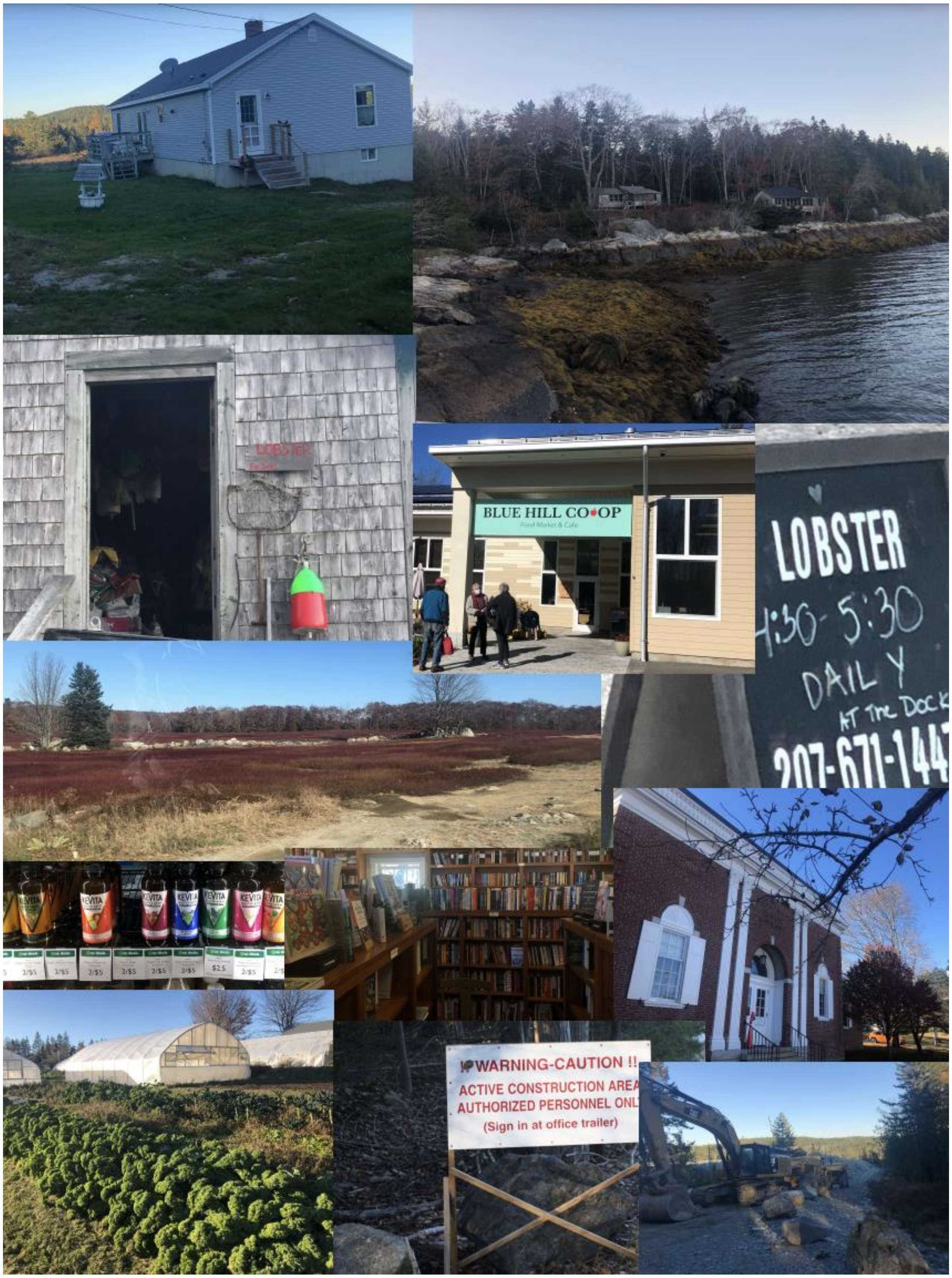

Figure 3. Collage of the Blue Hill trip.

Located on 120 acres, the 300-foot-deep open-pit mine produced 800,000 tons of copper and zinc ore from 1968 to 1972 (Rajakaruna et al., 2011). Following its closure, the Callahan Mine site was subsequently used for salmon and oyster aquaculture in

Goose Pond from 1974 to 1979 (Marvinney & Berry, 2015). However, arsenic and lead have been found in the site, as well as Polychlorinated biphenyls (PCBs), copper and zinc (Marvinney & Berry, 2015). In 2002, the Callahan Mining Corp Site was added to the National Priorities List of superfund sites (U.S. EPA, n.d.). In December of 2021, the U.S. EPA announced a $1 billion investment in 49 previously unfunded superfund sites across the country, including the Callahan Mining Corp Site (Rumph, 2021). Presently, the U.S. EPA is working to stabilize and install a cover system over the Tailings Impoundment to prevent leaching. While the work was expected to be completed in 2021, no announcement on its status has been made as of April of 2022 (U.S. EPA, n.d.).

Just minutes away from the superfund site, farms and orchards can be found scattered throughout the Peninsula and in neighboring towns, such as Harborside. While tourism and fisheries are integral to the Blue Hill area's economy, apple orchards, blueberry barrens, and farms have historically been tied to the area's land use, especially during the "back to the land" movement of the 1960s and 1970s (Maine Memory Network, n.d.). Interestingly, some of the farmers spoken to during the casual visit had never heard of this superfund site, despite being in close proximity. Although many of the farms visited during the trip pledge to use organic methods, there is some evidence that arsenical pesticides were likely used in the Blue Hill Peninsula in the past. While no specific records for arsenical pesticide use in the Blue Hill area (and most of Maine) exist to the best of our knowledge, the best estimate for arsenical pesticide application comes from Robinson and Ayotte (2006). Using agricultural census data for apple, blueberry, and potato crops from 1935 to 1977 in New England, their findings indicate a high probability that most of the Peninsula had arsenical pesticide applications during that period. Hence, there is a chance that traces of arsenic could be found in layers of topsoil in retired or active farmland that hosted such crops. Due to time and resource constraints, this fieldwork was not completed for this project but is a direction for further research.

Arsenic Contamination and Health Outcomes

Most of the towns included in this study and the surrounding Blue Hill Peninsula area have shown heightened levels of arsenic in well water. Surry has the highest rate of well contamination, with 46.6% of wells testing showing high levels of arsenic, followed by 43.1% of wells in the town of Blue Hill (Figure 10B). On average, 21.4% of wells in Hancock County have elevated levels of the contaminant (MTN, 2017).

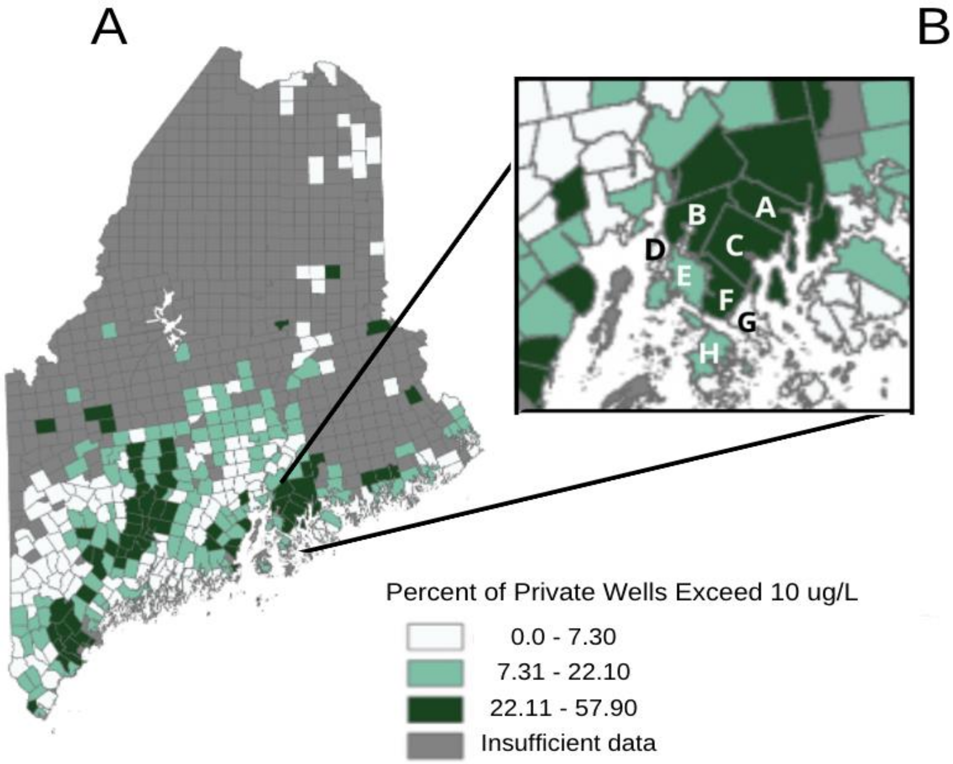

Figure 4. Percentage of private wells that exceed 10 ppb for arsenic. Data from water samples tested by the state of Maine Health and Environmental Testing Laboratory between 1999 and 2013 per each Maine town (4A) and per each town in the Blue Hill Peninsula (4B). B: A= Surry (46.6%); B=Penobscot (29.1%); C=Blue Hill (43.1%); D=Castine (7.0%); E= Brooksville (13.5%); F=Sedgwick (36.8%); G= Brooklin (5.8%); H=Deer Isle (8.3%). The data were analyzed by the Maine Environmental Public Health Tracking Program (2018).

In terms of health outcomes, no statistical analysis has been completed assessing the relationship between elevated arsenic levels and bladder cancer for this paper. Regardless, the age-adjusted incidence rate of bladder cancer in Hancock County was 34.5 cases per 100,000 persons from 2010-2014 (MTN, 2018). This is the highest age-adjusted rate of bladder cancer cases among any other county in Maine (Figure 5).

