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Kathleen Spooner

Union College - Schenectady, NY

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There Must be Something in the Water:

A Comparative Study of Ground Water Contamination in the U.S.A. and Canada

By

Kathleen Spooner

UNION COLLEGE

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ABSTRACT

The regions of Nova Scotia and New Hampshire are naturally susceptible to arsenic water contamination due to their geological makeup. These locations are relatively rural, with many of their citizens reporting low incomes and lacking education, the majority of which are unaware of the risk of arsenic poisoning. There is also a high dependency on private wells which are not regulated in terms of water quality under federal law in both countries. Arsenic water pollution is undetectable as it is both odorless and tasteless and potentially very dangerous, and therefore water testing must be performed on wells, which is currently the responsibility of the well owners in both regions. Through numerous case studies regarding arsenic contamination in Nova Scotia and New Hampshire, research found that federal policy is needed to protect against long-term exposure to arsenic in private well water. This policy must be accessible and affordable in order to ensure the safety of the most vulnerable populations in Canada and the United States.

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CHAPTER ONE: LITERATURE REVIEW

1.1 Introduction

The public health issue of water contamination is a common theme in politics that does not discriminate globally, as it negatively effects countries of all levels of development, wealth, and climate. It is estimated that 2 billion people worldwide drink impure water, contaminated by foreign substances that could be harmful to their health (NIEHS). The United States of America and Canada are no exception as both struggle with water pollution. The National Institute of Environmental Health Sciences defines water pollution as, “any contamination of water with chemicals or other foreign substances that are detrimental to human, plant, or animal health. These pollutants include fertilizers and pesticides from agricultural runoff; sewage and food processing waste; lead, mercury, and other heavy metals; chemical wastes from industrial discharges; and chemical contamination from hazardous waste sites” (NIEHS). A compiled study of all contaminants would be an extremely extensive project, and for this reason, a narrowly focused approach on heavy metal private water contamination will take place. There is currently no substantial public health policy in place in either New Hampshire nor Nova Scotia, a problem that this thesis seeks to address. This thesis aims to bring together the social demographics and natural geology of New Hampshire and Nova Scotia in the creation and suggestion of new, accessible, and, effective federal public health policy, protecting against the threat of arsenic contamination in private water sources. The issue of arsenic contamination in private well water will be viewed through the perspective of conflict theory, as the risks of contamination affect those in positions of vulnerability more so than those in power. The lack of resources and wealth within the effected populations is a subject that must be addressed from the perspective of conflict theory in order to properly evaluate the inequality occurring in the United States and

Canada. In offering new, effective policy, vulnerable groups could be empowered to take control of their health and wellness, and support others in doing the same regardless of their educational background or income as this policy would aim to be accessible to *all*.

1.2 Demographics

The northeastern United States and Atlantic Canada regions both have rich histories of water pollution struggles within their rural communities. Rural water is at greater risk of contamination because families rely on private wells dug into the bedrock of the area. These communities consume their well water daily, for years upon years, and the quality of their water is the responsibility of the owner. On the other hand, urban communities co-depend on municipal water (public water), and its quality is regulated by the municipality and is the responsibility of the government in both Canada and the United States. The lack of regulation of private wells in rural communities is one cause of contamination issues, and the outcome of consuming contaminated water includes major diseases within the families who drink the private, polluted water. For this reason, the rural regions of Nova Scotia and New Hampshire will be the focus of this paper as their communities are often reliant on well water, which the government has failed to protect thus far. It is necessary to mention first though, why this issue is important, especially if you are located outside these two regions. Arsenic does not exist strictly in these chosen locations. Rather, it is a global geological health issue. Whether you reside in Nova Scotia or New Hampshire is beyond the point, as you could still be detrimentally affected by the health risks associated with arsenic, and potentially be unaware of its existence in your well water. The two regions of Nova Scotia and New Hampshire have been selected as case studies with the purpose of comparing their geology and the existing policies of both countries.

However, it is vital that the information in this thesis reaches an audience beyond these locations as so that the effects of education about the issue of arsenic becomes widespread.

Nova Scotia, one of four Atlantic provinces in Canada, has a total area of 21,300 square miles and its population is 940,600, 44 percent of which live in Halifax, the provincial capital, and the vast majority of which are white (Nova Scotia Population). Many Nova Scotians live in rural conditions and these rural-based families must rely on private well water. It is estimated that 40% of Nova Scotians rely on private wells and here, well owners are responsible for the safety of their water. This latter fact will become a theme throughout this paper.

The United States shares many commonalities with Canada, one of which is that certain states are significantly more rural than others, one being New Hampshire which is comparable to Nova Scotia. Two vital commonalities in regards to health safety is their high percentage of rural dwellers, as well as their struggles with naturally occurring arsenic, causing private well water contamination. New Hampshire is more heavily populated than Nova Scotia, with 1,360,000, citizens in an area of 9,349 square miles (New Hampshire 2019). Once again, the racial construction of New Hampshire is extremely polarized, with 93 percent of the population reporting as white (New Hampshire). The state, like Nova Scotia, is said to have approximately 40 percent of the population reliant on domestic wells, (NHDHHS), and both regions struggle with aspects of rural living, which include poverty, lower levels of education, and polarized racial groups often, in this case majority white. Poverty is a theme throughout rural areas globally, although the image and reality of poverty differs depending on where one is located. In New Hampshire, the median household income is \$71,305USD (New Hampshire 2019). On the surface, this state does not struggle with poverty as it ranks quite high against other states in terms of median household income. However, there are rural communities who are not as

economically stable as the state average suggests, and this group will be explored further later in this paper. If the median income of New Hampshire is compared to Nova Scotia's median income, there is a noticeably large wealth gap; the median household income reported in 2016 for Nova Scotia was \$60,764CAD, which is equivalent to \$46,215USD (Nova Scotia Finance and Treasury 2016). This difference of nearly \$25,000USD demonstrates that poverty is not uniform across geographical regions. Poverty in New York City looks different from that in New Hampshire, which in turn does not mirror the economic situation in Nova Scotia. The characteristic of poverty within the rural communities of New Hampshire and Nova Scotia is significant because testing and treating your own water can be expensive. If these people are struggling to meet their basic needs, it is very unlikely that they would put aside money for inspecting their water quality, especially if they are not showing any health symptoms commonly associated with water contamination. The low-income communities in these regions are exposed to the health risks of arsenic exposure due to the inequalities posed by conflict created by competing interests, which in this case are the interests of the government (Conley 2017:32). Competition is essential in nature, especially in terms of economics in capitalist societies. There are no economic benefits to better these communities in the eyes of both Canadian and American governments, and such attempts to do so have been futile. Unfortunately, these notions are supported by conflict theory in which the government would not engage in actions that would not be beneficial to them. This conflict drives social change, and this could turn into evolution in our society which would see change in low-income communities. However, this is not an excuse to deny rural communities' access to clean, uncontaminated water. Therefore, it is suggested that subsidies be available to families in economic need to treat their water in order to protect themselves and their families.

Poverty is not the only demographical characteristic of rural areas; education is also a common factor here. Most New Hampshire citizens have their high school diploma, 93 percent, however, only one third of citizens achieved a bachelor's degree or higher (New Hampshire). This can be compared to its neighboring state of Massachusetts that has an education rate of 42 percent, well over one third, of the population receiving a bachelor's degree or higher. On the other hand, the educational background of Nova Scotia includes 25 percent of the population holding a high school diploma as their highest level of education, and 36 percent of the population holding a college diploma or bachelor's degree (Statistics Canada 2016). The reason that education matters when it comes to water safety is similar to the issue of poverty; less educated people are less likely to be aware of arsenic and its dangers. In order to be proactive about regulating your own water supply, one must be aware of the possibility of contamination in the first place. Those who lack education are also less likely to have the tools to advocate for themselves on a state or federal level. Here, it can be seen how widespread the effects of inequality between rural and urban communities are. The common rural characteristics of poverty and a lack of education in both regions, paired with the detrimental geology, creates the premise where arsenic poisoning is an unknown threat to these communities.

