WATER QUALITY REPORTING AND ITS ASSOCIATION WITH CONSUMER CONFIDENCE AND USE OF WATER IN NORTH TEXAS

A DISSERTATION

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Martha Gibson entitled "Water Quality Reporting and Its Association with Consumer Confidence and Use of Water in North Texas." I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Health Studies.

Kristin Wiginton, Ph.D., Major Professor

We have read this dissertation and recommend its acceptance

Department Chair

Accepted:

Dean of the Graduate School

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ABSTRACT

MARTHA JACKSON GIBSON

WATER QUALITY REPORTING AND ITS ASSOCIATION WITH CONSUMER CONFIDENCE AND USE OF WATER IN NORTH TEXAS

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Clean water is the cornerstone in public health initiatives and is essential for good health. Often consumers take clean water for granted, in spite of the fact that 1.1 billion people globally do not have access to clean, safe drinking water. The U.S. Environmental Protection Agency (EPA) enforces standards that protect this water, and water suppliers provide annual Water Quality Reports that inform consumers of drinking water's origin and any possible contaminants that pose a threat to the consumer. This exploratory study used an online survey of 293 residents of the central-northeastern section of Texas. The study explored the effectiveness of the annual Water Quality Report as a consumer confidence tool by determining whether the participants read and understood the report, and whether the Water Quality Report provided information that allowed the consumer to make informed decisions about water usage. The results of the study indicated that the descriptive covariates could not predict reading the water report; however they did prove predictive of understanding the report with population size, age, and education being a significant contributing factor. Significance was also seen in areas of age, education, and gender when looking at understanding of specific contents of the report. Further evaluation revealed descriptive covariates affected confidence in drinking the water and tap water consumption. The study was based on the Theory of Reasoned Action (TRA) used by health educators to explore the relationship between behavior and beliefs, attitudes, and intentions and to apply that information when planning interventions that encourage reading and understanding of the annual Water Quality Report.

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CHAPTER I

INTRODUCTION

Clean water is the cornerstone of progress in public health initiatives and is essential for good health. Often consumers take clean water for granted, in spite of the fact that 1.1 billion people globally do not have access to clean, safe drinking water (Blakeney & Marshall, 2009). Only one percent of all global water can actually be used for consumption (EPA, 2003). The U.S. Environmental Protection Agency (EPA) enforces standards established by the National Primary Drinking Water Regulations (NPDWR) that apply to public water systems. These essential standards protect the public's health and well being by limiting the levels of contaminants in their water. By most measures Americans have the safest drinking water supply in the world. However, the actual process of treating water sources to make them potable may create disinfectant by-products (DBPs) that can pose health risks for consumers.

The Safe Drinking Water Act (SDWA) was passed originally by Congress in 1974. In 1998, amendments were made to this legislation to protect drinking water and in particular surface water sources to "strengthen and control chemical disinfectants and their potentially cancer-causing byproducts" (Stage 1 rule: paragraph 4). As part of these amendments, surface water systems with populations of 10,000 or more people had until 2002 to comply, and small surface water systems with populations less than 10,000 had until 2004. In 1999, the stage 2 federal advisory committee again visited the DBP and associated cancer effects. In that report the EPA conceded that the assumption was made that higher DBP levels would be expected in small systems, because separate analysis had not been done at that point. Therefore there would be a higher cost and a greater need for risk reduction in these smaller systems. At that time the focus was on larger systems despite the fact that 94% of all systems in the United States represented populations under 10,000. As a result of these amendments to the SDWA, small water systems are provided special consideration and resources to assist in complying with established drinking water standards (EPA, 2006).

According to Macler and Regli (1992), the intention of the SDWA was to protect the public from health risk that arise from water consumption by directing the EPA to establish drinking water Maximum Contaminate Level Goals (MCLGs) at levels where no actual or anticipated effects on the health of individuals occur and which allow a range of safety that is acceptable. The EPA requires that risk assessments be utilized when establishing these regulations. The use of MCLGs is not enforceable by law but provides direction to the EPA. However the NPDWRs are enforceable and are required to be set as close as possible to MCLG as is feasible considering both the technical and economic aspects. These consist of either the Maximum Contaminate Level (MCL) or the treatment technique if measurement of the MCL is not technologically or economically feasible. The NPDWRs are a product of "risk management" and must be "health protective".

Also as part of the SDWA, drinking water suppliers provide reports that inform consumers of the drinking water's origin and any possible contaminants. This Consumer

Confidence Report (CCR) is communicated through annual Water Quality Reports (EPA, 2008). Public water consumers are expected to make choices about risks to their health and weigh that with use of public water based on these Water Quality Reports. While these standards might be expected to give consumers confidence in their drinking water supply, what about those who are immunocompromised, the very young or the elderly? What about consumers who are on dialysis and are exposed to more water annually than most people are over their entire lifespan? Exposure to any contaminants is a valid health risk for people on dialysis (Chamney & James, 2008) or who are immunocompromised, and small amounts of contaminants such as lead can prove fatal to the very young (Magnarelli & Jaret, 2005).

Statement of Purpose

The purpose of this study was to determine the effectiveness of the annual Water Quality Report as a consumer confidence tool by ascertaining: 1) Whether the participants read and understood the report, and 2) Whether the Water Quality Report provided information that allowed the consumer to make informed decisions about water usage, and whether they identified any barriers? The study applied the Theory of Reasoned Action (TRA) to explain concepts such as the reading of the annual Water Quality Report and making decisions based on the contents of that report. In using this theory it is believed that a health educator could strengthen existing attitudes, beliefs or norms, increase motivation to comply, or to remind consumers of a possible forgotten belief or norm (Aizen, 1991).

Research Questions

This research questions for this study were:

1. What proportion of participants actually read and acknowledged an understanding of the information on the annual Water Quality Report?

2. Does reading the annual Water Quality Report influence decisions to drink the water?

3. Among the participants who are hesitant to drink the water, what are the barriers?

Null Hypotheses

The following null hypotheses were tested at the .05 level of significance:

H01- There will be no statistically significant difference in consumer confidence and use of water among consumers who read the annual Water Quality Report or those who acknowledged an understanding of the information in the report and those who did not read the report or did not acknowledge an understanding of the information.

H02- Descriptive covariates (age, gender, race, education, occupation, size of population, health condition) will be neither predictive nor protective of participants reading and acknowledging an understanding of the annual Water Quality Report.