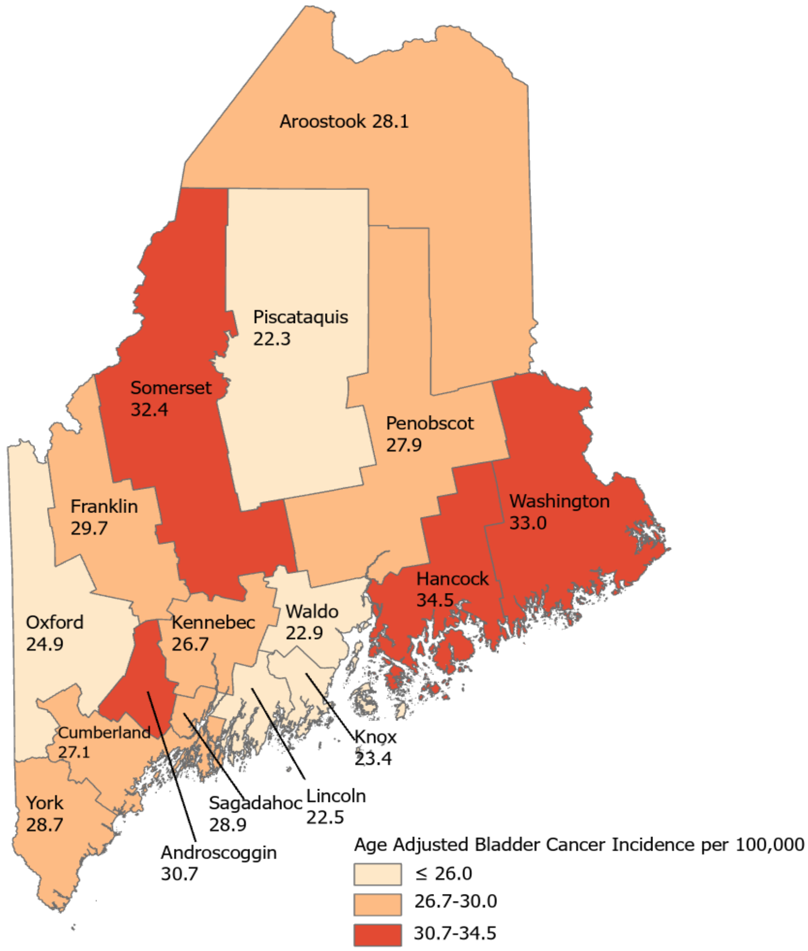

Figure 5. Age-adjusted bladder cancer incidence per 100,000 persons (2010-2014). The Maine CDC, Maine Cancer Registry provided the data for this display, including cases from 2010-2014. The data were analyzed by the Maine Environmental Public Health Tracking Program (2018).

The incidence of new bladder cancer cases in Hancock County also exceeds the statewide age-adjusted incidence rate of 27 cases per 100,000 persons, averaged across 2014-2018 (National Cancer Institute, 2022). Nationally, the rate of new cases of bladder cancer was 19.7 per 100,000 persons for the same period (National Cancer Institute, 2022). It is highly plausible that the elevated arsenic levels in some parts of Hancock County are contributing to the high incidence of bladder cancer relative to the state of Maine and the country at large.

Blue Hill Peninsula Geology

The following figure displays the bedrock map of the Blue Hill Peninsula from the U.S. Geological Survey (USGS), coupled by an analysis of the dominant geological features. According to Amber T. H. Whittaker, Senior Geologist at the Maine Geological Survey, the arsenic in the Blue Hill Peninsula can be attributed to sulfide deposits, such as those at the Callahan Superfund Site in Brooksville, which are hosted in volcanic and metasedimentary rocks (personal communication, January 5, 2022; Marvinney, 2015). The Castine volcanics are another source of arsenic contamination in this area, along with mafic igneous rocks, which are associated with sulfide deposits (A.T.H.W. personal communication, January 10, 2022; Yang et al., 2009). Consequently, the Ellsworth schist and the greenstones present in the area are possibilities for arsenic contamination, given their igneous composition (A.T.H.W. personal communication, January 10, 2022; Marvinney, 2003). Granite has also been found to be associated with arsenic in other regions, such as in New Hampshire, and there is an association between arsenic occurrence and metasedimentary rocks when accompanied by granite intrusion (Peters & Blum, 2002; Ayotte et al., 2003; McGrory et al., 2021).

In the map below, the pink by Penobscot depicts iron-sulfide rich schist, as well as limestone and calcareous sandstone (Figure 6). This is consistent with arsenic-bearing sulfide deposits and the presence of arsenic in calcareous rock. The dark orange in Deer Isle, Brooklin, and Surry represents the presence of the arsenic-bearing Ellsworth Schist and greenstones. Varying types of granite are also represented by the bright orange in the area by Blue Hill and Surry and the green by Sedgwick and Brooksville. The blue by Castine and Brooksville represents the Castine volcanics, which indicate the likelihood of sulfide deposits. The geological qualities of these rocks in the Blue Hill Peninsula contribute to the elevated arsenic levels in groundwater observed in the region.

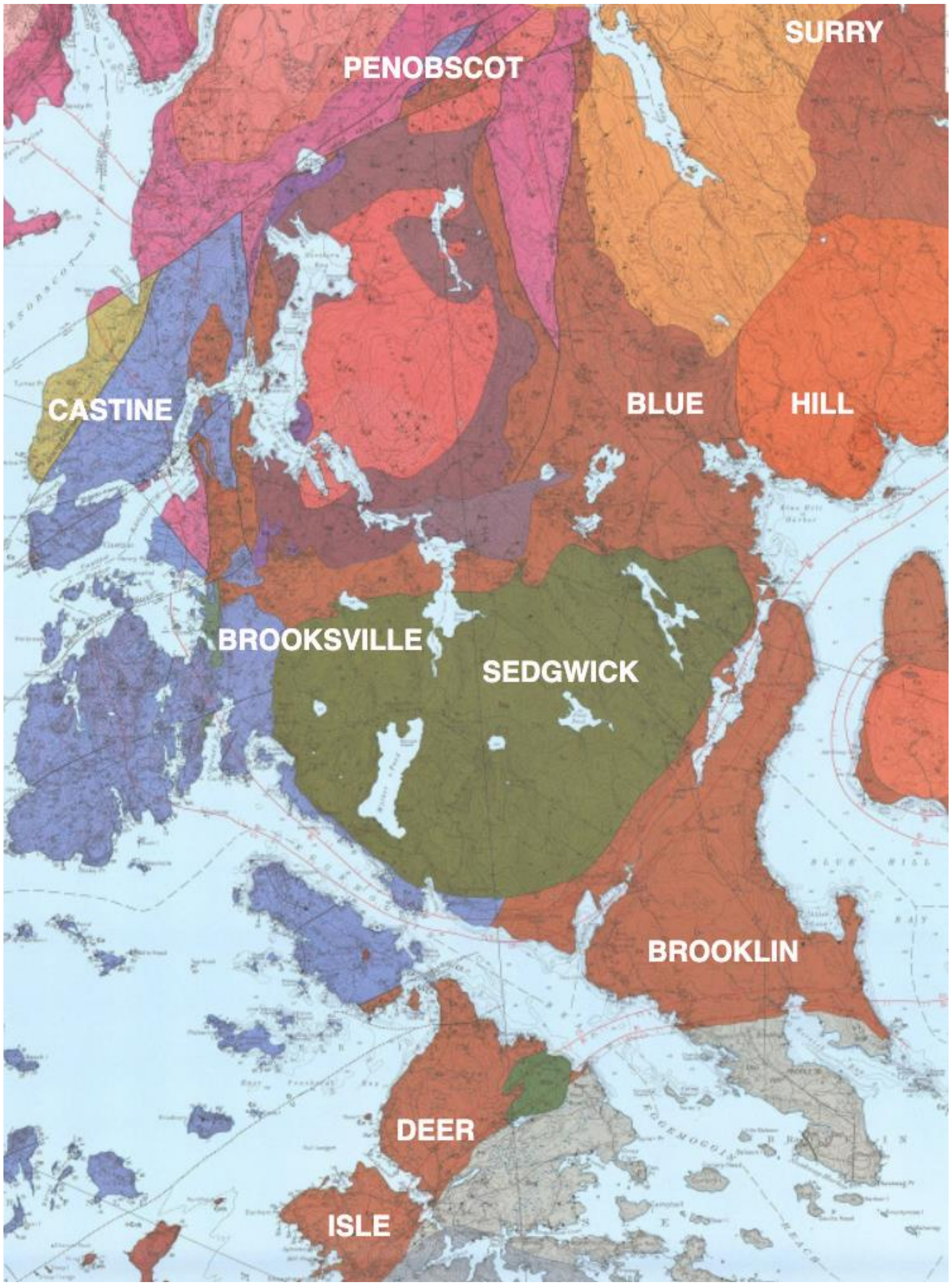

Figure 6. Bedrock geology of the Blue Hill Peninsula and Deer Isle. Stewart, D.B., and Tucker, R.D. (1999). Geology of northern Penobscot Bay, Maine, with contributions to geochronology. *U.S. Geological Survey*. https://ngmdb.usgs.gov/Prodesc/proddesc_19222.htm

Qualitative Study Background

Scientists interested in toxins exposure have widely approached hot spots from geological, chemical, and environmental backgrounds. Resident perspectives remain less utilized, and when studied, are typically dominated by the use of mail-in surveys rather than open-ended interviews (Flanagan, Marvinney, Zheng, 2014; Flanagan et al., 2015; Flanagan et al., 2016a; Flanagan et al., 2016b). While some qualitative studies have emerged in recent years, particularly in Canada, private well owners are generally an understudied group (Munene et al., 2019; Hooks et al., 2019; Imgrund et al., 2011).