1.3 Arsenic

Arsenic is the second most important global health hazard related to drinking water, and is classified as a toxic metalloid and class I human carcinogen (Chappells et al. 2015:1251). It is a very common element in the Earth's crust, and its effects are not limited to any one area, instead spanning the globe. Although it is a metalloid, arsenic exists in three different compounds: inorganic, organic, and arsine gas. Arsenic poisoning is caused through four main avenues of exposure: food, water, soil, and, air, the second of which is the focus of this paper.

With these different forms of arsenic in mind, it is then a question of how does arsenic appear in the water of private wells. Arsenic can appear in any source of water, but the water quality of public sources are government regulated and therefore will not experience the issue of arsenic contamination that private, unregulated wells experience. In the area of New England, 2.3 million citizens are estimated well users (Dartmouth). The single state of New Hampshire is estimated to house approximately 100,000 private well users reliant on water with elevated arsenic concentrations (Dartmouth). In Nova Scotia, 40 percent of the population rely on wells, and in both cross-border locations, well owners are responsible for the safety of their water (Chappells et al. 2015:1260). However, in order for arsenic to enter any source of water, arsenic must first exist in the bedrock, which will also be referred to as the geology of the region. Due to this reason, the geology of New Hampshire and Nova Scotia must be examined in depth in order to understand the problem of arsenic contamination.

As has been previously stated, New Hampshire and Nova Scotia's geology is a main factor as to why both states suffer from high arsenic levels in private water. However, their geology is not identical. Following the diagnosis of one major case of arsenic poisoning, an investigation examining Nova Scotian water sources suspected of arsenic contamination was performed. Nova Scotia has a long history of mining, specifically for gold, as its geology includes deposits of arsenopyrite within the quartz containing gold (Grantham and Jones 1997:654). One specific band containing such arsenic spans 430 kilometers of the province from Yarmouth to Canso (Grantham and Jones 1997:654). While it was thought that arsenic was only an issue in the gold mine regions of the province, it has been discovered that arsenic reaches far beyond this. Zheng and Ayotte explore Nova Scotia through a study where samples from wells in various gold mine districts indicated that 13 percent of wells contained $>50\mu\text{g/L}$ of arsenic

(Zheng and Ayotte 2015:1238). Next, 12 percent of well samples taken from non-gold mine district wells were found with $>50\mu\text{g/L}$ of arsenic, which suggested that arsenic in groundwater is not limited to gold mine districts (Zheng and Ayotte 2015:1238).

As arsenic has been found to exist beyond the gold bands in Nova Scotia, the next realization was that arsenic can also occur in granite, coal, and the oil of shale or sandstone, all of which exist in Nova Scotia's geology. There are man-made causes of arsenic too, the most credible being mine tailings and waste rock; mine waste rock is distributed across the province in the forms filling roadbeds or walling wells. One study concerning arsenic water contamination found that wells are the most susceptible water source because they are affected by both tailings and waste rock. Also, they may accidentally drill into abandoned mine workings, and may have to be drilled into the primary geology of the area which as previously discussed, consists of bedrock containing arsenic associated minerals (Grantham and Jones 1997:654). The movement of arsenic into groundwater is made possible in Nova Scotia in part due to the mining activity that has taken place in the past. Arsenic can also contaminate groundwater, and hence private wells, without any assistance from man. This lack of purity is true in the case of New Hampshire, where natural arsenic movement into local groundwater is the main way through which water becomes contaminated. The state naturally has water with the right geochemical conditions to create high levels of arsenic: relatively high PH levels, paired with little dissolved oxygen (Dartmouth). New Hampshire is at a greater risk of arsenic contamination, as opposed to other American states, due to metasedimentary bedrock units in which 30 percent of wells drilled in this region had elevated arsenic concentrations (Ayotte et al 2003:2075). Through the study of several wells in New Hampshire, it was found that arsenic concentration levels in the water varied from low (safe) levels to levels which are potentially harmful to humans (Levitt et al.

2019:1669). Private wells located in areas drawing from glacial aquifers had lower levels than those drawing from bedrock aquifers, suggesting a positive correlation between New Hampshire's bedrock and high arsenic concentrations in private well water (Levitt et al 2019:1681). Supporting Levitt's research is another study that took place in New Hampshire which examines potential causes of arsenic contamination in the region. Water samples drilled came from bedrock and surficial wells, with the former containing higher arsenic levels and the latter containing the lowest levels. From this information, it is suspected that the majority of the groundwater arsenic in the New Hampshire region comes from weathering of bedrock materials (abundant pegmatite dikes associated with nearby granites), and not from anthropological contamination (Peters et al. 1999:1328).

Armed with the information of how arsenic moves into groundwater, the next question one may ask regarding arsenic safety is why should one care about this natural contaminate. The answer lies in various studies done on the numerous negative health effects caused directly by acute and more recently, long-term exposure to arsenic in drinking water. There are three human samples that are most often used when testing for arsenic: hair, toenail clippings, and urine samples. By looking at a toenail clippings, for example, which provide a biomarker of exposure, researchers are able to explore the levels of arsenic and infer conclusions from those findings. It is important to note that the symptoms of arsenic poisoning appear the same no matter where in the world the contamination takes place. Arsenic poisoning in the New Hampshire populace will mirror the symptoms of Nova Scotians who are affected, and because arsenic is tasteless, odorless, and transparent, one will not be aware of arsenic contamination without testing. A study coming from Nova Scotia used a sample size of 892 men and women all of whom provided drinking water samples along with toenail clippings. These samples were analyzed for

arsenic levels, and it was found that geological and environmental factors correctly predicted arsenic concentrations, and these factors contribute to high levels of arsenic in well water (Dummer et al. 2015:1254). Body burden can be understood as the effects a pollutant has on the human body, and how drastic the consequences of specific levels of said contaminant are. In the case of Dummer's study, the high concentration of arsenic found in drinking water held the responsibility for arsenic body burden among Nova Scotian residents (Dummer et al. 2015:1255). The long-term effects of arsenic have a heavy body burden, often ending in late-stage cancers as was discovered in the research of Saint-Jacques et al. that observed the long-term effects of low-level exposure to arsenic in drinking water. The results show an increased risk of bladder cancer, and potentially of kidney cancer, from exposure to drinking water with arsenic levels that are thought of as 'safe' (Saint Jacques 2016:8). These 'safe' concentration levels are currently within the boundaries of acceptable levels of arsenic in drinking water, as stated by the World Health Organization (0-5ug/L) (Saint Jacques 2016:8). A case derived from Nova Scotia has findings that support knowledge that arsenic exposure higher than 10ug/L (which was the current regulatory guideline set by the Canadian government) in drinking water can increase the risk of bladder cancer by a minimum of 40 percent (Saint Jacques 2016:145). Nova Scotia has high rates of bladder and kidney cancers, a fact of which will be studied throughout the remainder of this paper. Along with these cancerous effects, there are non-cancerous consequences of arsenic. These include cardiovascular, pulmonary, immunological, neurological, and endocrine effects (United States Environmental Protection Agency 2018). If the owners of private wells are not aware of the threat arsenic poses in both New Hampshire and Nova Scotia, as well as other effected areas globally, the public is not able to protect themselves nor their families. Furthermore, individuals are forced to be reactive to the issue rather than

proactive in ensuring a high quality of water. Public policy must extend past municipal water sources into the private sphere in order to uphold the health and water rights that all of humanity deserves.