H03- There will be no statistically significant difference between those who reported an understanding and those who did not report an understanding of the annual

Water Quality Report based on descriptive covariates (age, gender, race, education, occupation, size of population, health condition).

H04- Descriptive covariates (age, gender, race, education, occupation, size of population, health condition) will be neither predictive nor protective of participant understanding of water contaminants, maximum contaminant levels (MCL), fluoridation, and softening of their water.

H05 - There will be no statistically significant difference between those who report confidence and those who report no confidence in the safety of the drinking water based on descriptive covariates (age, gender, race, education, occupation, size of population, and health condition).

Delimitations

This study had the following delimitations:

1. Participants were at least 18 years of age and must have seen and/or received a Water Quality Report.
2. Participants had access to the internet and were able to complete the online survey using Psych Data (Addendum C).
3. Participants were from North Texas (the area forming the central-northeastern section of Texas that includes the area south of Oklahoma, east of Abilene, north of Waco, and west of Louisiana).

Limitations

This study had the following limitations:

1. A non-probability convenience sample using a snowball sampling technique was used. Therefore no generalizations can be made beyond the scope of this study about the results.

2. Recall bias may have occurred as participants were asked to recollect information from the Water Quality Report.

Assumptions

This study had the following assumptions:

1. The participants answered the questions honestly and accurately.
2. The participants had access to an annual Water Quality Report.
3. Participants spoke, read, and wrote English at a minimum of an eighth-grade level.

Definitions of Terms

Contaminant- a substance that is present in an environment where it does not usually belong that can cause harm to the environment, humans or animals (Greenfacts, 2009).

Disinfectant By-Products (DBPs) - form when disinfectants that are added to treat the drinking water to eliminate germs react with the naturally occurring organic material in water (EPA, 2006a).

Exemptions- the ability of a state to consider whether a community may be defined as "disadvantaged" for the purpose of receiving Drinking Water State Revolving Funds (DWSRFs), or whether DWSRFs are realistically likely to be received. States must decide what areas would improve water quality or achieve compliance before granting exemptions. They must show schedules for compliance including progress noted and plans to develop alternate sources of water supplies (EPA, 2004).

Ground Water- comes from lakes, rain, snow, sleet, and hail that soak in the ground. It is stored in the ground and is usually provided through wells that pump it from the aquifer (EPA, 2010).

Immunocompromised- unable to develop a normal immune response usually from disease, malnutrition or immunosuppressive therapy (Jong & Freedman, 2009).

Maximum Contaminant Level (MCL) - the maximum strength of a chemical that is allowed in public drinking water systems (Extoxnet, 1997).

Maximum Contaminate Level Goal (MCLG)- the maximum level of a contaminant in drinking water at which no known or potential adverse effect on the health of persons would occur, and which can be ingested safely (EPA, 2004).

Nonpotable water- water that shall not be used for ingestion including bathing, washing, cooking, or on eating utensils, or clothing (OSHA, n.d.).

Potable water- meets the quality standards prescribed in the U.S. Public Health Service Drinking Water Standards and is approved for ingestion by the State or local authority having legal jurisdiction (OSHA, n.d.).

Rural- communities having fewer than 20,000 residents or having fewer than 99 persons per square miles (Stanhope & Lancaster, 2005).

Secondary Maximum Contaminant Level (SMCL) - drinking water standard developed to protect against any adverse "aesthetic" effects (Pedersen & Kleinschmidt, 1997)

Surface Water- water in rivers, lakes, oceans, streams, and wetlands. It is replenished by precipitation and depleted by evaporation and seepage into groundwater. Land surface water is the biggest source of fresh water (EPA, 2009).

Tap Water- drinking water that is monitored and/or filtered to protect from contamination Water provided by a water company by way of a home or business plumbing system (EPA, 2009; Natural Resources Defense Council, n.d.).

Trihalomethanes (THMs) - the most common by-product formed when water is disinfected. They are comprised of four compounds: chloroform, bromodichloromethane, dibromochloromethane, and bromoform that cause disease at different levels (D.K. Nix, personal communication, July, 2010; Environmental Working Group, 2010).

Total Trihalomethanes (TTHMs) –are not a single chemical but a class of compounds that includes the four different kinds of THMs. They are more commonly used when discussing regulations since regulations do not include individual THMs (D.K. Nix, personal communication, July, 2010; EPA, 2010b).

Variances- granted by states for systems serving up to 3,300 people who cannot afford to comply with standards as established by the EPA (through treatment, an alternative source, or restructuring). The system then installs the variance technology that must ensure adequate protection of human health. States can grant variances to systems serving 3,300-10,000 people with EPA approval and must review variances every 5 years and will have 3 years to comply with the requirements of the variance. The EPA has 2 years to establish the requirements for the said variance (EPA, 2004).

Vulnerable Populations- people whose range of options is limited or who may be unable to give informed consent. They are vulnerable by financial circumstances, their place of residence, health, age, ability to communicate, developmental status, disability, or chronic or terminal illness (Agency for Health Care Policy and Research, 1999).

Importance of the Study

According to Healthy People 2010 there is a need to promote health for all through a healthy environment including water quality. Access to clean water is vital to health, is a matter of public concern, and is the goal of water suppliers and public health officials. In a 2001 survey of 384 rural health care providers, Robson and Schneider reported that groundwater pollution and surface water contamination were the respondent's top two health concerns. As the annual Water Quality Report is intended to improve consumer confidence, the results of this survey and others like it can be used by water systems, the EPA, and the consumer to develop strategies that enhance or promote reading and understanding of this annual Water Quality Report. The results of this study may open dialogue about the importance of this report in informing consumers as well as suppliers about the potential effect that the Water Quality Report has on water use.

CHAPTER II

REVIEW OF THE LITERATURE

Whether a drinking water source is from tap, a well, or is bottled, it initially traveled across land surface or through the ground. As the water moves, it dissolves minerals that are naturally occurring and picks up contaminants from the presence of animals or from activities by humans. While these contaminants might not necessarily pose a health risk to the general population, this might not be the case for vulnerable populations. "Contaminants that may be present in source water before treatment include: microbes, inorganic contaminants, pesticides, herbicides, radioactive contaminants, and organic chemical contaminants" (EPA, 2008). Throughout history a lack of clean water has been a concern.