To the best of our knowledge, this is the only study to date that takes a qualitative approach to studying well water contamination in Maine. No prior research has been conducted with residents of the Blue Hill Peninsula or Deer Isle to ascertain their knowledge, perceptions, and behaviors related to clean water access. We seek to understand emotive and subjective experiences of water contamination along with gathering objective data such as filtration and testing history among a sample of residents. This study expands the current scope of hot spot research by centering the human experience of water contamination and social dimensions of well water pollution in a rural community. We seek to understand how residents in a known hot spot use their water, perceive their water's safety, barriers to safe drinking water, and potential policies to address these issues.

METHODS

During January of 2020, Caroline Wren, a 2020 graduate of Colby College, conducted interviews of well owners in the Blue Hill Peninsula and Deer Isle, Maine. The following sections on the study sample, interviews, and test kits draw from Wren's methods.

Study Sample

Wren used existing contacts from a summer internship working on well water access and safety with Defend Our Health, a nonprofit organization based in Portland, Maine to start a snowball method of identifying subjects for interviews. Wren contacted an existing contact at the Blue Hill Public Library, who in turn referred Wren to other members of the community. Community members distributed flyers at the Blue Hill Public Library, Blue Hill Co-op, the Blue Hill Community Bookstore, and several locations in surrounding towns with Wren's name, email and phone number (Appendix A). Any person that uses well water on the Blue Hill Peninsula over the age of 18 was eligible to participate in the research. Individuals were not excluded based on owning/renting status, or whether or not they lived in the property in the Blue Hill area full time. All participants confirmed that they used a private well and lived in Maine at least part-time during the year. These two criteria were sufficient to be included in the study sample. The research area was limited to the Blue Hill Peninsula and Deer Isle.

Interviews

A total of 17 interviews with 19 participants were conducted for this research by Wren during January 2020. The survey used in this research includes a set of 18 interview questions asked of the participants in semi-structured interviews (Appendix B). Content covered included participants' contaminants of concern, experience with testing, definition of clean water, perceptions of water in Maine, barriers to testing, awareness of these issues and the Maine Arsenic Abatement Program, and opinions on policy intervention. Questions varied based on the participant's specific relationship to well water, and additional follow-up questions were added during the interview process as deemed necessary by the interviewer. Interviews were conducted in participants' homes or in public spaces, such as the local library, and were recorded on a mobile device with prior participant consent. While most interviews were conducted individually with one participant, two participants were interviewed alongside their spouses. The project and the survey of questions received IRB approval from Colby College (IRB approval number: 2019 - 059).

Test Kits

Free well water test kits were offered to all research participants. The test kits were purchased by Wren at privately-owned Northeast Laboratory Services, located in Winslow, Maine, with funding from the Buck Lab for Climate and Environment at Colby College. Northeast Laboratory Services was selected because of its proximity to the college and previous participation in Colby College research projects. The test kits analyzed water samples for the following substances: arsenic, calcium, chloride, copper, fluoride, hardness, iron, lead, magnesium, manganese, nitrate nitrogen, nitrite nitrogen, pH, sodium, coliform bacteria and E. coli. Test results from Northeast Laboratory were sent directly to the participants. Participants were under no obligation to send Wren their well water, as described in the study's consent form (Appendix C).

Data Analysis

All recordings were transcribed by Otter.ai software by Wren. I then joined the project at this stage. I prepared the transcribed interviews and performed qualitative analysis. I cleaned and de-identified all transcripts to remove errors made by the transcription software and to redact personal, identifying information from participants and individuals referred to in the interviews. De-identified transcripts were prepared for qualitative coding. Data analysis followed an inductive-deductive coding scheme, a methodology that provides a systematic framework for data aggregation and analysis that derives both novel and theory-driven themes (Fereday & Muir-Cochrane, 2006). This approach was taken to best suit the exploratory nature of the study, which aimed to capture a broad range of opinions and descriptive information from well owners in a known hot spot. Given that no prior research has been conducted in the Blue Hill Peninsula, this approach provided the opportunity to extract a broad scope of data that could have otherwise been excluded or less enhanced using a purely inductive or deductive technique.

In the first step of the iterative coding theme, initial themes were established by reading through all transcripts and noting common phrases, emotions, or ideas (Fereday

& Muir-Cochrane, 2006). Most themes were drawn directly from the common concepts or feelings found in participants' answers to the interview questions and were divided up into subjective (such as feelings of well water) and objective (such as use of filters) data categories. These themes were applied to the data systematically by using the NVivo 12 software package (QSR International, 2022). Another coder not familiar with this research was recruited to code one transcript and compare attribution with the researcher to ensure consistent coding.

We then used a deductive approach to organize initial data into overarching themes that use existing theoretical frameworks, such as risk perception, physical context, and collective responsibility (Munene et al., 2019; Hooks et al., 2019; Imgrund et al., 2011; Smiley, 2017). These domains were selected based upon previous theoretical models in qualitative studies of well owners (Fereday & Muir-Cochrane, 2006). We then used an inductive approach to extract subthemes in each thematic area in an iterative manner and refined and condensed sub-themes to remove inconsistencies or redundancy (Fereday & Muir-Cochrane, 2006; Bannon et al., 2021).

RESULTS

Nineteen participants were interviewed but one audio recording was lost, so results from 16 interviews with 18 participants are included in the analysis. Characteristics of the study participants are summarized in Table 1. Results from the free test dissemination are also discussed. Eleven respondents (representing nine different households) sent the full results from their water tests, and one participant sent partial results.

Table 1. Demographic characteristics of the study participants (N=18).

Demographic Characteristics	*Number of participants (%)*
Gender	
Male	5 (28%)
Female	13 (72%)
Retired	
Yes	4 (36%)
No	11 (61%)
Data Not Available	3 (17%)
Children in Household	
Yes	3 (17%)
No	15 (83%)
Homeowner	16 (89%)
Yes	2 (11%)
No	
Town	
Blue Hill	6 (33%)
Brooklin	1 (6%)
Brooksville	3 (17%)
Deer Isle	2 (11%)
Sedgwick	4 36%)
Surry	2 (11%)

Free Test Kit Results

Of the 11 participants that sent back test results, three were testing their water for the first time. Eight participants who sent back some results had reported testing at least once before. Five participants who accepted a free test reported having filters, and three had reported not drinking their own well water.

One sample had highly elevated arsenic, at least one had high coliform, and four water samples had pH values outside of the U.S. EPA's recommended range of 6.5-8.5 (Table 2). No participant sent back results that showed elevated lead, uranium, or radon.

Table 2. Testing results from participants' free tests (N=11).

Participant	Town	Arsenic (ppb)	Lead (ppb)	Uranium (ppb)	Radon (piC/L)	Coliform (Count)	pH
1 & 2	Brooksville	2.38	<1.000	<1.000	645	3	6.15
4	Deer Isle	<1.000	<1.000	<1.000	298	6	7.07
5	Surry	5.57	5.01	3.84	--	3	3.84
7	East Blue Hill	3.32	<1.000	<1.000	3723	<1	5.96
9	Brooklin	<1.000	2.63	<1.000	377	1	4.73
10	Blue Hill	1.27	<1.000	<1.000	434	<1	7.73
11	Deer Isle	<1.000	1.04	2.64	1338	4	6.56
14	Blue Hill	--	2.68	--	855	--	--
16 & 17	Sedgwick	61.9	<1.000	<1.000	852	<1	7.84

Well Water Usage

How do you access drinking water?

- Drink the well water: 12 participants
- Use bottled water instead: 3 participants
- Fill up jugs from another source: 3 participants

Twelve participants said they currently drank their well water, including the two living in the household that showed elevated arsenic following the free water test (Table 2). Six identified as currently not drinking their well water and utilizing other sources, which include purchasing bottled water and filling up jugs from other water sources:

> *"We have a lot of gallon jugs that we then go over to a sister-in-law's house or friend's house and we have to fill up…We've been doing it all three years that we've lived in the house. We've had to do that. The house*

was built in the 80s and the water has never been drinkable." – Participant 5

and:

> *"Right now I go to institutions like the church or the radio station or I volunteer at the food pantry. I do not drink from my own tap anymore for cooking and drinking…I just trust that the institutions are probably better than I am." – Participant 9*

Only one participant expressed frustration over their experience accessing well water due to making the effort to obtain clean water from a relative's house and not having the capacity to haul enough clean water for their farm animals:

> *"It's a pain. Yeah, it is an inconvenience. We've worried about it. We have farm animals and we're just not able to haul enough of the clean water for them…And that's been a question too for us because we raised the pigs at least for food. So we're not entirely sure how that's impacting them and what long term impacts there are. It's definitely something in the back of our mind, but there was no feasible way to be hauling that much water." – Participant 5*

Overall, despite needing to purchase bottled water or drive to obtain well water, nearly all of the individuals who did not consume their own well water did not convey feelings of annoyance or resentment towards their situation.