1.4 Public Health Policy

Although there is a wealth of literature revolving around the health issues caused by arsenic poisoning and its natural occurrence in specific geology, there is ultimately no public health policy that protects private well users against the dangers of arsenic. Across both Canada and the United States, there is either state or federal law, or both, actively in place that ensures the safety of municipal water sources. Within Canada, federal law regulates public water quality, while in the U.S., there are federal and state laws in place for this same reason. However, as has been previously stated, a large portion of both populations live in rural areas and rely on private well water for their families. Here lies the center of the issue of arsenic contamination and therefore the center of this paper. There are several points that must be described in terms of public policy regarding arsenic: to start with, how has policy evolved over time, what policy exists today, and what methods of regulation work and do not work to keep the public safe.

In terms of the regulation of inorganic forms of arsenic levels in public water sources, the allowable or 'safe' concentration number has fluctuated over time. In Canada, it took the case of arsenic poisoning in the year 1976 in Nova Scotia for intense research to begin regarding arsenic contaminated water (Grantham and Jones 1977:653). The investigation of the poisoned individual's water quality revealed arsenic levels of 5000 $\mu\text{g/L}$, which far exceeded the previous standard of 50 $\mu\text{g/L}$ set by the Canadian government (Grantham and Jones 1977:653). The investigation that took place resulted in the conclusion that "there is virtually no doubt that water with an arsenic concentration of >100 $\mu\text{g/L}$ is toxic, and it appears that there is no justification for

raising the maximum permissible limit above 50µg/L” (Grantham and Jones 1977:653). While this investigation thought 50µg/L to be a safe level for arsenic, the pathologists did not believe this to be true. Instead, they believed that water with arsenic concentrations of > 50µg/L should be considered toxic (Grantham and Jones 1977:653). This study is extremely relevant in this paper as it illustrates the controversy and indecision regarding what the safe level of arsenic in water is. Nearly 40 years after this original investigation in Nova Scotia, researchers at Dartmouth College agreed that the dose threshold is unknown. There would be a massive benefit of knowing the dose threshold of arsenic because it would allow both scientists and politicians to have a strict guideline as to what specific amount of arsenic is unsafe over a certain exposure duration. This idea of an unknown dose threshold will be explored in later sections of this paper.

Decades after this unfortunate health event took place, the Canadian government currently has the federal Canadian Drinking Water Standards level of arsenic at 10µg/L (Government of Canada 2008). While the Canadian government believes this level to be safe, the language used to support their regulation limit is vague: “this guideline for arsenic has been set at a level that is higher than the level that would be considered to be associated with an ‘essentially negligible’ risk, based on limitations of available treatment technology” (Government of Canada 2008). Immediately, there is controversy over this allowable level of arsenic as has been voiced by Grantham and Jones, Saint-Jacque et al., and others, as they believe it is too high and does not protect the public from the effects of long-term exposure to arsenic in water (Saint-Jacques et al. 2018:102) (Grantham and Jones 1977:656).

The federal government of Canada’s neighbor, the United States, has much more informative text surrounding arsenic contamination of public water and is more up to date than the information provided by the Canadian government: “in 2001, the EPA adopted a lower

standard for arsenic in drinking water that applies to both community water systems and non-transient non-community water systems. The new arsenic standard of 10 parts per billion (ppb) replaces the old standard of 50 ppb” (United States EPA 2018). This new standard reflects Canada’s regulatory limit, although it includes a confession of previously higher standards that were not safe for public consumption. Although the language of the two laws differ, the message remains the same: public water is protected and monitored under federal law, private water sources are not.

Far beyond the United States and Canada, there is informative material on arsenic water contamination, both strong and poor in its effectiveness. The World Health Organization (WHO) is an international organization that holds a vast amount of information covering almost every field related to health and health problems. However, their coverage of arsenic as a contaminant and poison falls short in terms of its wealth of data. They are not the only organization to fail in presenting proper data, however they are perhaps the most accessible source on a global scale, and for this reason the WHO will be examined first. The WHO provides a basic explanation of the adverse health effects that both short and long-term exposure to arsenic can have on humans, as well as the different sources of arsenic in the diet (Arsenic). With this being said, Saint-Jacques reveals that long-term consumption of water that has arsenic levels within the currently acceptable levels as stated by the World Health Organization (0-5µg/L), showed increased risk of bladder cancer, and potential kidney cancer (Saint-Jacques et al. 2018:95). The fact that this level of arsenic is considered safe by both Canadian and American governments, when it has been proven it is not, is a direct example showing that the WHO must review the regulation of arsenic. Furthermore, the WHO does not offer many realistic nor effective solutions to the world problem of arsenic contamination, specifically of drinking water. Their suggested solutions to the

problem include: substituting high-level arsenic sources for low-arsenic water, marking high-level wells, and installing arsenic removal systems (Arsenic). These suggested solutions are not realistic in rural regions that may have little access to any water, least of all clean water, or even in urban areas these may not be cost-efficient for homeowners to afford. In the case of New Hampshire and Nova Scotia, many private well owners would not be able to afford these solutions should they even know about the contamination to begin with.

Authors including Chappells et al., Pye, and, Saint-Jacques, all speak of a lack of knowledge and policy when it comes to arsenic contamination in private water sources. Through the WHO and Saint-Jacques' critique, it has been demonstrated that existing accessible literature fails to properly educate the public on the risks associated with arsenic water poisoning through short and long-term exposure. The fact that citizens in high-risk areas, like New Hampshire and Nova Scotia, do not know that they are at risk is one issue, while the lack of effort in ensuring the safety of residents from the state and federal government is another issue. While a segment of the American and Canadian populations has embraced capitalism and succeeded in this type of society, other have not reaped the benefits of this system. The governments of these countries have awarded municipal communities with water treatment systems, while they have ignored those communities reliant on wells. Well users are now left to fend for their health safety without any assistance, financial or educational, from their local, state, or federal governments. The issues of poverty and education are not independent from one another; rather they are intertwined in the overall lack of awareness and research on the subject. The government has a responsibility to inform their citizens of potential natural water contaminants, including but not limited to arsenic. Currently, there are government strategies aimed at raising public awareness of arsenic poisoning; however, these attempts are neither abundant nor effective in their operation. A

particular study found a new avenue of education targeted at vulnerable populations and at-risk groups. Zheng and Ayotte explore eastern New England and Atlantic Canada water quality, specifically arsenic contamination, and policy in said regions. These sources show that neither Nova Scotia nor New Hampshire have any regulations regarding testing in private well water occurrence rate at the state/provincial level even though both have a geological predisposition to high levels of arsenic (Zheng and Ayotte 2015:1242). The authors suggest policy that aims to protect at-risk populations, namely fetuses and young children. They suggest that public health campaigns target young families and pregnant women. This is an example of public policy that must be explored more and applied even further than the groups mentioned, as it could be effective in reaching rural people, those of low-income and the less educated. These health campaigns that Zheng refers to could either be private or publicly funded. While Zheng does not specify which is better, Chappells' research in Nova Scotia examined this very fact. In using a sample of Nova Scotian residents located in areas with varying risk of arsenic exposure, Chappells et al. explored the level of knowledge these residents held regarding the risk of arsenic exposure in well water in Nova Scotia. The results showed that there was a general satisfaction with overall well water quality, and the majority (83 percent) reported using the well as their primary source of drinking water (Chappells et al. 2015:1264). Of the total respondents, less than half were very confident that their well water was safe to drink, while 41 percent were only 'quite confident' in their water quality (Chappells et al. 2015:1265). What can be seen as concerning in these results is the finding that although people were very concerned of arsenic as a contaminant, the majority had little to no concern of the risk of arsenic in their well water. This disconnect was failed to be seen in Zheng's research, along with many others. The public must first be made aware of the risk of arsenic in well water, and know that they should be concerned