Historical Perspective

The quest for clean water began in prehistoric times. Records that come from Sanskrit writings and Egyptian inscriptions revealed the earliest water treatment. In these writings there were accounts of medical concerns dating as early as 2000 B.C. Water that was considered "impure" was boiled, heated by the sun, purified by sand and gravel and cooled and filtered through charcoal (Jesperson, n.d). There was also a primitive purification method with stone, known as "Gomedaka", and Strychnos potatorum seed. In

1627 a desalination process was used to remove salt water from the sea by percolating it through the sand. During the 17th century A.D., there were accounts of sand filtration methods that were also used. In 1804 the first recorded public water treatment plant was installed in Paisley, Scotland (Baker & Taras, 1981). The Broad Street Pump in London emphasized that taste and clarity did not always equate to pure clean water. Multiple cholera deaths were linked to a single pump that had drawn the public to the water source due to the good taste of the water (Baker & Taras, 1981; EPA, 2000; Jesperson, n.d.; Stanhope & Lancaster, 2005). Clean public water supplies continue to be an important public health concern today with the sources of public water including both surface and ground water supplies.

Surface Water

Over 267 million Americans get their water from public water systems (EPA, 2003a). The average American uses 100 gallons of water each day at home accounting for a household use of 107,000 gallons a year. Americans drink more than one billion glasses of tap water daily. They use this water also to flush their toilets, to water their lawns, to wash their dishes, to clean their clothes and cars, to bathe, to shower and to consume. In this process nearly 14 percent of all water that Americans purchase is wasted down the drain. This is important considering there are no new water sources, and because nearly 96 percent of the world's water is salty and not fit to drink (EPA, 2003; EPA 2010d). Native Americans understood this concept well and knew that what we do today affects the next seven generations (Stanhope & Lancaster, 2005). Abraham

Lincoln echoed these thoughts best when he said, "you cannot escape the responsibility of tomorrow by evading it today" (Chiras, 2006).

In the United States, surface water that comes from lakes, rivers, and streams supplies about three-fourths of the freshwater needed each day (Chiras, 2006; Millichap, 1995). According to the Texas Commission on Environmental Quality (TCEQ), about 94% of Texans are public water consumers of this surface water with the remainder using private wells or ground water as their water source. The bulk of this water consumption occurs at home with additional uses for recreation and at work. Since so much time is spent at work, the United States Department of Labor Occupational Safety & Health Administration (OSHA) Drinking Water Regulations dictate that potable water has to be provided in all places of employment (Millichap, 1995). Since the majority of the water consumed comes from surface water sources, it is important for consumers of this water to be aware of its quality. However consumers also need to be aware of the potential for ground water contamination.

Ground Water

Many Americans depend on well water for their water consumption that is supplied either by small communities or individual systems. Outbreaks of waterborne disease are a common problem for well water users and are one of the largest public health challenges in the nation. These issues arise from the fact that these wells are unregulated; thus, the owners need to be informed consumers in making sure their wells are safe (Morris, 1996).

This groundwater can move from 2 inches to 2 feet a day and supplies about one fifth of the United States freshwater needs. In remote rural areas, groundwater supplies 95% of the drinking water. About 3% of the daily precipitation drains underground and supplies some of the groundwater that makes up the rest of the supply. Natural underground water supplies also exist in the forms of wells and underground springs. About 4500 billion liters of contaminated water seep into the ground in the United States every day from septic tanks, cesspools, oil wells, landfills, agriculture, and ponds holding hazardous waste (Chiras, 2006; Millichap, 1995).

In rural areas, groundwater can also be contaminated by agricultural chemicals, such as pesticides and fertilizers. Many contaminants are tasteless and odorless at concentrations thought to threaten human health. The most common pollutants are chlorides, nitrates, heavy metals, and various toxic substances such as pesticides, degreasing agents, and petroleum products (Chiras, 2006; Millichap, 1995). The Office of Ground Water and Drinking Water (OGWDW) protects public health by partnering with state agencies to ensure safe drinking water and to protect these ground water sources (Millichap, 1995). Yet, results from the EPA's five-year nationwide survey of the amount of nitrate and pesticides (NPS) in drinking water wells were alarming (Chiras, 2006). Of the 10 million rural wells that were examined, nitrate was detected in 57 percent, pesticides in 4 percent, and both were detected in 3 percent. Pesticides and herbicides were the main offenders. In about 80 percent of homes and farms where household wells were located, contaminants were at levels above their maximum contaminant levels

(MCLs) and health advisory levels (HALs). The evidence of extensive migration of chemicals into wells further illustrates the need for improved in-ground water source protection (Chiras, 2006; Millichap, 1995; Singh, n.d.).The EPA estimated that 1% of the drinking water wells in the United States have contaminants that exceed the standards designed to protect human health (Chiras, 2006). While the primary sources of public water are from surface and ground water, some consumers choose bottled water as their drinking water source.

Bottled Water

Consumers often turn to bottled water citing health risk concerns, taste, and odor preferences as reasons. There is also a perception that bottled water is a cleaner, purer, and healthier product (Doria, 2006). The dramatic increase in the use of bottled water has been attributed to fears of waterborne illnesses which cause over two million deaths globally a year, most under the age of 5. In developing countries, adding a disinfectant like chlorine saves lives, so bottled water is seen as a healthy alternative. In the United States tap water is often just as safe as bottled water and is much cheaper (Petrie & Wessely, 2004). In some cases bottled water is just tap water that is packaged in a bottle (Annual Water Quality Report, 2008; NRDC, n.d.). However in developing countries buying bottled water is not an alternative due to the cost and a lack of access. Disinfection by adding one capful of chlorine to water sources reduces disease that cause diarrhea by 22-84% and cost about 0.01-0.05 US cents per liter of treated water (CDC, n.d.; CDC, 2006) as compared to the $1,000 estimated cost for a five-year supply of bottled water at the recommended intake of eight glasses a day (NRDC, n.d).