Motivations for Water Drinking Behavior

Of the six that did not drink their water, four had either tested their well water before they stopped drinking their water (and found high arsenic, radon, or bacteria, most frequently) or had become aware of the water quality prior to moving in and decided not to drink it. Two participants who did not drink their well water cited prior health concerns or experiences in other states as motivation for avoiding their well water, even without having tested it to know its quality:

> *"Well 3, 4, 5 years ago I was having bladder issues… so just experimentally I stopped drinking it." – Participant 9*

and:

"We also live most of our time outside of Moab, Utah where there's lots of uranium works. We worry about that there, but not in Maine. So we're just sort of in the habit of not drinking water out of the tap." – Participant 3

One renter from Blue Hill who saw elevated lead and arsenic in the water quality test her landlord showed her prior to signing her lease cited prior health concerns as well:

"I think they are both carcinogens so they both concern me and also because I am in treatment for cancer. I don't want to do anything that's going to bring it back." – Participant 14

Risk perception was therefore a key theme weaved throughout responses, in which participants with strong perceptions that their health could be jeopardized by their water responded by not drinking it. Although they avoided direct water consumption, all six who said they did not drink their water confirmed that they still showered in their water and used it for doing laundry and dishes. Only some used their water for basic cooking:

"If I'm cooking pasta or something – I feel better if I boil it. So I don't worry about it if I boil it." – Participant 3

Others did not use their water for any form of consumption:

"We don't even give our pets the water…We wash the dishes in the water and we shower and wash our clothes in it." – Participant 5

These behaviors were mostly influenced by participants' perceptions of what safe water habits were and the ability to feel less anxiety if certain uses were followed. But one participant noted that boiling water was actually worse for health and described how receiving education from an organization changed the way he consumed his water:

"Two years ago following the Blue Hill fair…there were a couple ladies there selling water purification equipment, and they offered a free test and they came by and tested it and I don't remember all the chemicals they said, but it scared me…They said cooking is even worse, so I stopped cooking with it." – Participant 9

Thus, well water usages varied typically because of feelings of fear and perceived health risks based on certain forms of consumption (i.e. drinking, cooking, bathing)—whether based on concrete scientific knowledge or not.

Water Testing and Treatment

Have you ever tested your well?

- Yes: 12 participants
- No: 6 participants

Do you remember any of the results?

- Yes: 9 participants
- No: 3 participants

Do you have any type of water treatment system installed?

- Yes: 8 participants
- No: 10 participants

There was a wide range of reported testing frequency; the most recent testing reported was within the last two years while the longest length of time since testing was 17 years ago for one participant. Two participants who did not report testing previously said it was because they were informed of their water quality prior to purchasing their home or signing a lease but had not personally tested their water since. The participants in the household with elevated arsenic found in their free water test reported never testing their well water previously and not using a filter (Table 2).

Risk Perception

Motivation for previous testing (not including the free water tests offered to participants in this study) included concerns surrounding the individual's health or their family. Some of these concerns contained feelings of anxiety and fear:

> *"I guess I had it tested once. It was like five or six years ago. I just had fear about my water cause I knew about the arsenic. I can't believe I waited as long as I did, actually. It was kind of scary. And I have a 12 year old daughter so that was my first concern." – Participant 10*

General concerns surrounding contamination, even without concrete knowledge of the impacts of exposure, were also found to motivate testing:

"It always tests fine. But you wonder if that can change. There's so much geology, you wonder what could be leaching into it as things shift." – Participant 3

Hence, perception of bodily health risk or concern around environmental quality changes were expressed. Participants who said they had not tested previously were not asked directly to explain why they had never tested. While barriers will be discussed later, the depth of our understanding of the motivations behind not testing is limited. But, when asked why they accepted a free test as part of the study, two participants who had never tested previously cited that they had been wanting to test but had not prioritized it:

"Well, I've been wanting to test for years and just never got around to it." – Participant 16

Many participants had only tested once due to concerns of contamination they became aware of during the homebuying process. Although it is not mandatory for water testing to occur prior to real estate transactions in Maine presently, this was cited as a prompt for some participants to test:

"I did a home radon test first and saw it was so high that somebody, it was even my realtor, suggested getting the water tested too." – Participant 13

Conversely, others had tested multiple times based on health concerns and the concern that contamination could be possible over time. One participant noted that their partner's health concerns had prompted them to test their water and when contamination was found, they added multiple water filters:

"My late partner died of ovarian cancer, which she thought or we all thought was IBS of some kind for years and years. So the water testing was really important because for some years, we forgot to, or didn't do it. And then when it came up that it had E. coli, she was thinking that that was the cause of problems even though it was more systematic than that." – Participant 7

In terms of filtration, even just "carry over" concerns from other states influenced filtration behavior. Similar to Participant 3 that avoided his water based on experiences in Utah, one participant said he used a filter based on prior experience of poor water quality in another state, despite never testing their well water:

"We just have a Berkey [filter]…I lived in Pittsburgh before this, where it's un-advisable to drink the water. So that's just what everybody has there." – Participant 15

Additionally, all participants with filters reported drinking their well water except for two—both renters—who had lingering concerns about either remaining arsenic in their water after filtration or the filter's general functionality:

"There's like a lot of arsenic in the water and they filter it out but there's still not zero arsenic. So that's why I'm not drinking the tap water." – Participant 14

and:

"They installed some type of filter, maybe a crushed rock filter, but [the landlord] has not tested it since the filter was installed, though it has been tested in the past few years. So [I am] not comfortable drinking the water." – Participant 18

Thus, testing appears to motivate participants to add a filter if contamination is found, but participants do not always trust that their water is safe even when it is filtered. Similar to well water avoidance, testing behavior is widely motivated by perceptions of health risks.

Beliefs About Contamination and Maine Water Quality

What have you heard about contaminants in drinking water?

- 14 participants cited arsenic, followed by several other contaminants (Table 3)

What comes to mind when you think about drinking water in Maine?

- Negative perception: 9 participants
- Neutral perception: 5 participants
- Positive perception: 3 participants
- No opinion: 1 participant

Arsenic was the most commonly cited concern among participants, followed by several other contaminants (Table 3). Most respondents mentioned more than one contaminant. Seven participants listed a different contaminant from those listed below; these include fluoride, salt, iron, manganese, plastics, cyanide, and acid rain.

Table 3. Reported water contaminants of concern.

Contaminant	Arsenic	Radon	Other	Geology	Bacteria	Pesticides	Color/ Taste	None	Lead
Number of participants (%)	14 (78%)	7 (39%)	7 (39%)	6 (33%)	5 (28%)	5 (28%)	2 (11%)	2 (11%)	1 (6%)

Awareness

There was a general consensus surrounding arsenic's toxicity across all participants that mentioned arsenic. However, the degree of knowledge or awareness of arsenic's properties varied across participants. Some had only heard of arsenic but did not know if any safe levels existed or how exposure would occur:

> *"It's a poison. It's like 'Arsenic and Old Lace', the play. It's something that you should be afraid of. I think it could kill you in the right quantities. And if it's in the water, I wonder if there's a safe amount—is it possible there's a safe quantity of arsenic that you can intake? And does it add up? Does it accumulate in your body?" – Participant 3*

and:

> *"I think if I hadn't had cancer, I wouldn't worry so much. But like, for example, when I'm taking a shower, you know, it's like an arsenic bath, like, yay. How is it going to get through my skin? Is it gonna [enter my body] if I have cuts on my fingers?" – Participant 14*

Others, however, had more specific knowledge, such as knowing there are different types of arsenic:

> *"I know that there's a couple different kinds of arsenic and one can be the more poisonous one and the other one's more of a natural one that's not so bad or something. I don't know. I feel like I heard that somewhere but otherwise, I just know to stay away from it." – Participant 5*

While not all participants had a clear understanding of arsenic, fear of the contaminant was expressed throughout a few responses. Only one participant believed that no health concerns were related to arsenic exposure:

"There's arsenic all over the place. And I know the body stores arsenic and body fat handles arsenic okay. And it depends on the health of my body to handle any of those kinds of issues. Because I eat very specially. Good foods. I make my own cereals and grains and all of that stuff. And so anyway, I don't worry about it." – Participant 6

Thus, the extent of scientific knowledge and awareness of arsenic's effects varied among participants. While awareness of water contamination influenced some negative perceptions of Maine's water quality as a whole, most participants who avoided their well water did not hold negative opinions of Maine's water at large. Those that do not drink their water were not more likely to have negative opinions on Maine's water.

Physical Context

Nearly half of the participants that held negative opinions on the state's water quality expressed concern surrounding the presence of industry in Maine, especially bottled water companies— not just arsenic contamination. This highlights the importance of the perceived physical context of Maine and one's ideas surrounding the physical characteristics of the state. When asked about their private well water, four participants expressed concerns due to their home's proximity to surrounding agricultural operations (mostly blueberry barrens):

"We have a blueberry barren behind our house. And they do spray. So that's a concern." – Participant 8

Thus, physical context is also related to how one views their own water. In parallel, the lack of or presence of industry in Maine was also prevalent in responses surrounding Maine's water quality as a whole. All three participants with positive opinions of Maine's water quality cited lack of pollution and industry relative to other states:

"I think of [Maine] as being clean and fresh. Because I think there's less pollution up here. So I think that the water, the lakes are cleaner for sure." – Participant 11

and:

"We don't seem to have those kinds of problems in Maine because we don't have any industry. No containment…We generally do not have water

issue problems. Now, if we lived in Chicago and we're drawing water out of a river and lake, how's the water taste?" – Participant 6

Yet, many participants—who fell in the majority that held negative opinions on Maine's overall water quality—did point to existing or historical industry in the state, which they believe has contributed to diminished water quality:

"So there were Copper Mines down there and the tailings are still leaching into the water and everything…There are three ponds that are from the mines. And I don't even know if I'd want to swim in it." – Participant 13

and

"I'm concerned about the amount of water that's taken out of the aquifer and sold as bottled water. I've spent quite a bit of time literally going around the entire state looking for aquifers to supply fish hatcheries." – Participant 16

These responses show the diversity in thought regarding the perception of both one's well water and Maine's water as a whole, which deviated from solely discussion of arsenic contamination.

Sources of Information on Private Water Quality and Resources

Have you heard of the Maine Housing Arsenic Abatement program?

- Yes: 2 participants
- No: 16 participants

Have you heard government, town, or non-profit organizations talk about the dangers of arsenic in well water?

- Yes: 13 participants
- No: 5 participants

Sources of information:

- Social networks: 9 participants
- Organizations: 5 participants
- Media: 5 participants
- Government: 4 participants

A few participants listed multiple sources, but the most popular source of information was from social networks, such as hearing about well water quality issues from family, friends, neighbors, or realtors.