about this possible contaminant. Once the public knowledge is established, then steps can be made towards water purification. The next question then is testing; if the public is aware of possible water contamination, are they being proactive in testing their water regularly in order to ensure quality? Water testing is crucial in the case of arsenic due to the fact that arsenic is both tasteless and odorless, making it undetectable unless testing takes place (Zheng 2015:1243). Both Chappells and Zheng found that the majority of their sample groups do not test their water regularly in line with advisories from government agencies (Chappells et al. 2015:1270) (Zheng 2015:1244). The reasons for not testing their water included inconvenience, inability to interpret test results, and cost. Inconvenience is a major factor as it encompasses various steps in the process of testing water samples, including: deciding which contaminants to test for, collecting sample bottles and delivery, and finding a testing laboratory (Chappells et al. 2015:1270). Recently, the Canadian government has revoked subsidies that covered the cost of supplying sample bottles, and therefore testing locations were even more limited in local Nova Scotian communities. Although it was shown that by making drop-off and sample collection easier and more convenient, more private well users opted to test their water regularly, there remain issues that restrict testing. An especially interesting factor that Chappells touches on is the idea of the source of arsenic awareness information, “results concerning sources of information suggest that official information in the form of government arsenic factsheets are failing to reach their target audience, with most well users accessing this information reporting it was self-sought. Many well users expressed distrust of arsenic awareness information from other sources, such as private testing or treatment companies, but this is reported as the main channel of information regarding well water concerns” (Chappells et al. 2015:1271). While the government is the most trusted avenue of raising awareness of arsenic risk among well users in Nova Scotia, the main

channel of communication is the private avenue as Chappells stated. Specifically, the property transfer process is used to inform buyers of any risk of arsenic, making realtors, developers, and contractors all important players in the area of arsenic awareness information among the private well user community (Chappells et al. 2015:1271). As Nova Scotia has no policy at this time protecting well users, the suggested policy in the following sections will take into account the current shortcomings of the government-provided information that is nowhere near effective enough to protect Canadians. New Hampshire is in a similar situation in terms of the population lacking knowledge on the natural risk of arsenic contamination in the region. However, New Hampshire citizens can go to the state, obtain a decanter free of charge, and have their water sample tested at a cost of ten to fifteen dollars (Dartmouth). The testing process includes heating the water sample up to extremely hot temperatures, which evaporates excess water, leaving behind any elements of contaminants. A mass spectrometer then counts the atoms of the elements which in turn determines the concentration of any present contaminants in the water sample (Dartmouth). An interviewed family reported it being a relatively easy process that is affordable to their family (Dartmouth). If samples were to come back positive for arsenic contamination at unsafe levels, there are two main options in terms of purification devices: whole house and point of use. The first treats upwards of 200 gallons of water per day, while the latter only treats the water that one consumes. In both Nova Scotia and New Hampshire, just as it is the responsibility of the well owner to test their water, it is their responsibility to treat any contaminated water. While the cost of testing may not seem too high, the cost of treating water can become quite expensive. Both treatment systems require a plumber for installation and prices start around \$450 and can run upwards of \$2,500 (Amazon). Here, it is seen how the price of treatment options may not be accessible to those of lower income, and therefore lower-class

families may be forced into a very difficult decision health-wise as a result of finances. For this reason, the policy suggested in later sections of this paper will appear with modifications based on the government structure of each country, taking into consideration their different cultures. The foundations of a new public policy will draw from the work of Zheng and Ayotte, as well as those who support a decreased legal regulatory amount of arsenic in public and private water sources. By bringing together the social demographics and the geology of New Hampshire and Nova Scotia, I will argue that the suggestion and creation of new, accessible, and, effective public health policy at the federal level is necessary in protecting people from the threat of arsenic contamination in private water sources.

CHAPTER TWO: NOVA SCOTIA CASE STUDIES

2.1 Arsenic Occurrence in Nova Scotia

Arsenic contamination can occur anywhere globally as long as the geological conditions are primed for creating arsenic. While Asia is best known for having high levels of arsenic water contamination paired with rural, poverty-stricken communities, there are several regions of North America that are considered at high risk for arsenic occurrence (levels above 10 μ g/L) (Chappells et al. 2015:1260). These hotspots in Canada include: southern British Columbia, Alberta, Manitoba, northeastern Saskatchewan, New Brunswick, Newfoundland and Labrador, and Nova Scotia (Chappells et al. 2015:1260). For this reason, Nova Scotia is an ideal location to address the issue of water contamination via this specific heavy metal. It is important to note that exposure to arsenic can occur by means of a number of different pathways including food, inhalation of cigarette smoke, and more. However, as there is an absence of information regarding the topic of private water contamination and lack of accessible and effective policy in place to protect users, the pathway of water contamination will be the focus of this paper.

Arsenic can occur in multiple main forms, however arsenopyrite and arsenic in its inorganic form will be concentrated on as they are the most abundant and dangerous forms in Nova Scotia respectfully. The combination of the geology of the region and the high number of private well users creates an unsafe environment for those in rural communities who source their water from unregulated wells. In terms of the health effects of arsenic on the human body, “the quantity of arsenic absorbed across a cell membrane will determine the potential of the compound to produce cellular damage and affect human health” (Saint-Jacques 2016:6). This means that consuming higher levels of arsenic in water will increase the likelihood of detrimental health impacts. Although early research on arsenic contamination focused on high-level exposure over short periods of time, it has been shown that long-term, low-level exposure has negative health effects. Therefore, the public health issue of arsenic risk exposure must be explored farther on various levels and awareness must be raised to protect those who are vulnerable, specifically rural, less educated citizens who may struggle with poverty as well.

2.2 Cases of Arsenic Exposure in Nova Scotia

The first case of arsenic poisoning in Nova Scotia that caught the media’s attention took place in 1976. An individual had been admitted to the local hospital nearby their home of Waverley, a region whose geology is known for high levels of arsenic due to gold bands (Province of Nova Scotia 1976:1). Once the hospital staff discovered that the patient’s symptoms were indicative of chronic arsenic poisoning, an investigation took place; “An investigation by Health Unit personnel assisted by the Environmental Chemistry Section of the Pathology Institute revealed that the water from the dug well at the -patient's home contained arsenic in a concentration which far exceeded the Canadian Drinking Water Standards "maximum permissible limit"” (Province of Nova Scotia 1976:1). While it is important that this

investigation took place, it is unfortunate that it took a case of this magnitude for it to occur. However, this is not surprising. Because there is no regulation of private water currently, there would have been no reason for the government, provincial or federal, to test the water in this area.

While the circumstances of the 1976 case are less to be desired, it did prompt the formation of a task force whose responsibility was to investigate the occurrence of arsenic in water wells in Nova Scotia (Province of Nova Scotia 1976:1). The task force formed included specialists from four different departments: The Department of the Environment, Department of Mines, Department of Public Health, and the Pathology Institute (Province of Nova Scotia 1976:1). It is interesting to see that immediately there are geologists from the Department of Mines involved, most likely because arsenic often occurs in remaining mines, as well as mine waste rock and tailings. There are also engineers and pathologists, but there are no individuals who represent those who might be found to have issues with water contaminations, or task force members looking at remedial work, or solutions to the issue at hand. The results of this investigation show that there was indeed an astonishing number of wells with arsenic levels higher than normal. Of the areas sampled, Waverly, Oldham, and Lawrencetown, which are all members of Halifax County, had the highest number of wells containing arsenic levels above or near the limit of 50µg/L (Province of Nova Scotia 1976:5). This investigation took place at the very beginning of the rise in awareness of arsenic, and many regions of Nova Scotia are left out of the work done at this time.