The EPA does not have jurisdiction over the bottled water quality. The EPA regulates water according to the SDWA. Bottled water is regulated by the Food and Drug Administration (FDA) as a consumer beverage under the Food, Drug, and Cosmetic Act and does not have the same regulations as tap water (CDC, 2009; EPA, 2010). According to the World Health Organization (WHO) and the EPA, when bottled water is analyzed, often the result is a product that is "over-treated" rendering it deficient of essential minerals. In some cases lead has also been found in these products (Magnarelli & Jaret, 2005; Mahajan, Walia, Lark, & Sumanjit, 2006). At the other end of the spectrum, high mineral content has been found in some brands of bottled water, making it unsuitable for babies and children. It is interesting to note that if water is bottled and packaged in the same state, the FDA completely exempts that bottled water (Annual Water Quality Report, 2008; Natural Resources Defense Council, n.d.). This further communicates the importance of consumer responsibility in understanding the contents of their water, regardless of the source.

An additional concern with bottled water is polycarbonate jugs and bottles and the chemical, bisphenol-A, that may pose a risk to developing fetuses (FDA, 2010). Standards for bottled water also do not guarantee that the water is cryptosporidium free (Facts for Families, 2001). According to the SDWA, the FDA was required to publish a bottled water consumer study on the achievability of suitable methods for informing consumers of what is in their bottled water (EPA, 2004). Whether the source of the water is surface, ground, or bottled, contaminants and DBPs in the water is a concern.

Contaminants and DBPs in Water

There are two types of contaminants: regulated and unregulated. Regulated water contaminants are heavy metals, arsenic and other possible contaminants that have been shown to cause or have the potential to cause illness in otherwise well individuals. These contaminants are monitored by state and federal agencies that regulate all public water supply systems in the United States. Unregulated contaminants are agents that may affect the perception of water quality, such as PH, hardness, taste, and smell, but have not been shown to cause adverse effects on well persons (EPA, 2010c). These include minerals, chemicals, and biological agents.

The EPA uses the Unregulated Contaminant Monitoring (UCM) program to gather data and statistics for contaminants that are assumed to be currently in drinking water, but do not have health-based values set under the Safe Drinking Water Act (SDWA). Every five years the EPA evaluates the list of contaminants, largely based on the Contaminant Candidate List (CCL). The SDWA Amendments of 1996 provided for surveillance of no more than 30 contaminants per 5-year cycle, looking at only a representative sample of public water systems that serve less than 10,000 people and storing systematic data in a National Contaminant Occurrence Database (NCOD) (EPA, 2010c).

All water contains some form of contaminant and chemicals that are usually created by human activity. In spite of contamination by pesticides, runoff from petroleum and animal waste that is deposited into our surface and ground water supplies, we are able to enjoy potable water. This is due to concerted efforts to provide us with quality water by the water suppliers, the EPA, the WHO, and public health officials (Shane, 2008).

There are just 91 contaminants that are regulated by the Safe Drinking Water Act despite the fact that there are more than 60,000 chemicals utilized in the United States. Thousands of those chemicals have been inspected with hundreds having an associated risk to cancer and other diseases at even small levels in drinking water. Despite these concerns, not one chemical has been added to the data of those enforced by the Safe Drinking Water Act since 2000 (Duhigg, 2009).

Source-water contaminants that are the most alarming include arsenic, asbestos, radon, agricultural chemicals, and hazardous waste (Morris, 1995). The EPA reports that in Texas the more common chemicals that pose a risk are the DPBs, arsenic, fluoride, and nitrate (TCEQ, 2008). Public water systems are required to monitor the amounts of potential contaminants present in treated water and make sure they do not exceed the EPA's maximum contaminant level (MCL). The EPA has set standards for about 90 of these contaminants in the major categories of "microorganisms, disinfectants, DBPs, organic and inorganic chemicals, and radionuclides" (TCEQ, 2008). The SDWA placed more of an emphasis on prevention of contamination problems rather than previous efforts that emphasized "after the fact" regulatory processes. The real issue in prevention of these contaminants is the ability to identify the areas at risk (Fellin & Riley, 1998). This requires extensive assessments and baseline information to be gathered at all levels.

To prevent contamination, states are required to develop programs based on guidelines established by the EPA and based on their own natural resources available. Assessments must be done on the state's source waters and submitted to the EPA within 18 months of current guidelines that are released by the EPA (EPA, 2004; Fellin & Riley, 1998). The EPA is then required within a six-month period to review the existing state programs and to provide guidance to states on ways to meet the requirements. This then places the burden back on the state to have the legal authority to ensure there are strategies in place to assist existing water systems that need improvement and to ensure new water systems have the resources including technical, managerial, and finances to meet the EPA standards and guidelines (Fellin & Riley, 1998). Some contaminants are present in such low levels they are difficult to detect and remove by conventional methods already in place. In some cases the EPA has not established levels yet for these contaminants (Srinivasan, 2009). While levels of contaminants are sometimes difficult to detect and regulate, there are some real health effects that are associated with exposure.

Health Effects of Contaminants in Water

The strongest support for a cancer risk as related to contaminants involves arsenic, which is linked to cancers of the liver, lung, bladder, and kidney (Morris, 1995). Human exposure to arsenic in drinking water occurs mainly via ingestion with secondary routes arising from inhalation during showering or cooking, and skin absorption during showering, bathing, or brushing of teeth. Skin contact with waters containing arsenic above drinking water standards will result in some arsenic absorption (Spayd, 2009).

Perchlorate is a major inorganic microcontaminant in drinking water. Perchlorate salts are used in pyrotechnics and fireworks, blasting agents, solid rocket fuel, matches, lubricating oils, nuclear reactors, air bags, and some fertilizers. Perchlorate has been found in a number of public drinking water systems around the United States, especially in the southwest, and has serious health impacts associated with it including normal iodine uptake by the thyroid gland, leading to a decrease in thyroid production. The thyroid gland is essential for normal growth, development, and metabolism in the body and the effects can be particularly significant in pregnant women and fetuses. While the EPA has not established MCL and MCLG for perchlorate, several states have already started the process by establishing their own levels for perchlorate contamination in the drinking water supply (Srinivasan, 2009).

As was discovered in the District of Columbia in 2001, it can be difficult to reach an optimal level of disinfection and to reduce contamination by DBPs. In an effort to prepare for the EPA's DBP rule, the district's water system changed their disinfection agent. As a result, lead levels started rising in the drinking water which caused the water system to also exceed the EPAs lead action level. The issue was eventually resolved, but this situation highlighted that in attempting to balance contamination of water and the resulting DBPs of treatment, public health needed to take a look at risk, the perception of risk, and the communication of risk (Goldsmith, Guidotti, Moses, & Ragain, 2008).