Accessibility

The ability to access and also understand information was an important theme in participants' responses regarding where they learned about arsenic contamination or resources to address this issue. Five participants cited receiving information from community organizations such as the Mount Desert Island Biological Lab (MDIBL) or the Blue Hill Public Library. While most participants expressed positive opinions of these resources, a few pointed out that information from local organizations can be inaccessible and too technical:

> *"The MDIBL has a lecture series in the summer for civilians or not scientists, because we've been to a couple of their technical stuff also at the Jackson lab. But I think within about 10 minutes, my brain goes to mush. It's too high end." – Participant 2*

and:

> *"I've heard a couple of lectures about the water in this area. I think it was at the Blue Hill library or something like that. And the scientific language was so far beyond my understanding that I can't quote any of it." – Participant 9*

Government resources were not widely accessed by participants, as only four said they had seen information on arsenic from the state of Maine website. Additionally, five participants said they did not hear about Maine's arsenic issue anywhere. Yet, no responses indicated feelings of frustration regarding lack of information or accessibility. Rather, they were matter of fact:

> *"No, there's nothing you know, there's not been a poster I don't think at the town hall about [arsenic]." – Participant 11*

Social Networks

Informal social networks, mentioned by half of the participants, were the most widely cited source of knowledge. This manifested as hearing stories of arsenic contamination from friends, family, and neighbors, receiving information from realtors, or getting help changing filters from friends:

> *"My in-laws built a house and they sent in a water test…and the testing agency called them because their arsenic levels were so high. They're like, 'we did not want to wait to email or mail your report to you; we needed to call you to make sure that absolutely no children were even touching your water, not even bathing in it, because your arsenic levels are so dangerously high.'"– Participant 5*

and:

> *"Within my group of friends, we're concerned about what's in our water. So that's what comes out in our conversations. And some of my friends have had their water tested." – Participant 16*

On the flip side, two participants noted that water quality tended to be a private issue:

> *"I never hear about people having problems. And I don't go around and say, well, how's your water?" – Participant 6*

and:

> *"It's not a topic that's come up in any conversation even with my friend. We both decided like 20 years ago, we should get our water tested and then we never did anything about it." – Participant 9*

National Context

Four participants mentioned the Flint, Michigan water crisis when discussing their knowledge of general water quality issues. The issue of Flint was brought up unprompted by these individuals. Some affirmed that Flint sparked general awareness of water quality issues in their communities:

> *"I think what happened in Flint, Michigan, has gotten everyone very alert about the drinking water. Where does it come from? Anything in it that we need to be concerned about?" – Participant 1*

and:

"I haven't heard a whole lot of conversations happening at community levels around drinking water other than like the national stuff happening with Flint and things like that." Participant 5

But, others acknowledged that the issue in Flint was a very different circumstance than what is happening Maine:

"The whole Flint thing I think did raise some awareness but again, that was town water, that was government-provided water and look at that. So I think there is some thought of, well water may be safer. And I think we worry so much about you know, like Matt Damon's water project and everything and then we don't know about the poverty in our own backyard sometimes." – Participant 13

Regardless of different perspectives on the Flint water crisis among participants, the mention of Flint illustrates another level of influence or an information source not explicitly asked by the interviewer. There is a national dialogue expressed among participants related to their source of water quality information, beyond the scope of their specific hot spot in Maine.

Barriers to Clean Water:

What has been the biggest barrier for you to access clean drinking water that you feel comfortable drinking? Is this barrier one that your friends and family face as well?

- Cost: 9 participants
- Awareness: 6 participants
- Self-barriers: 6 participants
- No barriers: 3 participants
- Landlords or drillers: 2 participants
- Unsure: 1 participant

A few participants listed more than one barrier, with awareness and cost most commonly grouped together. Most participants who had never tested their water expressed knowledge of arsenic contamination. All but one of the participants who cited lacking arsenic awareness in the community as a barrier to safe drinking water mentioned having previous awareness of the issue. Thus, most people that possess knowledge of arsenic contamination believe that others in their community do not.

Additionally, over half of those that tested their water cited cost as a barrier they had personally faced or felt others in their community would encounter in accessing safe water:

> *"We looked into getting a filtration system and it was going to be like $6,000 to treat everything…It came recommended to us and there was a UV component…but it was so much money. We were like we can't do it, we will just haul jugs around." – Participant 5*

and:

> *"Because I'm privileged I don't feel like I've had too much of a problem [accessing getting clean water] but I think it's unethical and kind of just unconscionable that we all don't have a surety of clean drinking water."– Participant 7*

Although cost was the most frequently cited barrier among all participants, especially among those that had tested their water previously, most individuals who had never tested their water previously did *not* mention cost. Rather, a majority of those that had not tested previously cited personal barriers, such as the "lack of capacity" or inertia:

> *"I've been wanting to get a test, like see the results for that. But I'm just trying to survive." – Participant 14*

and:

> *"My own laziness. Yes, my own inertia to figure out how to get the well tested and get it done and then take action based on the results. I don't get any outside encouragement or pressure— it has to come from me." – Participant 4*
>
> and:
>
> *"People don't know or aren't informed. I think some people are just overwhelmed with day to day living. And they talk about, 'oh arsenic, they told me I have arsenic', and it's just another thing." – Participant 11*

These responses indicate the internal struggles or difficulties in making time or effort to test water, even if individuals are aware of potential contamination risks. Yet, Participant 11's response also demonstrates the issue of lack of awareness. Lack of capacity or “personal barriers” can coincide with less awareness. Another participant also noted:

> *“I think probably a lot of people like me, particularly people who aren't really tuned in, you know. They got so many other things to worry about that one assumes that drinking water is safe.” – Participant 4*

Therefore, balancing other life needs or obligations in one’s life may detract from action to test water and also the capacity to seek out information. Not all barriers were internal, however. On the flip side, two individuals discussed “external” or more “institutional” barriers, such as struggles accessing testing by drillers and landlords:

> *“Not being a homeowner, [we have] to go through landlords and be on their timetable for getting things done.” – Participant 18*

and:

> *“I actually got the idea that my driller wasn't into testing really… He's a second generation well driller…I don't think he is into that…He's a smoker and like, why would you want to go there?” – Participant 10*

These two responses suggest other layers to clean water access and potential barriers from institutions. Beyond their recognition, participants did not expand on these external barriers, so assessing them to further depth or understanding the impact of these two barriers that are distinct from all others mentioned is limited. Overall, through their discussion of aforementioned barriers, participants mainly did not express sentiments of frustration over these hurdles in accessing clean or safe drinking water. Only one participant clearly expressed feelings of frustration when describing the inconvenience of hauling jugs:

> *“It seems so silly but in your day to day life when you're running around, it just can be really hard to make the effort to go get the jugs filled and fit that in. We make it happen because we have to, but it's amazing how much of a pain in the butt that can be.” – Participant 5*

State Intervention

What role do you think the state of Maine should play in regulating well water?

- Support regulations: 15 participants
- Oppose regulations: 2 participants

If you support state intervention, should tax dollars be spent on helping well owners (via education, testing resources, remediation assistance etc.)?

- Yes: 14 participants
- No: 1 participant

Government intervention was generally viewed as favorable among the 17 participants that answered this question. All but two participants reported they would support government-run awareness, educational, and testing campaigns. The main themes identified among these responses that supported intervention were the notion of collective responsibility and fiscal responsibility.

Collective Responsibility

The term "collective responsibility" describes a paradigm that assigns a moral impetus to act on a particular problem within a group, rather than on individuals, and also assigns blameworthiness on groups rather than the latter (Smiley, 2017). In our study, this theme was conceptualized as government responses to arsenic contamination. The concept of collective responsibility appeared to stem from the belief that water contamination was not an individual's responsibility and also due to the perceived duty of the state to address social issues:

> *"I think the state has a role, it's like safe highways. And the reason I feel that way about it is because the presence of water in the aquifer isn't an individual matter. It's beyond community. The presence of water in our ground is something that needs to be fairly regulated like the speed at which people drive over roads or the structure that supports the defense of our country. All of that is a collective responsibility." – Participant 16*

and:

> *"I think that government is supposed to look out for the welfare of the people, which means that...all people—not just like my class of privileged people who can afford to get water systems put on to their wells—should be able to have water they can drink." – Participant 7*

There is an emphasis on shared safety and shared benefits if water is regulated beyond the individual capacity as well as a dimension of fairness if the burden of water testing and ensuring access to protective resources is shouldered by a government entity.

Fiscal Responsibility

Other individuals took a more fiscal approach, citing that they supported government regulations because this could lower the burden of Maine's healthcare spending:

> *"I think all governments should protect its citizens to the highest level that's possible…Because goodness knows how many diseases are going to cost the state and the federal government and families' money from unhealthy water." – Participant 9*

and:

> *"How much money could we save on healthcare if we did [testing] proactively? These are the things I think the state should be involved in. And again because it levels the playing field for the poor members of this community." – Participant 13*

Another dimension of fiscal responsibility includes thoughtful spending, as one participant noted:

> *"I think [state intervention] should be done thoughtfully and efficiently. I think if the state's going to be providing [filters]...people can get their drinking water from a single tap. I think spending five or 10 [thousand dollars] so like every tap of their house was [filtered], just isn't necessary given the cost." – Participant 10*

Opposition

Two participants voiced opposition towards state intervention, due to either individual responsibility or a lack of perceived need. The latter is shown by this response:

> *"We have so much water in Maine, this is not India. We have so much water in Maine and it's good water. They say we don't have contaminants, so it's not an issue. So I don't see any surveillance by the government or anything like that…I think testing might be good to satisfy especially newer people because we have more people moving out of Maine than moving in…So, newcomers that are coming are going to be more cautious." – Participant 6*

Although this participant opposed intervention on the basis of its lack of necessity, he stated that free testing could incentivize more people to move to the state of Maine. Common threads can be seen between the two opponents to state intervention. They had either never tested their water or only tested once for bacteria. Both opponents had also previously stated they were not aware of any arsenic issues in their community and did not cite any barriers related to accessing testing or filters.