2.3 Health Risks of Arsenic Exposure

The original investigation into arsenic in Nova Scotia which took place in 1976 produced a number of important recommendations made by the task force. While there are over a dozen

recommendations made, those deemed most important and relevant to the present-day issue will be identified and analyzed individually. The first recommendation made was “That under no circumstances should water with an arsenic concentration in excess of 0.05mg/l (ppm) (comparable to 50µg/L) be used for consumption or cooking” (Province of Nova Scotia 1976:6). As research regarding arsenic in water was only beginning at this point in time, it was unknown of the long-term effects of low-level exposure of arsenic. Luckily, the Canadian Government has responded to the previous standard of arsenic at 50µg/L by changing it to 10µg/L. The Government website does not specify at what levels arsenic contaminated water can be consumed, rather stating that their failure to set a lower limit on the standard of arsenic is due to limitations of available treatment technology (Government of Canada 2008). There is a clear separation between the suggestions proposed by the task force of 1976 and the Canadian Government, as the first is transparent in their recommendations, while the government is extremely vague in theirs. This is a major issue on the topic of water safety because vague information does not allow for the public to educate themselves on the issue at hand. The users of private wells require clear, decisive information on the health effects, exposure, and treatment of arsenic in order to best protect themselves and their families from the hazardous effects of arsenic poisoning.

The second recommendation is “That arrangements be made to have M.S.I. accept blood arsenic, hair arsenic, and urine arsenic determinations as insured out-patient tests, to be performed only at the discretion of a pathologist” (Province of Nova Scotia 1976:6). It is a step in the right direction that the task force acknowledged the need for arsenic testing to be available. It is also encouraging to see that it is recommended that M.S.I. (Medical Services Insurance Programs) accept these tests as insured out-patient procedures, therefore making the services

affordable and accessible to all who are within reasonable distance to a clinic. As M.S.I. is available to all Nova Scotian residents, it is reasonable to assume that this method of testing for arsenic levels is accessible and effective.

Thirdly, the task force of the investigation of 1976 recommended, “that a long-term medical study be carried out in Waverley and possibly other areas. This would be a research project, the main aim of which would be to further medical knowledge in this regard. The Clinical Trace Metals Research Group, Dalhousie University is interested in this matter and could carry out such a study if funds are made available” (Province of Nova Scotia 1976:7). It is difficult to determine whether this suggestion was put into effect, and if so, to what capacity was this research project performed.

Finally, it is suggested from the investigation that, “a study be carried out on various water treatment units to determine the suitability of each unit to remove arsenic from water and that research be carried out to develop a suitable arsenic removal process for use in individual houses if none of the units currently available is satisfactory” (Province of Nova Scotia 1976:8). While technology in all aspects has improved in the past 40 years, water filtration systems continue to be limited in their treatment processes. In-home treatment systems vary depending on the need of the user. No filter eliminates all contaminants, so the buyer must understand what contaminants are of concern to them, as well as which filters eliminate said contaminant (CDC 2018). Already it is visible that there are restrictions to buyers depending on education level, in terms of if they comprehend the complexity of water filtration systems. Next, there is the cost of in-home water treatment systems. A wide variety of systems exist on the market, ranging from 20 dollars to hundreds of dollars plus a professional installation fee (CDC 2018). The CDC is careful in mentioning addition ‘costs’, such as the ease of schedule and maintenance of changing filter

cartridges, or having professional maintenance done to the system (CDC 2018). This is the second restriction of access that the 1976 task force fails to address, as does the Canadian Government. A low-income household is likely to feel added financial stress as a result of these costs if they are faced with a decision of treating their contaminated well water. This stress should not be their responsibility as it disproportionately affects the lower class. The government must explore subsidy options in order to protect all of their citizens, whether they rely on public or private water.

With this being said, it is important to discuss perhaps the most threatening health risk related to arsenic: cancer. Various authors have vocalized their concerns about increased rates of cancer, which are linked to arsenic exposure. One of these individuals is Saint Jacques, who studied this correlation at Dalhousie University. Her results show that low levels of exposure can have detrimental effects, including the possibility of increasing risk of bladder cancer by at least 40 percent (Saint-Jacques 2016:xii). This is critical information because while the federal government claims water with arsenic concentrations of $10\mu\text{g/L}$ or less to be safe, the findings of Saint Jacques shows otherwise. The bladder is not the only region affected, as kidney cancer also experiences an increased risk with low-level arsenic exposure in drinking water (Saint-Jacques 2016:16).

These examples of disease associated with low-level arsenic exposure are devastating to say the least. However, the risks only increase as arsenic concentrations rise, “High levels ($> 150\mu\text{g/L}$) of arsenic in drinking water have been associated with increased risk of: cardiovascular diseases; diabetes mellitus; gastrointestinal, 13 vascular, respiratory and neurological effects; adverse obstetric and pregnancy outcomes; and cancer, including lung, bladder, non-melanoma skin, liver, and kidney cancers” (Saint-Jacques 2016:12). Here, there are numerous negative

health outcomes as a result from low and high level arsenic concentrations in drinking water. It is vital that the disconnect between this research and the statements from both WHO and the Canadian federal government come to reflect the information that the public has a right to know, which is that low-level exposure to arsenic in drinking water over long periods of time has detrimental health consequences.

CHAPTER 3: NEW HAMPSHIRE CASE STUDIES

3.1 Arsenic Occurrence in New Hampshire

Arsenic is a contaminant that is not unique to one region of the United States. Rather, numerous states suffer from arsenic contamination of private water, including New Hampshire. One of the main reasons that this state in particular was selected for this comparative study was that 40 percent of its population rely on private wells, most of whose wells have not been tested for arsenic (Peters, Stephen C., et al. 1999:1328). This number can be compared to the 15 percent of the entire American population reliant on wells. Similar to Nova Scotia, the local geology is to blame for the high occurrence of arsenic in the groundwater of New Hampshire. Arsenic can enter surficial water sources in two ways: first, the weathering of geological materials, or, secondly, through mixing with high-arsenic geothermal waters (Peters, Stephen C., et al. 1999:1329). Unlike Nova Scotia, the arsenic occurring in the geology of New Hampshire does not originate from gold-bearing rocks. Rather, pegmatites, formed from late-stage residual magmas during granite crystallization, hold the majority of arsenic concentration (Peters, Stephen C., et al. 1999:1330). Original studies investigating wells in these geological areas determined that water from bedrock wells contained more arsenic than water from surficial wells (Peters, Stephen C., et al. 1999:1330). This is intriguing as many studies focus on surficial water, even though bedrock wells contain higher levels of arsenic. This discrepancy may be due to the

fact that many surficial wells exist and research must be done on those in order to preserve the safety of their users.

New Hampshire is at a greater risk of arsenic contamination, as opposed to other American states, due to its metasedimentary bedrock units in which 30 percent of wells drilled in this region had elevated arsenic concentrations (Ayotte et al 2003:2075). The main issue associated with contamination from bedrock aquifers is that the water quality is inconsistent, and water chemistry can be marked differently in each well (Ayotte, Joseph D., et al. 2003:2075). In comparison to Nova Scotia, where arsenic exists in correlation with gold bands, the state naturally has water with the right geochemical conditions to create high levels of arsenic: relatively high PH levels, paired with little dissolved oxygen (Dartmouth). The correlation between consistently high PH and low dissolved oxygen was cited by Levitt et al. as well (Levitt et al. 2019: 1675). The research done in this case consisted of a small number of sample wells. In order to improve the reliability of these results and the correlation between high PH levels and low dissolved oxygen, a larger sample size must be utilized. For example, in a larger research sample, “only 1 percent of the surficial wells contains arsenic in excess of 2 µg/L, compared to 35 percent of bedrock wells” (Peters et al. 1999:1331). Despite these reliability of these results, it is important to note that those people drilling wells in this region cannot easily avoid heavy metal contamination as it is a natural occurrence in the geology of the bedrock. However, this does not mean that citizens should have to suffer the health and financial burdens of arsenic poisoning, rather the government must provide both information and assistance to best protect the populations affected.