Lead usually enters the water through the corrosion of plumbing materials and older pipes that have lead joints. However even new homes that have pipes considered "lead free" can have up to eight percent lead in them (EPA, 2003). Lead in any concentration can pose health concerns, but lead at any level in the bloodstream of a child can be fatal, and water can be a source of such lead exposure and poisoning. It is estimated that more than ten million Americans may be drinking lead-contaminated water (Magnarelli & Jaret, 2005).

Older lead pipes that are still in use are a major contributor to lead exposure. To further complicate this issue, federal regulation loopholes as part of the Federal Lead and Copper Rule have allowed some states to report inaccurate tests and to even report diluted results. This results in the underreporting of lead contamination (Lambrinidou, 2009). As a result, the Lead-Free Drinking Water Act of 2004 required the EPA to re-examine its national policy for lead in water. The consumer's lack of awareness and understanding of the effects of the exposure to lead also poses some serious health issues. Consumers who are not aware might not realize that even low levels of lead exposure in children can lead to a delay in mental and physical development (EPA, 2003), a loss of IQ points (Magnarelli & Jaret, 2005; NIEHS, 2009), minor deficits in attention span, and learning disabilities (EPA, 2003), hyperactivity, and deficits in fine motor function (NIEHS, 2009). Adults who ingest this water can develop kidneys problems or hypertension. Contaminants are not the only concern for the health of consumers of water.

Health Effects of DBPs in Water

Limiting the levels of these contaminants through disinfection and the resulting DBPs can increase the risk of attributable serious health threats that include but are not limited to various forms of cancer (EPA, 2008; Richardson et al., 2000), heart disease, low birth weight, premature births, miscarriages, still births, chromosomal abnormalities, and birth defects including neural tube defects for average trihalomethane level exposure during pregnancy. Although the use of chlorine reduces the risk of waterborne infectious diseases, it may also account for a substantial portion of the cancer risk associated with drinking water. Trihalomethanes (THMs), the DBPs created when chlorine is used to disinfect water cause long-term or delayed health effects including different cancers (Boorman et al., 1999; Chen et al., 2003; Do et al., 2005; Millichap, 1995; Richardson et al., 2000; Woo et al., 2002). As far back as the 1980s, research suggested that alternative disinfectants should be considered to limit the formation of Total Trihalomethane (TTHM) levels (Greenburg, 1981; Hubbs, Amundsen, & Olthius, 1981; Reynolds, Mekras, Perry, & Graham, 1989).

Disinfection by chloramines has fewer negative consequences when compared with disinfection by chlorine alone, especially in regard to THMs and haloacetic acids (HAA5) (Dodds & King, 2001). DBPs occur when water reacts with chlorines and other chemicals that are used to treat water to form organic matter. TTHMs are a class of

DBPs and trichloracetic acid (TCAA) is a specific DBP in the class of HAA5 which have both been used in research as potential biomarkers to study the effect of DBPs and disease. Contact with these DBPs can occur through ingestion, inhalation, and dermal exposure (Nieuwenhuijsen, Toledano, & Elliott, 2000; Nuckols et al., 2005; Ritter et al., 2002; Spivey, 2009; Zhang, 2006). However, chloramines are not as good of a disinfectant as chlorine in killing pathogenic organisms such as bacteria, viruses, and protozoas. Therefore systems still have to come "off line" once a year for 2 weeks to run straight chlorine through the systems to disinfectant for these agents (Chiras, 2006; Corso et al., 2004).

Using information from the Birth Registry and Waterworks Registry of 396,049 Taiwanese births from 2001-2003, a population-based cross-sectional study that looked at TTHMs at three different exposure levels suggested that prenatal exposure to DBPs raised the risk of ventricular septal defects (holes in the heart), cleft palate, and anencephalus (Backer et al., 2000; Biomed Central/Environmental Health, 2008; Hwang, Jaakkola, & Guo, 2008). Another nationwide cross-sectional study of 285,631 Norwegian births from 1993-1998 revealed similar results. Results from multiple logistic regressions revealed an increased risk of any birth defects, and effects on cardiac, respiratory, and urinary tract systems for those exposed to medium to high levels of DBPs as a result of chlorination. Again this study emphasized the relationship between chlorination and the natural organic matter that forms the DBPs (Hwang, Magnus, & Jaakkola, 2002).

Long-term exposure to these harmful DBPs as a result of chlorination has also been linked to a greater risk of colon cancer (Chowdhury, 2009; Dodds, King, Woolcott, & Pole, 2001; King, Marrett, & Woolcott, 2010) and are particularly associated with an appreciable risk of bladder (Chang, Hob, Wang, & Yang, 2007; McGeehin et al., 1993) and rectal cancer, possibly accounting for 5000 cases of bladder cancer and 8000 cases of rectal cancer per year in the United States (Morris, 1995). There have been suggestions that THMs are associated with colorectal cancer, pancreatic cancer, brain cancer, and other cancers including a possible link to childhood leukemia (Chang et al., 2009; Chiu, Tsai, Wu, & Yang, 2010; Healthy Child, n.d; Invante-Rivard, Amre, & Sinnett, 2002; Natural Resources Defense Council, n.d.; Williamson, 1981).

THMs in drinking water are also thought to account for as many as 2-17 percent of the bladder cancers diagnosed each year in the United States (Chiras, 2006; Corso et al., 2004). These findings were significant after years of exposure to chlorinated surface water. Even after adjusting for gender, cigarette smoking, coffee consumption, and medical history factors, there was still a significant association with bladder cancer. The findings also revealed a time trend, with risk going up with length of exposure (McGeehin et.al, 1993).

Given the fact that numerous activities, such as drinking, boiling water, cooking, dishwashing, bathing, showering, and swimming, have been associated with the uptake of DBPs, there is a need for consensus on measurement of water intake. Some studies have reported a correlation between human uptake of DBPs and water concentrations while others found a strong relationship between TTHM concentrations in exhaled breath. Exposure assessment in epidemiological studies have been inadequate which complicates the understanding of these results and suggested the need for standard assessments for future studies of potential health risks (Nieuwenhuijsen, Toledano, & Elliott, 2000). There seems to be a higher TTHM uptake when swimming (Whitaker, Nieuwenhuijsen, & Best, 2003). With potential health risks and exposure to contaminants and DBPs in water, water treatment is an important part of ensuring that standards of clean water are established.