DISCUSSION

In this study, we ascertained opinions on well water safety, water concerns, government intervention, and gauged testing and filtration behaviors among well owners in a known arsenic hot spot located in the Blue Hill Peninsula in Downeast Maine. The overarching objective was to utilize qualitative methods to determine private well owners' opinions, drivers of testing and filtration, and their experiences of incurring barriers when trying to access clean drinking water.

We find that the main factors that appear to motivate water testing and filtering include prior health concerns (i.e. bladder issues or cancer), new homeownership, and general concerns of contamination due to changes in environmental quality over time. This reaffirms earlier studies in Canada that have observed that previous experience with illnesses may increase a well owner's negative perceptions of their water and heighten risk perceptions (Jones et al. 2006; McLeod et al., 2015).

Yet, nearly all participants note at least one barrier in accessing clean drinking water, with cost being the most prevalent. This aligns with other literature on private well testing behavior at the national scale. Across states, higher income and more well educated individuals have been found to be more likely to test their wells (Lothrop et al., 2015; Flanagan et al., 2015, Flanagan et al., 2016; Morris et al., 2016; Zheng, 2017; Colley et al., 2019). While cost and awareness are notable, other barriers exist.

Importantly, not testing does not necessarily mean lack of contaminant awareness or lack of risk perception. In contrast, over two-thirds of our sample expressed awareness of arsenic. Personal barriers, such as the "lack of capacity", which is characterized by the lack of time and effort to get water tested, were important. Aside from cost and awareness, personal barriers were the most common reason cited for participants' lack of prior testing. This is consistent with other research that has found inconvenience as a factor that lowers one's rate of water testing in the U.S. and Canada (Jones et al., 2006; Hexemer et al., 2008; Roche et al., 2013). Therefore, providing free tests or leading awareness campaigns alone may not increase well water testing and treatment if the process of testing or remediation is still perceived as too laborious.

Since a majority of those that had never tested cited these personal barriers to clean drinking water, as opposed to low awareness or high cost, it is important to not underestimate such barriers or diminish them as “laziness” or apathy. In contrast, the lack of water testing prioritization observed by several well owners is most likely because attention and concern are “scarce resources” (Xu et al., 2017). Individuals may be concerned about their water, but this worry may not take precedence over immediate concerns in their lives. This is not an isolated problem. Researchers in China noted low rates of air pollution concern among individuals living in highly polluted communities. They attributed this not to apathy, but rather due to the possibility of a “crowding-out effect” in competing for one’s attention and action (Xu et al., 2017). Since one’s capacity to provide attention is finite, this can pose barriers to following through with protective action. While some participants certainly may be apathetic towards the issue of water safety, we offer this alternative perspective to add greater nuance and caution against broadly assigning the label of apathy when evaluating the testing behavior of individuals in our sample.

Additionally, we find that besides individual barriers, two “external” barriers are important to discuss. Two participants noted that navigating the attitudes of drillers and landlords can pose barriers to accessing a well water test. While these respective concerns are only present among two separate well owners, no previous study on well water issues, to the best of our knowledge, has noted these forms of potential “institutional” barriers. As will be discussed later, this presents groundwork for further research.

Another component of the experiences documented among well owners in this hot spot included perceptions of Maine’s water. We find that among participants who avoid their well water, most do *not* hold negative opinions of Maine’s water at large. Those that do not drink their water are not more likely to have negative opinions on Maine’s water. Thus, personal experience with known contamination does not necessarily predispose one to negative perceptions of the quality or safety of water in the entire state. Rather, one’s opinions on the physical context of Maine influences their perceptions of water safety in the state as a whole.

A frequent characterization of the state being infiltrated by water bottle companies and private extractors contributes to negative water perceptions of the water in

Maine, not the contamination of the hot spot itself. Similarly, all positive perceptions of Maine's water that participants expressed surround their perceptions of place, characterizing the state's landscape as pollution free or lacking in industry. The notion of one's sense of place is derived from a social theory that argues that one's meaning and attachment for a specific geographical space influences how it is perceived and valued, aside from its actual physical attributes (Farnum et al., 2005, taken from Mulvaney et al., 2020). Sense of place analyses have found that one's perception of or attachment to their environment shapes their level of environmental concern or desire to engage in pro-environmental activities (Mulvaney et al., 2020). The dichotomous characterization of Maine as either being a natural landscape or a contaminated and extracted area reflects participants' very different senses of place. Our findings help to show that sense of place may shape perceptions of community water, aside from personal experience with contamination.

In addition to sense of place, we find that social and cognitive factors also influence well water behaviors and perceptions. This is because social networks, such as friends and family, are the most widely used source of information on arsenic among individuals in our sample, as opposed to more formal avenues such as the government or nonprofit organizations. Many participants spoke of others' stories of contamination when they discussed their own concerns or recalled experiences from past states and homes in other contexts. This supports previous studies in social and cognitive psychology as a predictor for safe drinking water behaviors (Hooks et al., 2019; Huber et al., 2012; Caputo et al., 2022). In particular, Albert Bandura's (1986) social cognitive theory, which holds that learning occurs in a social context and is influenced by one's environment as well as prior lived experience, is exhibited (Hooks et al., 2019). Thus, the main influences on perceptions towards the state's water include sense of place and social-cognitive factors.

The concept of social factors influencing well water beliefs is also exhibited in the opinions of state intervention. This is because there was an overwhelming notion expressed that preserving private water is a collective responsibility. A majority of participants report that they would support government-run awareness, educational, and testing campaigns and would use their tax dollars to do so. However, interviews with private well owners in Ireland revealed high levels of opposition towards government regulation, mostly due to distrust in government as well as fear of paying new taxes or fees if the government attempts to regulate water (Hooks et al., 2019). The lack of mention of heightened costs due to regulation among those in our sample may further demonstrate the belief of collective responsibility for private water protection. It is unclear, though, whether cost concerns would have surfaced if participants had been asked directly to speak to this topic. In contrast to the findings from Hooks et al. (2019), some participants in our study even cited that government regulation could be a cost-savings measure, in terms of cutting back state healthcare costs by investing in public health measures.

Besides influencing support, these social-cognitive factors may motivate opposition to state regulation, too. Given that both individuals who did not want state intervention reported not experiencing any barriers in accessing clean drinking water or hearing about barriers or reports of contamination from others, the social learning theory could explain this behavior.

Despite the widespread feelings of collective responsibility and the lack of participants that cited the government as a source of knowledge surrounding well water safety, feelings of frustration or anger towards the government are less observed. This is partly attributed to the nature of the interview questions. Participants were not asked explicitly to explain their feelings regarding water contamination or government intervention. Another reason for the observed lack of anger or blame assignment expressed in our sample is likely because there is not one individual or entity to point to for the contamination problem. The presence of arsenic is widely due to the underlying bedrock in Maine, not a specific source of pollution or government oversight. This is acknowledged indirectly in some responses. For example, although some individuals cite the Flint water crisis as an event that sparked concerns regarding their own water, they do not necessarily liken themselves to that situation. There is self-awareness observed among some individuals in our study regarding the difference between the respective hot spots and the context of each contamination problem.

The nature of the contamination is massively different in Flint than in the Blue Hill Peninsula. The former stems from corrosive water exposing lead in aging pipes and the latter is mainly the result of naturally occurring sources. In Flint, there is also evidence of government neglect, racial bias, and lawlessness, while Maine state officials have widely acknowledged the problem of arsenic and recognized its existence throughout the state. These key differences can also account for the less emotional or blame-driven responses observed. This is further supported by existing research that explores the impacts of "technological catastrophes", which are man-made disasters resulting from human technological error or malfunction (Baum et al., 1983, taken from Hamilton, 1985). They often take the form of chemical spills, meltdowns, and other forms of toxic waste exposure that carry long term public health impacts (Baum et al., 1983, taken from Hamilton, 1985). It is may be the case that naturally occurring contamination elicits a different psychosocial response than contamination that can be attributed to human error or failure to control point-source pollution. This could help to account for the lack of blame or "victimhood" expressed by individuals in the study.

Overall, these findings add important nuance to the limited literature on the lived experience of hot spots, particularly given the unique feature of this case where the contaminant is mostly naturally occurring rather than the result of intentional and point-source pollution, besides the potential role of residual lead arsenate application. These distinctions and the community members' perceptions of their own contamination have vital policy implications.

Limitations

Our research contains a few limitations. First, there is a lack of representation of renters in the interviews, as well as limited representation from individuals from each town in the study site. The size of the sample hinders our ability to generalize the findings beyond the study group. Similarly, given that the sample only had two opponents of state intervention, we caution before generalizing what factors may be contributing to residential opposition towards private well water regulation in the Blue Hill Peninsula. Additionally, no income information was collected, so it is difficult to understand how these responses may be related to one's financial situation. Even though cost was commonly cited as a barrier to testing or remediation, we do not know whether this sentiment reflected a specific socioeconomic experience. Moreover, while emotive data were collected in this study, there is no form of measurement. Emotions from participants were captured but, given the study design, we do not know how much weight they bear on individuals' opinions or perceptions. So, our capacity to draw conclusions from the emotions and feelings presented is limited.

Future Research

Future research should aim to include a greater number of well owners across known hot spots in order to increase the sample size and ensure a diverse set of perspectives related to well water perspectives and state intervention. Additionally, asking questions that include a scale to measure feelings such as trust, anger, and resentment related to water quality or the perception of the government can also help to capture more precisely the opinions of residents on these matters. Another approach to researching contamination would be to compare attitudes across those living in known hot spots and those in unaffected communities to observe how beliefs and opinions on water or state regulation may differ. Conducting a site comparison could also more clearly assess how living in a known hot spot may shape perceptions of Maine's water or the role of the government in regulating private well water. Because we note the finding of potential landlord and driller barriers to water test access, we believe future research targeting the perceptions and attitudes of private well drillers and landlords who manage a well on their property would increase the depth of knowledge of this potential "institutional" barrier related to water testing access.