3.2 Cases of Arsenic Exposure in New Hampshire

While the epidemiology of arsenic poisoning is consistent regardless of location, it is important to note the cases and methods of discovering the effects of long-term, low level exposure, as it has been under-researched until this point. Scientists interested in the Northeastern regions of the States were more proactive than those in Nova Scotia in regards to researching arsenic in private water sources. While it took the case of 1976 in Nova Scotia to spark an investigation into the cause of arsenic poisoning, there exist many reports involving research concerning arsenic in New Hampshire. Just as there is the Task Force Investigation in Nova Scotia, the EPA finalized the current drinking water standard for arsenic at 10 µg/L from the previous 50 µg/L (United States Environmental Protection Agency 2018). This was done after a report (1999) originated from the National Academy of Sciences, concluding that the then current standard of arsenic was too high to protect Americans from the harms of arsenic exposure (United States Environmental Protection Agency 2018). Other studies confirmed these findings, which was ultimately the first step in America to lower the standard of arsenic in order to safeguard its citizens. These other studies use similar methods, including water sampling, toenail concentration testing, as well as geological investigations. There have been no acute, high-level exposure cases of arsenic poisoning in New Hampshire, however this does not mean that citizens do not feel the effects of arsenic. While Nova Scotia saw the 1976 acute, case of arsenic poisoning, the state of New Hampshire has only seen the outcomes of low-level, long-term exposure thus far. These low-level cases are not any less serious however, in fact they are potentially more dangerous as people are unaware of their consistent, long-term consumption of arsenic, and are left unprotected against its detrimental effects. The reasons as to why New Hampshire has not seen an acute case of arsenic poisoning are unknown, however possibilities

include that New Hampshire citizens may be better educated on the issue of arsenic, although this is less likely to be the case, or it may have been an unfortunate occurrence in Nova Scotia that an individual contracted severe arsenic poisoning, while being quite uncommon. The lack of any reported cases of arsenic could be viewed as positive in the sense that people are not reporting any struggle with the disease. However, keep in mind that arsenic poisoning can show in other diseases, which will be discussed in the following section.

3.3 Health Risks of Arsenic Exposure

The health risks of both high-level short-term and low-level long-term exposure to arsenic are serious in nature, but are not similar in their symptoms. The region of New Hampshire struggles the most with the health effects of low-level long-term exposure. This means that well users whose water is contaminated consume the water over a long duration, and eventually see detrimental symptoms and diseases as a result. Unlike Nova Scotia, both the State and the Federal government explicitly state the health risks associated with arsenic in drinking water. Among these health risks stated by the EPA are: cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate (United States Environmental Protection Agency 2018). Many of these cancers lack public information, including the most prevalent of the diseases which is bladder cancer (NHDHHS 2018). The State of New Hampshire has “the highest rate of bladder cancer cases in the nation and a rate that is 37 percent higher than the national rate ... one of the leading causes of bladder cancer in the State is exposure to arsenic in private drinking water” (NHDHHS 2018). Bladder cancer is so prevalent in research involving the effects of arsenic for the reason that the water you ingest spends the most time in the bladder, “It is estimated that 60-70 percent of daily-ingested inorganic arsenic is excreted in urine and that most humans exposed to arsenic excrete 10-30 percent as inorganic arsenic” (Saint-Jacques

2016:10). Of the ingested arsenic, 38 percent of the dose is excreted in urine within 48 hours, and 58 percent within 5 days (Saint-Jacques 2016:10). From these statistics it can be found that over 40 percent of the ingested dose of arsenic continues to lie within the body after 5 days.

Beyond bladder cancer, the rates associated with exposure to arsenic are astonishing. Prior to the United States decreasing the standard to 10 µg/L, it was thought that the cancer risk for consumers was as high as 1 in 100 (Dartmouth). This number can be compared to the risk of cancer associated with the consumption of man-made contaminants (pesticides, fuels) which is estimated at 1 in 1,000,000 (Dartmouth). Even with this extensive research, it is still undecided within the scientific community exactly how arsenic carcinogenesis operates. That is, how arsenic forms cancerous cells, and grows into a potentially deadly disease. In order for private well users suffering from arsenic poisoning to access the best healthcare, medical providers and scientists must continue their research on the dangers of arsenic on the human body.

However, there are diseases other than cancer that are associated with exposure to arsenic in drinking water. Private well users are at higher risk of cardiovascular, pulmonary, immunological, neurological, and, endocrine effects (NHDHHS 2018). The results of a study involving almost 4000 New Hampshire citizens showed a strong relationship between the risk of developing ischemic heart disease and the measured arsenic levels in the toenail clippings of long-term smokers' (Farzan et al. 2015:93). It is concerning that the link between America's struggle with obesity, and consequently heart disease, as a nation was not stated in either article by Farzan or the New Hampshire government. The CDC confirms the existence of a prevalent relationship between obesity and cancer, among other diseases related to a high BMI (body mass index), "Obesity-related conditions include heart disease, stroke, type 2 diabetes and certain types of cancer that are some of the leading causes of preventable, premature death" (Adult

Obesity Facts 2019). The issue of obesity is relevant in terms of arsenic poisoning because it is correlated with heart disease, which is a health risk associated with arsenic exposure. While cancer and heart disease have been significantly studied in regards to arsenic, the contaminant's relationship with other prevalent diseases in North America have not. Academics and government should not limit themselves to researching one aspect of the effects of arsenic, rather explore arsenic poisoning as a whole to better understand the relatively unknown impacts of low-level, long-term arsenic exposure.

CHAPTER 4: PUBLIC HEALTH POLICY SURROUNDING ARSENIC

4.1 Public Policy in Nova Scotia

While the water standard of arsenic has seen improvement in the past decades in both Canada and the U.S., the regulation of private wells has not. The lone change that has occurred across Canada in regards to arsenic water contamination was the reduction of water level standards from 50 µg/L to 10µg/L (Government of Canada 2008). However, there are risks associated with arsenic levels under the current standard of 10 µg/L. Arsenic is not harmless, in fact it is a class I human carcinogen, and among the most important global health hazards related to drinking water, along with microorganism contamination (Chappells et al. 2015:1259). For this reason, it is vital that knowledge surrounding arsenic improves, as it is deadly especially being odorless, tasteless, and colorless. You would never know whether or not you are exposed to arsenic unless you have tested your water for its contamination. Furthermore, it is suggested by several authors that the current standard of arsenic continues to carry unknown risks, as the long-term, low level exposure risks are still unidentified and unknown (Dartmouth) (Saint Jacques et al. 2018). What is worse is that Nova Scotians are relatively unaware of any risks involved with arsenic exposure, and often do not know that well users are responsible for their

water safety. Given the demographics of the regions affected in Nova Scotia, rural dwellers are at a greater risk of contamination due to lower income and less education. The average household income in Nova Scotia is \$46,215USD (Nova Scotia Finance and Treasury 2016). Families who are reliant on this level of income may struggle to provide daily necessities for their families, such as rent, food, or clothing, let alone treatment systems of arsenic. Paired with financial struggles is a lack of education in the province as only 36 percent of Nova Scotians hold a bachelor's degree (Statistics Canada 2016). While this poses a recipe for inequality of opportunity, among other issues, it is a direct cause of why rural well users are at high-risk for arsenic exposure health related diseases.