Water Treatment

Water treatment is important in terms of regulation of United States drinking water policies. However since water can be polluted from point and non-point sources, this process requires constant diligence and expertise (EPA, 2003; Ritter et al., 2002). Point sources are discrete locations that are relatively easy to identify and control. Some examples are factories, power plants, mines, oil wells, sewage treatment plants, and livestock. Although they are obvious sources for which controls can be effected, pollution control can be costly. Flooding where there is a natural watershed can carry livestock feces to many sources of water that potentially could contaminate their integrity as evidenced by an increase in Echoli, a bacteria that is normally found in the gut and is now being found in the lungs, the blood, and urine. Non-point sources are less discrete- such as farms, forests, lawns, and urban streets. Rainwater washes the pollution from these sources into nearby streams (Chiras, 2006; Stanhope & Lancaster, 2005).

Water treatment involves the addition of chemicals to aid in the removal of contaminants from the water and optional fluoridation and softening of the water in some cases. Water treatment involves the use of either chlorine or chloramines as bactericidal agents (EPA, 2008). The quality of drinking water varies from state to state depending on the condition of the source of the water and the treatment modality (EPA, 2003). Since there is a relationship with THMs and adverse health effects, to protect the public, the EPA established an MCL of 0.08 milligrams per liter (mg/L) for TTHMs. To comply with regulations, many municipal water systems changed to an alternative method of disinfection using chloramination, a combination of chlorine and ammonia (Chiras, 2006; Corso et al., 2004).

Denver, Colorado has used chloramines since 1918 (Water Quality Association, 2005) and larger water systems in north Texas have been using chloramines to disinfect the water since the 1970s. Yet, smaller systems did not begin using this form of disinfection until around 2006 (D.K. Nix, personal communication, April 2008). These delays emphasize the fact that smaller communities encounter the biggest challenge in supplying water of satisfactory quality and quantity. They have smaller populations and therefore often have limited funds required to hire experienced operators and to preserve and upgrade the water supply facilities. Delays in water service because of insufficient management, as well as violations of drinking water standards, are problematic for some of these systems (Millichap, 1995). Although this is not a new problem for smaller water systems, the situation has become more of an issue with the increase number of smaller water systems (Millichap, 1995; National Academy of Science, 2010).

Macler and Regli (1992) noted that treatment using conventional filtration methods and appropriate chemical disinfection to minimize microbial risks might still yield high DBPs in some systems especially those with compromised source water quality. The use of ultra filtration and the use of chloramines were recommended as a long term solution if the health risks from chloramine by-products were deemed to be less risky. This did prove to be the case as evidenced in previously cited reports (Chiras, 2006; Dodds & King, 2001; Nuckols et al., 2005; Spivey, 2009).

To ensure water is treated properly and is cost effective is to mandate that the knowledge and skills of public water system operators meet the high standards as established by the EPA. It is important for consumers to be aware of regulations on licensing for water operators to determine if their water is properly supervised and treated by the proper personnel (Fellin & Riley, 1998). All states must carry out an operator certification that meets or exceeds guidelines as established by the EPA. If states do not comply with operator training they will be subject to penalties affecting their drinking water state revolving fund (SRF). This fund assists communities in installing and upgrading safe drinking water facilities. This is part of the SDWA amendments and allows states flexibility in making decisions that impact their own constituents' drinking water (Fellin & Riley, 1998).

According to D.K. Nix, the EPA does not have a specific regulation that says systems have to be run by a certified (licensed) person, however, most states have adopted licensing regulations for their water operators. The only one that does not have a licensing system in place is Wyoming, which the EPA has primacy in (personal communication, May 21, 2010). In Texas, every public water system operations company must maintain an applicable registration with the Texas Commission on Environmental Quality (TECQ). All public water system operators who carry out process controls when producing, treating, or distributing drinking water must also have a license, and any operator that is in employment with a public water system operations company must also hold a license. However, an operator-in-training is excused from the licensing requirements (TCEQ, 2009).

The exception to this rule is when an individual performs duties in manufacturing or distributing drinking water for a transient non-community water system. These systems serve at least 25 people for at least 60 days a year (i.e., a trailer/RV park) and are exempt from the licensing requirements if the water for the water system is treated water that is bought or groundwater that is not under the direct influence of a surface water source. All other Public Water Systems, including those that purchase (distribute) have to have a licensed operator operating the system (D.K. Nix, personal communication, May 21, 2010).

According to the Texas Administrative Code on environmental quality and public water system operation companies and operators, there are four classifications of licensure (A, B, C, D) with varying requirements based on educational level at entry and the requirements based on the volume and size of the operating system (TCEQ, 2009). The A license is more technically advanced than the D, and the level of license is dependant on the size of the water system (number of connections), and the presence of any type of advanced treatment. In Texas, the licensing system works as follows: 1) A certain number of course hours have to be completed for each level of license. The D license only requires one 20-hour course (Basic Water), whereas the A license requires 164 course hours; 2) Each license has a list of "required" courses, and the remaining hours consist of "elective" courses; 3) Except for the D licensure, all other levels require a certain number of years of experience. An A license requires 8 years of experience in operations in a plant, although some time is granted for having a BS or MS degree; 4) The A and D licenses are classified as "water" licenses, which mean they are good for any type of system. However, the B and C licenses are specific to the area of work (i.e., surface water, ground water) or in distribution. A person with a surface water license can work in a ground water system but not vice versa. This is because the level of treatment for surface water encompasses all of that for ground water plus additional treatment. The distribution license only allows the individual to work in Distribution systems; and 5) In recent years, the A license test was changed to include 25 essay questions that generally takes 8 hours to complete (D.K. Nix, personal communication, May 21, 2010; TCEQ, 2009).

Not only is there a lack of uniformity in licensing requirements in the United States, there are also variations in water filtration and treatment. Some cities and states do not include filtration as a necessary step in water treatment which poses an additional threat for cryptosporidium. There are approximately 400-500 cases of the parasitic disease, cryptosporidium, in New York each year (New York State Department of Health, 2006).