Future researchers should also include more renters to compare barriers depending on homeowner status and collect data related to participants' racial or ethnic identity (though this diversity would be limited in rural areas) and income to better understand the distribution of barriers and identify systemic problems. Future research could explore the effectiveness of various outreach and free testing campaigns in arsenic hot spots in rural Maine. This would be best achieved by partnering more closely with local nonprofit or community-oriented organizations within communities to carry out more accessible public health measures for protection against contamination.

POLICY RECOMMENDATIONS

Beyond capturing narratives and uplifting personal stories of individuals in our sample, there are policy implications that can be learned and subsequently implemented. There are important financial dimensions of testing and the capacity to respond to arsenic contamination. In recent years, Maine has responded to such financial concerns related to testing and remediation, which was the most frequent barrier cited in our study. Newly passed policies in Maine, such as LD 1570 and LD 1263 appear to address these concerns by allocating funding for free or subsidized water testing and remediation, respectively, for low-income well owners. Other proposed measures, such as LD 1891, seek to ensure the longevity of these resources. Following the implementation of these measures, it will be important for the state to assess their effectiveness.

Yet, policy has still lagged behind in its ability to address well owners' apparent internal barriers, such as lack of time or capacity to seek out resources, concerns most expressed by those in our sample that had never tested. We propose utilizing some state funding already allocated for awareness and free test initiatives towards investing in free test pick-up and drop-off points. This could take the form of free tests available for pick up and then drop off on certain days in highly trafficked spaces, such as the Blue Hill Public Library, or dropping off free tests at individuals' homes. The latter has been assessed in previous studies. Hexemer et al. (2008) found that dropping off free water tests to homeowners in Ontario and retrieving them the following day doubled water testing rates relative to non-participants in the area (consisting of well owners that presumably had to pick up and deliver their own water tests to the lab).

Besides easing individuals' barriers of time if tests are dropped off and picked up by a third party, promoting testing incentives is another potential intervention. One way this could be achieved is by establishing a testing lottery modeled off of Maine's "Don't Miss Your Shot: Vaccinationland Sweepstakes" promotion. This promotion, which Governor Mills announced in June of 2021, encouraged coronavirus vaccines in the state by sponsoring a cash prize for eligible residents who received at least one vaccine and entered (Revello, 2021). If homeowners, renters, and landlords who accept and send back well water tests to HETL—whether for free or at a cost—are entered in a lottery to win money or receive another reward, this could increase testing rates. The winner of the Vaccinationland Sweepstakes won $1 for every resident that received at least one vaccine prior to the lottery's end date, increasing the incentive for more people to enter (Revello, 2021). Utilizing this form of incentive would be a novel strategy to address well water testing efforts but could be informed by key lessons from the state's coronavirus lottery.

Moreover, given our finding that very few individuals in the study have heard about well water issues from the government and instead rely on personal networks and local institutions, future policy in Maine should leverage partnerships with organizations that are local to the Blue Hill Peninsula, such as the MDIBL and the Blue Hill Public Library. Although state outreach may be ineffective currently due to few participants listing the government as a source of knowledge, because most participants were aware of arsenic, it appears that local organizations and social groups are filling the void in terms of awareness. Therefore, policies aimed at increasing accessibility of testing and remediation— rather than just awareness of arsenic— are more likely to produce greater protective behaviors in the community. It appears that individuals may be aware of water concerns but still lack access to means of protection. While some participants note that lectures from scientific institutions are sometimes inaccessible to lay audiences, their presence appears to be a meaningful avenue of knowledge. Hence, utilizing these existing community ties between well owners and local organizations may prove to be a beneficial strategy to bolster testing and protective behaviors.

One suggestion made by a participant during their interview was to start outreach in local schools. This strategy has seen success. Citizen science, when members of the public pursue research initiatives, such as data collection, has been a crucial and increasing form of arsenic outreach and testing. Since 2017, the MDIBL has spearheaded the "Data to Action" and "Arsenic in All Seasons" projects that involve students and their teachers in Maine and New Hampshire in the collection of water and soil samples for testing at the Trace Element Analysis Lab at Dartmouth College (All About Arsenic, 2019). Thus far, over 400 students have participated in submitting more than 1,000 samples (EurekAlert, 2020). A new grant-funded project called "Orchards, Gardens, and Fields" started up at the end of 2021 and seeks to engage communities in arsenic testing and gather more information about the potential implications of historical lead arsenate applications on Maine's orchards and farmland. Expanding upon similar efforts where community members in known hot spots are engaged in the water testing or outreach themselves is another suggestion for state funding allocation for the future.

The final note regarding policy suggestions is geared towards the framing of the arsenic issue and the actual dialogue surrounding the impacts of water contamination in Maine. The findings overwhelmingly demonstrate the need for multiple frames regarding the issue of arsenic in Maine. Frequent characterizations of Maine's arsenic problem often revolve around correcting an environmental injustice through state intervention, due to beliefs, as well as empirical data ascertained in some studies, that testing is linked to one's level of awareness and income (Defend Our Health, 2017; Belliveau & Nahimana, 2019; Flanagan et al., 2016). While these findings point to important barriers, advocacy can also be expanded to account for factors beyond these.

Due to the influence of health concerns we note in our findings, framing water testing and well water action as a health-based campaign and increasing efforts to address arsenic issues at healthcare locations (i.e. delivering free water tests to physicians' offices) may be effective ways to target well owners. This is just one example of ways the arsenic dialogue or frame can be expanded beyond a social justice or financial problem. Our findings indicate that increasing access to water tests and remediation must move beyond improving affordability or awareness. We suggest that the nuance in the framing of contamination problems be highly considered in arsenic policy advocacy and discussion moving forward.

CONCLUSION

In summary, inorganic arsenic contamination is a widespread issue throughout the world and particularly in Maine due to the underlying geology. Salient health concerns related to cancer, cardiovascular disease, and brain development are linked with the consumption of this form of arsenic, especially if exposure spans over several years. Yet, private well owners across America are widely left to fend for themselves in terms of water safety due to the exclusion of private drinking water from the federal Safe Drinking Water Act. Some campaigns exist in Maine to increase water safety and contaminant awareness for well owners, such as through the nonprofit organization Defend Our Health or research institutes, such as the MDIBL, that aid in education and testing efforts. Current policies in Maine also seek to address concerns related to the affordability of testing and remediation as well as the accessibility of information. But we find that the human experiences in the Blue Hill Peninsula and Deer Isle, an arsenic hot spot, reflect a story that is far more complicated.

While many participants are aware of arsenic and may not have barriers cost wise, access to clean water still remains a problem due to personal barriers. This is an important gap for current policy to address. Moreover, despite living in a known arsenic hot spot, participants have strong concerns over the bottled water industry— presumably unrelated to the quality of their own private well water. The concerns among private well owners are not singularly related to the presence of arsenic. This is likely because one's perception of place, beyond their individual experiences with contamination, may be another driver of opinions on water safety or quality. Moreover, the biggest source of arsenic information came from peers and social networks, highlighting the importance of informal avenues of information. This is a key consideration for future water quality policy to leverage in the state. Another fascinating dimension of information spread was a national conversation. While the Flint, Michigan water contamination issue is vastly different from the arsenic contamination in Maine, some well owners in the study appeared to be involved in national conversations and cited that this incident served as a catalyst for awareness of the safety of their well water. This reaction to Flint among primarily white, rural well owners is important and, even on a smaller scale, furthers our understanding of the national reactions and responses to this water crisis.

Ultimately, there was a strong desire for greater state intervention. Although most participants did not learn about arsenic issues from the state government and were unaware of policies and current measures in place to increase water testing and remediation, there was widespread support for more government-led action. Much of this can be attributed to the opinion that well water regulation and protection is a collective responsibility. Among well owners in our study, privately owned water is still considered a public good in many ways. This sheds light not only on the policy interests of well owners—which is not widely studied—but also the beliefs that span private water ownership.

Overall, the lived experience of participants described in this arsenic hot spot reflect depth and nuance not widely observed within Maine’s policy arena or existing literature related to private well water. Our findings indicate that to best achieve public health protection against exposure to contaminants in private water, it is pivotal for further research and policy considerations to reflect various lenses and perspectives. This work helps to serve as a necessary link between people and policy and amplify the stories of renters, homeowners, parents, retirees, and more. In doing so, it is clear that although “hot spot” is a convenient label, it does not do justice to accurately conveying the rich gradient of needs, opinions, and perspectives that persist in such communities. Living in a contaminant hot spot is not a monolithic experience. It is crucial for lawmakers, advocates, and organizers to listen to those living in hot spot communities and factor in diverse perspectives for effective policies and public health measures.