One of the reasons why arsenic contamination is less well-known among well users, and people in general, is that it is only detectable through accredited laboratory-based testing (Chappells et al. 2015:1260). As there is no natural sensory or aesthetic prompt, there is a barrier to testing for arsenic contamination. While it is reasonable to think that this private laboratory testing would be expensive and pose a barrier to well users getting their water tested, it was found that the most common barriers to testing include inconvenience, procrastination, and a lack of knowledge and concern (Chappells et al. 2015:1260). A positivity within these findings is that more well users believe they have limited access to testing due to inconvenience rather than cost. If costs were a major barrier, then government subsidies would be necessary to alleviate some of the financial burden that is impeding well users to test their water quality. With this being said, the barriers of inconvenience and lack of public knowledge are real and can be deadly. The Canadian government found that citizens associate arsenic contamination with 'geographical hotspots', while in fact the spatial distribution of arsenic in groundwater can vary within small areas such as a neighborhood (Chappells et al. 2015:1261). Therefore, many well

users fail to test their water for arsenic as they are under the impression that their community is not at risk, or that arsenic cannot exist in their water as their neighbors do not suffer from contamination (Chappells et al. 2015:1261). It can be seen here that the first step to ensuring the safety of these citizens is to dismember these myths surrounding arsenic water contamination.

An important question to ask is, where do people source their knowledge on arsenic from, and how could these sources be made more reliable and accessible to their audience? There are two main sources responsible for passing information to well users: the Canadian Government and private entities (Chappells et al. 2015:1266). While the majority of respondents in Chappells' research did not recall receiving information from any sources, those that did receive something recall it often came from a private testing company which were found to be the least trusted source (2015:1266). The government was the second most common information provider, and was the most trusted provider. Immediately the discrepancy between the most consistent provider (private testing companies) and the most trusted provider (Canadian Government) is visible. This discrepancy also exists in the form of information. While private testing companies gave out pamphlets and sent flyers to private homes, and placed advertisements in local newspapers, people only found information from the government by directly visiting testing centers, or personally seeking out information at a government office or online (Chappells et al. 2015:1266). Clearly, the steps taken by private companies are more successful in reaching their audience compared to the methods used by the Canadian Government. The success is found through methods involving intimate contact in sending information out directly to the homes of well users. The user is presented with the information, rather than forced to search for information with the goal of educating themselves on arsenic contamination. The procedure of printing pamphlets, and posting local advertisements with the hope of raising awareness about

arsenic water contamination would not be costly to the government, and is a simple first step in raising the level of concern about a public health issue.

Once private well users believe that there is reason to test their well water, the next step is understanding current testing behaviors in order to improve health standards through said behaviors. Arsenic is a difficult contaminant in the sense that it is a chemical rather than a bacterial contaminant. Just as with disease, many are aware of bacterial infections, while they are unaware of chemical associated disease. This is significant because the majority of the population in Canada and around the world are aware of the risks of bacterial contamination in water, and therefore will test their water for these concerns. However, chemical contaminants are less widely known, and thus are not on the radar of many well users as being a threat to their water quality. The disparity can be seen in Chappell's research, "For chemical testing, only 12 percent of respondents tested once every two years or more as per the NSE (Nova Scotia Environment) guideline. Half of the respondents reported testing for chemical contaminants 'irregularly' (50 percent) and 29 percent reported testing 'only once ever'... Only 8 percent of respondents correctly identified a recommendation of 'once every two years' for chemical testing, while 74 percent 'did not know' how often to test for chemical parameters" (2015:1266). How can well users be expected to be responsible for their water quality if they are unaware of all risks involved with contaminations, and the different types of contaminants including arsenic? The first step must be education surrounding the issue. Only then testing can occur at the correct rate to ensure consistently high-water quality.

With this said, cost is not out of the picture. Once private water samples are tested, if a sample comes back positive for arsenic contamination certain steps must be taken in order to remediate the effects. It is here where costs can become a major barrier for well users to

guarantee the quality of their drinking water. The seventh recommendation made by the 1976 case task force stated, “That the Department of the Environment advise all well drillers in the Province to recommend to customers having wells drilled in slate and quartzite of the Meguma Group to submit samples of water from these wells to the Environmental Chemistry Laboratory, Pathology Institute for analysis for arsenic, the cost of the analysis to be charged to the customer” (Province of Nova Scotia 1976:7). The communities reliant on wells in Nova Scotia are comprised of a large range of socioeconomic backgrounds. People in these towns may or may not be able to afford these costs, but our focus is on those who cannot afford either one or both testing or treatment options.

4.2 Public Policy in New Hampshire

As Canada and the United States border each other, it is expected that some laws mirror one another in formation as information is learned and shared around the same points in time. The public health policies in both countries saw improvements around the same time, during the late 1900s to early 2000s. Due to the reason that Nova Scotia experienced a major case of arsenic poisoning, their laws developed prior to America’s. However, the United States Environmental Protection Agency created new ‘Chemical Contaminant Rules’ at the turn of the century to protect the health of its citizens. These rules oversee various chemicals, one of which is arsenic. Among these rules is one dictating the standard of arsenic, “In 2001, the EPA adopted a lower standard for arsenic in drinking water that applies to both community water systems and non-transient non-community water systems. The new arsenic standard of 10 µg/L replaces the old standard of 50 µg/L” (United States Environmental Protection Agency 2018). This is a positive first step; however, more must be done to protect private users. At the time of the reduction of the arsenic standard, the government was then responsible for replacing treatment systems to

mirror the lowered standard of arsenic. This rule effected millions of people across the country, the vast minority of who rely on private water sources (also referred to as non-transient, non-community water systems [NTNCWSs]). An estimated 1.7 million people categorized under NTNCWSs were affected by the reduction, compared to 11 million community water system users. There is a disconnect in data concern costs, as the estimated household costs are given for CWSs, but not for NTNCWSs. This disconnect may be due to the costs ranging in households depending on the severity of contamination, or it may be due to the fact that no information exists regarding a precise treatment cost estimate for those reliant on private wells. While the exact costs of treatment for private households is unknown and not stated by the federal government, there is the mention of funding which came into existence with the birth of the new contaminant rules. The two main sources of funding in the United States cited are the Drinking Water State Revolving Loan Fund (DWSRF) and the EPA (United States Environmental Protection Agency 2018). These funds are available to improve water system infrastructure, specifically to States and their public water systems. Once again, there is no mention of private systems and their need for funding and protection. Therefore, it is suggested that there be a private funding pool specifically for families and individuals who require financial assistance in treating their well water. The average household income is \$71,305USD in New Hampshire, which is over the national poverty line, but is potentially deceiving in terms of treatment affordability (New Hampshire 2019). One of the main communities affected by arsenic contamination is cited at Littleton, NH (Zheng and Ayotte 2015:1240). The average income of this community is well below that of the state average, sitting at \$37,419 (Littleton Data USA). This is only one example of the inequality that exists within one state, which occurs across the entire country, as well as the globe. The federal government cannot evaluate states based solely

on state-level data; rather an informed inquiry into the individual communities themselves must be performed to understand the level of financial need for subsidies. In the case of Littleton, NH, subsidies must be made available as the income average would not allow for the financial privilege of purchasing and maintaining a water treatment system independent of subsidies.