Some states such as New York, Oregon, and Washington do not filter their water because of the pristine water sources. However, point and non-point sources of contamination cannot be ignored (D.K. Nix, personal communication, April 4, 2009; EPA, 2009a). Recent laws have been amended to require these states to amend treatment processes. It was not until 2007 that the EPA required New York City to filter their water (Blair, 2010; EPA, 2009a). In some cases such inadequate or even failed treatment can lead to public crisis. In 1993, a contaminated water source in Milwaukee caused 403,000 cases of cryptosporidiosis, resulting in more than 100 deaths. The health department determined the cause was contaminated runoff from land-dwelling animals such as cows and pigs living near Lake Michigan. This enormous epidemic of watery diarrhea was caused by cryptosporidium oocysts that went through the filtration system of one of the city's water-treatment plants. At the time, water-quality standards and the evaluation of patients for cryptosporidium were not sufficient to detect this occurrence until it was too late (Blair, 2010; Corso et al., 2004; D.K. Nix, personal communication, April 4, 2009; Mac Kenzie et al., 1994). Uniform enforcement could reduce these incidences by as much as 90% (Gilson & Buggy, 1996). In addition to these water treatment measures, there are several optional steps to treating water including fluoridation and softening.

Fluoridation

Fluoridation is not a necessary step to the water treatment process, and there are no size or population requirements. Fluoride is not required because the EPA considers it a contaminant, and by charter the EPA can not require a system to add a contaminant. If fluoride is added to water, it must be monitored daily. The MCLG of fluoride was established in 1985 and was originally set at 4 ppm. However, the SMCL of fluoride was set at 2 ppm because a significant percentage of children drinking water with more than 2 ppm will develop moderate and severe forms of dental fluorosis. The EPA requires water suppliers to inform consumers that children should not drink water if it contains greater than 2 ppm fluoride. The EPA develops the standards for and regulates the amount of fluoride in drinking water, and in Texas the TDSHS monitors its use (D.K. Nix, personal communication, June 10, 2010; National Academy of Science, 2006). Currently the MCL of fluoride is 4 ppm, and the MCLG is 2 ppm. Within the state of Texas, fluoridation programs are administered by the Centers for Disease Control (CDC) and the Texas Department of State Health Services (TDSHS) (D.K. Nix, personal communication, June 13, 2010).

Fluoridation has always been considered important, because dental caries is one of the most prevalent childhood diseases, especially among lower socioeconomic groups and minorities (Edwards, Hutton, Patrick, & Sriraman, 2009). According to the TDSHS

(2005), fluoridation of community water was one of the great accomplishments of public health in the Twentieth Century. It is a relatively cheap method for improving the oral health of a community and the benefits cross age and socioeconomic indicators. However, excessive fluoride often presents as fluorosis or a mottling and darkening of the teeth. Children are the most vulnerable and the risk is compounded by their access to multiple sources of drinking water that vary in fluoride content (Edwards et al., 2009; Gingras, Grondin, & Levallois, 1998).

Long-term exposure can lead to the possibility of severe skeletal problems called skeletal fluorosis. Symptoms can include pain and stiffness in the joints with severe cases presenting with change in the bone structures and calcified ligaments that result in the deterioration of muscles with increased pain. The symptoms associated with acute high-level exposure to fluoride include abdominal pain, excessive salivation, nausea, and vomiting. There might also be seizures and muscle spasms (Gingras et al., 1998).

Studies cited in the report of the National Research Council (NRC), *Fluoride in Drinking Water: a Scientific Review of EPA's Standards*, have suggested that infants could consume excessive amounts of fluoride through liquid concentrate or powdered baby formula that has been reconstituted with fluoridated water. This is especially true during the critical period when developing teeth may be vulnerable to enamel fluorosis. Sporadic use of water that contains the optimal levels of fluoride should not noticeably increase a child's risk for fluorosis (American Dental Association, 2006). Fluoride can also be obtained from mouthwash, soda, juice, bottled water, and certain foods.

According to the CDC (2009), the FDA does not require bottlers to list the amount of fluoride in a bottle of water, but does require them to list the fact that fluoride is an additive. In 2006, the FDA approved the following labeling, "Drinking fluoridated water may reduce the risk of tooth decay," if the bottled water contains more than 0.6 milligrams per liter (mg/L) and up to 1.0 mg/L. The standards for regulating the "quality and identity" for bottled water are found in the Code of Federal Register 21 CFR 165.110 and state that bottled water with no added fluoride may actually contain between 1.4 and 2.4 mg/L fluoride, depending on many factors including the air ambient levels, which is the annual mean of maximum daily air temperatures at the location where the bottled water is retailed (CDC, 2009).

Bottled water that is imported with no added fluoride may not contain fluoride in excess of 1.4 mg/L. However, domestic bottled water with added fluoride can contain levels between 0.8 and 1.7 mg/L fluoride, again depending on the mean of maximum daily air temperatures at the location where the bottled water is retailed. There is a lack of congruency on whether the FDA stipulates or requires labeling that lists the actual fluoride content, so a consumer would need to contact the manufacturer to determine the fluoridation level of bottled water (CDC, 2009).

The CDC has a system in place for the optimum fluoride concentration for public water systems based on ambient air temperature. The thought is, the hotter the climate, the more water consumers drink, so the lower the optimum concentration (CDC, 2009). In North Texas, it is 0.9 ppm while in south Texas it is 0.8 ppm. However, in the northern latitudes, the CDC moves the optimum to 1.0 ppm. While improved monitoring systems are not required by the CDC or TDSHS, they would be a good idea. The current program doesn't require that water suppliers analyze the samples daily for fluoride. They just require that they collect the sample daily which could be stored for 30 days and then multiple samples could be analyzed all at once. Changing to a daily analysis would be the best practice (D.K. Nix, personal communication, June 13, 2010).

Some areas of Texas, especially those found in the western sections, have excessive levels of naturally occurring fluoride in the water which has to be removed to prevent over fluoridation. Residents from these areas are often found to have mottling or browning of their teeth (D.K. Nix, personal communication, April 5, 2009). Some cities in Texas have opted out of previous fluoridation programs citing concerns over the toxicity of fluoride in their water (Gleason, 2006). When a city has fluoride in the water that exceeds the MCL they might provide fluoride reduced water to families with children younger than 14 years of age. The city provides this at no additional charge with limits up to 10 gallons a day (Annual Water Quality Report, 2008; TCEQ, 2009b). In addition to fluoridation, water softening is another optional step in water treatment.