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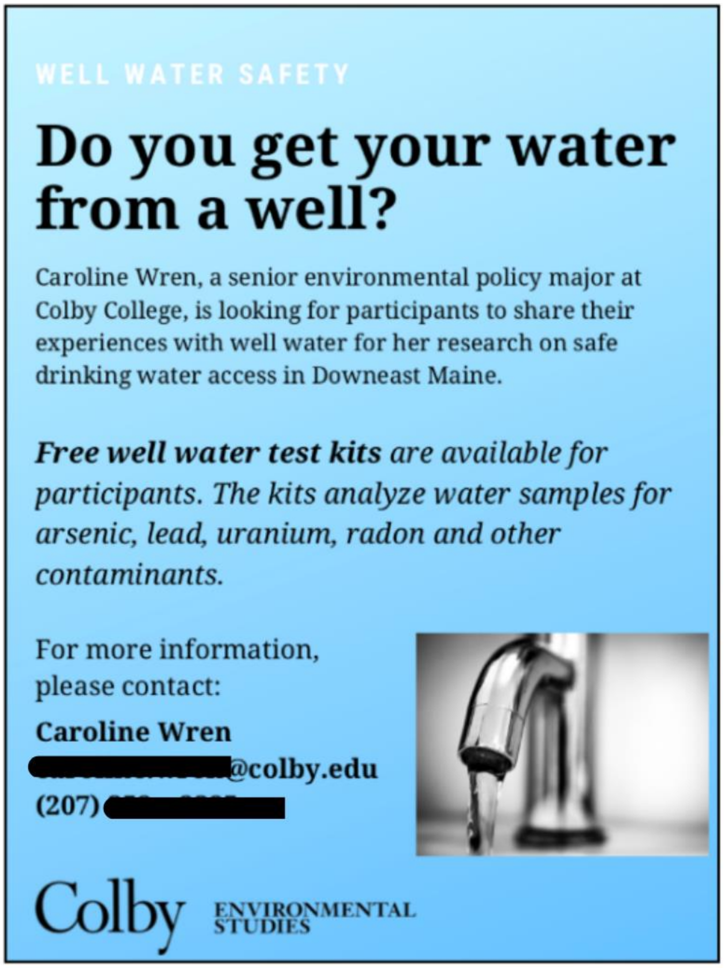
APPENDICES

Appendix A: Recruitment Poster



Appendix B: Interview Questions

Interview Questions

Questions will vary based on a participant's specific relationship to well water. Additional questions may be added as the interview progresses, and some questions that are not relevant to a particular individual may not be asked.

1. How do you access drinking water?
a. Do you know where you get your water from?
b. Have you ever experienced difficulties getting drinking water?
c. Are there any additional sources from which you get drinking water?

2. When you hear the phrase "clean and safe water", what do you think about?

3. What comes to mind when you think about drinking water in Maine?

4. Have you ever had any problems or concerns with your well and your well water?

5. What other concerns do you have about your drinking water?
a. Which of those concerns is the most troublesome to you?

6. What have you heard about contaminants in drinking water?
a. Which contaminant are you most concerned about that may be in your well water?

7. Specifically related to the issue of arsenic, what comes to mind when you hear about the problem of arsenic in well water? Lead? PFAS? Uranium? Bacteria?
a. Have you heard anything about these other contaminants?

8. Do you think everyone should have access to safe drinking water?

9. Do you have a well?
a. What type (Artesian, dug, drilled?)
b. How deep is your well?
c. When was it dug/drilled?

10. Who is responsible for maintaining the well (homeowner, landlord, tenant)?

11. If you are a tenant, how does your landlord communicate with you about the well water quality?
a. Does your landlord test the well water regularly?
b. How does your landlord report the results to you?

12. Have you ever had maintenance performed on your well?

13. Do you have any type of water treatment system (Reverse Osmosis, UV, ion exchange, etc.) installed in your home?

14. Have you ever tested your well?
a. How long ago? (If you don't remember, follow up with me later?)
b. Do you remember any of the results?
c. What made you decide you wanted to test?
d. Have you heard about your neighbors having contaminants in their well water?

15. Are you interested in testing your well (again)? *If they have never tested or it has been more than 5 years (Maine CDC recommendation is every year for bacteria and every 5 years for inorganic), or do not remember the results from their last test.

16. What role do you think the state of Maine should play in regulating well water?
a. Should tax dollars be spent on helping well owners (via education, testing resources, remediation assistance etc.)?

17. Have you heard of the Maine Housing Arsenic Abatement program?
a. Have you heard government, town, or non-profit organizations talk about the dangers of arsenic in well water? Lead? PFAS? Uranium? Bacteria?

18. What has been the biggest barrier for you to access clean drinking water that you feel comfortable drinking?
a. Is this barrier one that your friends and family face as well?
b. Do you know of any other barriers to accessing safe drinking water faced by friends and family?

Appendix C: Participant Consent Form

Consent Form
Colby College Department of Environmental Studies

Title of the Study: Well Water as a Human Right

Researcher Name: Caroline Wren, xxx@colby.edu, (207)-xxx-xxxx

The general purpose of this research is to understand barriers to accessing drinking water that exist in Maine based on personal experiences with well water. These barriers will be used to inform a series of policy recommendations designed to help guarantee water as a human right in Maine. Participants in this study will be asked to answer a series of interview questions about their own personal experience with drinking water. They may also be asked if they would like to test their well water as there are free testing resources available as part of this research. Understanding the challenges Mainer's face is important in order to develop effective and relevant policy that protects well users in Maine. The interviews collected will be used to create a short documentary about well water as a human right. There will also be a written component to the research in which participants may be referenced.

Informed consent is required by Colby College for any person participating in a College-sponsored research study. This study has been approved by the College's Institutional Review Board for Research with Human Subjects.

I hereby give my consent to be the subject of this research study. I acknowledge that the researcher has provided me with:

A. An explanation of the study's general purpose and procedure.
B. Answers to any questions I have asked about the study procedure.

I understand that:

A. My participation in this study will take less than one hour.
B. No unusual risks are anticipated as a result of participating in this research.
C. The potential benefits of this study include empowering participants with information about the safety of their well water, including test results in some cases, educating the general public about issues that real people face when accessing drinking water, and potentially informing policy change at the local and state level.
D. I will not be compensated directly for participating in this study, but there are free testing resources offered as a part of this research.
E. My participation is voluntary, and I may withdraw my consent and discontinue participation in the study at any time. My refusal to participate will not result in any penalty.
F. The specific nature of this research and what the investigators hope to learn from this study will all be fully explained to me at the end of the session.
G. Individual participants will be quoted and mentioned by name in the final product of this research, a short documentary and a written summary (See Permission to Record). All personal data collected for the purpose of coordinating interviews such as physical address and all forms of contact information will be

kept confidential. The physical home addresses and personal contact information of participants will not be included in the research in any way.

H. After the study's purpose and procedure have been fully explained to me, I may, for any reason, choose to withhold use of any data provided by my participation.

I. If I decide to test my well water as a part of this research, I give permission for my water samples to be transported to Northeast Laboratory Services in Winslow, Maine. The results from the water test will be sent directly to me, the participant. After receiving the results, I can decide whether or not to disclose those results to the researcher.

Signature ___________________ Date________________

Appendix D: Participant Permission for Audio and Visual Recordings Form

Permission for Audio and Visual Recordings
Colby College Department of Environmental Studies

Title of the Study: Well Water as a Human Right
Researcher Name: Caroline Wren
My name is Caroline Wren, a student at Colby College, and I am doing a research project that examines how people in Downeast, Maine access, experience and interact with well water. As part of this research project, the researcher will make an audio and video recording of you while you participate in the study. Please indicate what uses of this recording you consent to by initialing below. We will only use the recording in ways that you agree to. In any use of this recording, your name would not be used unless you consent to being personally identified.

A. The recordings can be studied by the researchers as part of this project.
Please initial: Yes ____ or No ____
B. The researchers can identify me by name in publications or presentations. (If you mark No or
leave this prompt blank, then the researcher will use an alias instead of your real name.)
Please initial: Yes ____ or No ____
C. The content recordings can be referenced in scientific publications.
Please initial: Yes ____ or No ____
D. The results from the recordings can be presented at scientific meetings.
Please initial: Yes ____ or No ____
E. The recordings can be presented to other participants.
Please initial: Yes ____ or No ____
G. The recordings can be presented on radio or television programs.
Please initial: Yes ____ or No ____
H. The recordings can be used in a short documentary film that will be shown at public screenings.
Please initial: Yes ____ or No ____

I have read the above description, I give my consent to be recorded, and I give my consent for the recording to be used as indicated above.

Signature__________ Date__________

Appendix E: Participant Debrief Form

Debriefing Form

Colby College Department of Environmental Studies

Title of the Study: Well Water as a Human Right
Researcher Name: Caroline Wren
Thank you for participating in this research study. I am conducting this study to understand the barriers that exist for individuals accessing drinking water from wells in Maine. I aim to develop policy recommendations for the state of Maine based on how people Downeast access, experience and interact with well water. The policy recommendations will help ensures that everyone can access safe drinking water, including well owners. The main research questions are: How do individuals in Downeast Maine experience drinking water? What are the barriers to accessing safe drinking water? What policies rooted in personal experience could the state of Maine implement to improve access to safe drinking water?

Your interview will be reviewed along with interviews from other participants and used to tell a story about drinking water access in Maine. I will make a short documentary film about this issue, as well as a written report. From previous conversations with well owners in this area, I expect that clean and safe drinking water is a luxury that not everyone has access to. Cost, lack of information and other barriers make it difficult for well owners to properly regulate and maintain their wells, and contamination and costs of mitigation may also be barriers to safe water. There are policy interventions that the State of Maine could employ to ensure that water is a human right.

If you are interested in learning more about this research or would like to share more information about your experience at a later date, please feel free to ask me questions in person, or contact me at xxx@colby.edu or (207)-xxx-xxxx. If you decide to test your well as a part of this research and would like to talk about your results, please do not hesitate to reach out to me as well.

If you would like to learn more about drinking water in Maine, I recommend the following readings:

Flanagan, S. V., Marvinney, R. G., & Zheng, Y. (2015). Influences on domestic well water testing behavior in a Central Maine area with frequent groundwater arsenic occurrence. *The Science of the total environment, 505*, 1274–1281. doi:10.1016/j.scitotenv.2014.05.017

https://bangordailynews.com/2016/10/31/news/state/study-less-than-half-of-maine-households-with-well-water-test-for-arsenic/

If you have any concerns about your rights as a participant in this study, please contact the Chair
of the Colby Institutional Review Board for Research with Human Subjects, Mark Tappan
(xxx@colby.edu). You may also reach out to research supervisor, Gail Carlson at xxx@colby.edu. Thank you again for participating!