The issue of arsenic contamination is interdependent, meaning one problem cannot exist nor be solved without considering other issues. Firstly, funding must be made directly available to private well users attempting to test and treat their water. Through research involving the different types of treatment, and one cost estimated by the government, households are looking at a financial burden between \$38 to \$327 (United States Environmental Protection Agency 2018). What is astounding is the difference compared to the cost to community water source households, which ranges from \$0.86 to \$32 (United States Environmental Protection Agency 2018). That means that the highest potential cost for public users does not overlap with the lowest cost estimated for private users. These costs can be afforded by some families, but are not within the income of others. Clean water is a human right around the world, and economics should not hinder that right especially in a wealthy, developed country such as the United States. As much of the New Hampshire population struggles with arsenic contamination in their wells, it is vital that the state and federal government come up with funding strategies specifically for private well users. The municipalities have up to date treatment systems that monitor chemical levels, however, the same cannot be said for private water sources. This is a matter of public concern because it is a widespread issue that can affect anyone of any social background, race, or class. While it may not affect you now if you live in an urban municipality, it may very well affect you later in the case of relocation, or if water system changes occur. If it does not affect you directly, it is very likely that someone you know relies on a well and could be at risk of

arsenic poisoning. For these reasons, it is suggested that the American government address the issue of private water contamination across the United States with funds allocated specifically towards the treatment of arsenic contamination in private homes. Studies show that testing is quite common in New Hampshire, and so in this region the emphasis of public policy must be on treatment methods (Dartmouth). The state is aware of the health risks associated with arsenic consumption, much in part to research performed by Dartmouth College. Interviews in the surrounding state communities show that residents are aware of the need to testing their water, however many are unsure of the steps to be taken after, in terms of treatment methods. As testing is cited as costing between 10 and 15 dollars, and testing is recommended to take place once every two years, the cost of testing is not of major concern (Dartmouth) (Chappells et al. 2015:1266). Rather, the cost of treatment is of the utmost concern as treatment systems can be extremely high in cost when coupled with the cost of installation and maintenance. Here, it is important to note that there are two different sizes of water treatment devices as mentioned by Dartmouth College researchers, whole-house and point of use (Dartmouth). While the first treats upwards of 200 gallons of water per day, the latter only treats the water that one consumes daily. Again, the major concern is the cost of treatment and this is because it can become very expensive. Both treatment systems require a plumber for installation and prices start around \$450 and can run upwards of \$2,500 (Amazon). While the assumed white, heterosexual, middle-class couple interviewed in front of a comfortable, free-standing home, may have no issues affording a treatment system, other individuals or families might. The poverty line for an American family of four was found to be \$24,250 in 2015 (Conley 2017:265). A family reliant on an income of this level should not have to decide between providing meals for themselves, or investing a large sum of money into a water system. Day-to-day survival is the lifestyle for many low-income

families, and if they are not aware or concerned with the low-level, long-term exposure risks of arsenic, they will have a very difficult time justifying the decision of buying an expensive, and seemingly unnecessary water treatment system. It is important to bring these numbers into reality with the example of Littleton, whose average community income is only ten-thousand dollars above the national poverty line. The issue of poverty and education resulting in disease are not unique to New Hampshire, rather an issue occurring around the globe. Therefore, public health policy practices will be discussed on both state and federal levels, and will go beyond the socio-demographics of New Hampshire and Nova Scotia in further sections.

4.3 Effective and Accessible Public Health Policy

The current public health policy regarding arsenic contamination in both Canada and the United States is not enough to protect the citizens in both countries. The purpose of this section is to offer new, effective policy, under which vulnerable groups could be empowered to take control of their health and wellness. In doing so, they would gain the ability to support others in doing the same regardless of their educational background or income as this policy would aim to be accessible to *all*. Health policy should not be limited to the privileged, rather it must protect all people, especially the most vulnerable in terms of class, race, and education. Both New Hampshire and Nova Scotia are predominantly white regions, and therefore the focus will be on the intersection of poverty and education. However, this is only for this *one* case study, and does not mean that race is not important. Rather, race is extremely relevant and vital to the conversation of health outcomes. With this being said, for the reasons of the demographics of the two regions, poverty and education will stay the focus of the remainder of this paper.

The first step to ensuring the safety of citizens is to dismember these myths surrounding arsenic. While it is unrealistic to expect governments be responsible for the regulation of all

wells due to costs and a geographical distance, it is reasonable to expect that governments educate their citizens on the issue at hand. The current methods used by the American and Canadian governments to educate the public on the issue of arsenic are failing. However, private enterprises are in fact succeeding in reaching the public with their information, while they struggle with gaining the trust of the public in being the solution to their problems. The government has the benefit of possessing the trust of the public due to their institutional status in society, and therefore must only change their practices of offering accessible information. It is suggested that the government adopt the methods used by private institutions, including: pamphlets, newspaper advertisements, and their current online educational websites. These methods are low-cost, and can be accessed by anyone regardless of whether they can afford to own technology to access the web, or not. The information included on these sources must include certain vital information. This comes from previous research, the results of which show what knowledge Nova Scotians lack the most surrounding arsenic. These points of knowledge include: testing regularity, arsenic occurrence geographically, long-term arsenic poisoning, and why one should be concerned about arsenic. A high health literacy rate is more likely to lead to a healthy life void of disease, and therefore it is the government's responsibility to educate their people regarding their water safety. If well users were armed with this knowledge, it is believed that they would be informed enough to be able to make their own educated decisions on testing and treating their water to ensure the safety of themselves and their families.

The second step is to make water treatment an affordable option. Currently, there are no known subsidies in place in either Nova Scotia or New Hampshire in order to assist with the high cost of treatment systems. The responsibility of these subsidies is suggested to lie at both a state and federal level. This is due to the fact that arsenic occurs at different rates across different

states due to the geology of the country. If states were able to apply for funding from the DWSRF and the EPA, which receive federal funding, it may be easier for individuals to apply for subsidies from their state government rather than the federal level. It is important that the funding made available be accessible to all, regardless of education or income, and therefore it must reside at a government level in which applicable residents can apply and access it.

The final point to be made is in regards to the awareness surrounding arsenic, but also water contamination as a whole on a large scale. While the 1976 case in Nova Scotia did raise awareness of the environmental health risk within the province, it did not create the same impact nationwide. The United States did not experience a case of the magnitude that Nova Scotia did, and therefore their laws surrounding water quality came out of alternate avenues of concern. Nevertheless, in both cases, the majority of the population continue to remain in the dark on the major health risks associated with low-level arsenic exposure in well water. Therefore, it is vital to discuss various avenues of advocacy for these people who may not have a voice due to the issues of education or poverty. If the people affected do not know of the risks of arsenic, or are unable to advocate for themselves or others due to socioeconomic reasons such as working overtime, how can we expect the situation of these people to improve? A handful of suggestions in terms of advocacy are to use other water crises as a platform for less-known water contaminants such as arsenic. For example, the Flint Water Crisis is one well-known across North American, and beyond, and would be a suitable platform to bring awareness to the fact that there are other relatively unknown, extremely harmful contaminants in existence that must be paid attention to by citizens and their governments. Along with this, it is necessary to encourage people to be proactive rather than reactive. If the government can reach communities with new forms of information, educating them on the risks associated with arsenic well water

contamination, individuals are awarded the opportunity to be proactive about their health and test their water, as opposed to being forced to react when they discover they have late stage bladder cancer as a result of low-level arsenic exposure. The government must present the statistics of the health risks associated with contaminants like arsenic in a clear, understandable form, through which all people, regardless of educational background, can understand the risks of water contamination. It must be made transparent that both low and high-level exposure health risks are serious, as they include cancer and cardiovascular issues which can be life-threatening. Lastly, regardless of which contaminant is under speculation, it is vital that societies attempt to decrease inequality through methods such as wage increase, scholarships, and means to incentivize education among racial and socioeconomic minority groups (Conley 2017:255). The closure of the inequality gap that exists not only in North American, but across the globe is deadly in ways well beyond starvation and hypothermia. Inequality kills through systemic methods, including water quality and regulation that exposes the most vulnerable groups. Every American and Canadian deserves the chance to provide safe drinking water to themselves and their families, and the first step towards doing so is recognizing our failure at raising the issue to the attention necessary for change to occur. It is with high hopes that this paper is the first step in improving the safety of the lives of these people affected by arsenic contamination across North America.

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