Water Softening

There are no regulations on softening, beyond the standard TCEQ rules. Industry and home consumers like soft water, because there is less rusting of equipment, clothes are easier to wash and it can provide a more pleasant bathing experience. It is important to remember that a water softener is not intended to remove microbiological contaminants that cause illness and should only be used to treat drinking water that is already considered to be safe (TCEQ, 2005)

Water softeners replace "hard" minerals with "soft" minerals such as sodium. Water that is softened at home accomplishes this by running the water through a bed of ion-exchange material that exchanges hard minerals (calcium and magnesium) with sodium or potassium. Using sodium to soften water elevates concerns about the possible health risks for individuals on sodium restricted diets, including those with hypertension, kidney disease, or congestive heart failure. Even if potassium chloride is used in lieu of sodium chloride, there are potential health risks since it is also a form of salt (Sheps, 2009).

The American Heart Association (AHA) suggests that the 3 percent of the population who follow a severe, salt-restricted diet should not use more than 500 mg of sodium daily. No more than 10 percent of this sodium intake should come from water. The easiest and most practical way to reduce sodium in the diet is to eliminate as much sodium in water as possible. This can be achieved by making consumers aware of the sodium levels in the water supply, as well as the amount of sodium that is added by softening (AHA, 2010; Henry, 2010; Kansas State University, 2002).

Consumers often add softeners to their system without knowing if water that they purchase is already softened. According to a publication by Kansas State University (2002), a consumer can determine the amount of sodium a home water softener adds by using water hardness in grains per gallon (gpg). If an individual's water test is reported in milligrams per liter or parts per million, they can convert it to grains per gallon by dividing by 17.1. To find the amount of sodium in softened water the following formula is used: Sodium added (mg) = volume of water consumed (L) x hardness removed (gpg) x 8 mg/L/gpg. However, for water that is softened before being received at home, the EPA's guideline of 20 mg/L for water protects those people who are considered most at risk.

Water containing large amounts of potassium or sodium should not be used for activities such as drinking, cooking, or making coffee, juice, and infant formula. Some states have banned or restricted the use of softeners, because of runoff associated with them and the potential for harm to crops when wastewater is treated and reused for crop irrigation (InspectApedia, 2008). Another option for consumers is to add additional filters to their water sources.

Home Water Filters

Consumers often cite using some form of water filtration for taste and odor control. The National Resources Defense Council (2006) recommends consumers learn the contents of their water so that an appropriate filtering system can be chosen for their home. They also recommend that these filters receive regular maintenance. This is important because as contaminants build up, the water can be made worse, by "starting to release harmful bacteria or chemicals back into the filtered water".

Home water filters also can pose a challenge when looking at the varying effects of fluoride in water. Some use distillation, reverse osmosis, and activated charcoal or carbon to filter water. Pitcher and faucet mount filters do not affect fluoride content (Edwards et al., 2009). The EPA stresses that these filtration systems are not intended to remove organisms and chemicals that threaten one's health. However, certain filters such as reverse osmosis can indeed lower levels of some contaminants. Ultimately, it is the consumers' responsibility to know the contents of their water, to use effective filtration, and to change the filters as directed by the manufacturer. Filters not changed on a regular basis can cause more harm than good (Millichap, 1995). Despite the efforts to reduce contaminants and DBPs in the water through treatment and additional filtration, there are some populations that are more vulnerable to ill effects of the water treatment process and the end product.

Vulnerable Populations

Certain groups or individuals may be more vulnerable or at risk for complications when exposed to contaminants in drinking water. These include but are not limited to individuals living in rural areas, those undergoing chemotherapy, persons living with HIV/AIDS, transplant patients, children and infants, the elderly and pregnant women, and their fetuses (EPA, 2003). Immunocompromised individuals are especially vulnerable when there is a lack of filtration of water sources as evidenced by 40-60% of the AIDS patients in New York City dying of effects of diarrhea from Cryptosporidium (EPA, 2009a;).

Rural areas are at risk for some unique health situations making them a more vulnerable population. Only about 40-60% of fertilizers in the actual agricultural process are utilized by crops (Ayebo, Plowman, & States, 2006), leaving significant run-off from the remaining nitrate that causes water contamination (Benjamin, Kok, Grinsven & Ward, 2006; Singh, n.d.). This really becomes an issue in Texas where despite the rapid increase in rural populations (American Planning Association, 2002) the majority of the water quality studies have focused on larger urban areas. At the very least, baseline assessments need to be conducted for these areas (Singh, n.d.). As mentioned previously, the smaller rural systems are also the last to fall under mandates for new regulations and requirements established by the EPA (EPA, 2006; Millichap, 1995; National Academy of Science, 2010).

Pregnant women, unborn fetuses, infants, and children are also vulnerable populations. Exposure assessments are essential when determining the relationships between DBPs and negative birth results. A cohort study of 39 multi ethnic pregnant women in the north of England indicated that the average tap water intake was 1.8 liters/day and an average of 146 minutes per week showering and bathing. If the woman was unemployed 100% of this intake occurred at home with 71.8% occurring at home if they were employed. There were some variations related to demographic data collected including age, income, and ethnicity (Smith, Toledano, Wright, Raynor, & Nieuwenhuijsen, 2009).

Infants are especially vulnerable to nitrate levels in drinking water, often resulting in methemoglobinemia or "blue baby syndrome". This ensuing condition leads to the reduction of the oxygen carrying capacity of the red blood cells. There has also been some discussion of an association between high nitrate levels and non-Hodgkin's lymphoma with some animal studies also linking exposure to high nitrate levels and birth defects (Ayebo et al., 2006; EPA, 2003; Millichap, 1995).

In 2004, the World Health Organization (WHO) set a nitrate level standard of 50mg/l for drinking water to protect against blue baby syndrome. Although some scientists question the effectiveness of nitrate standards, scientists at the International Society for Environmental Epidemiology Symposiums in 2004 and 2005 suggested that nitrate's role as a carcinogen and its effect on reproductive conditions must be more thoroughly investigated. Part of the reasoning behind the difference of opinions is the lack of quality discussions between key stakeholders. The conclusion was that it was not feasible to weigh the economic costs and gains from changing the nitrate level standards to the potential consequences to human health (Benjamin et al., 2006).

Dialysis patients are also a vulnerable population. The water used to dilute the concentrated dialysate fluid is important because of the continual contact between dialysate and the patient's blood. As these patients are easily exposed to 300-400 liters of hemodialysis fluids weekly (Canaud & Mion, 2008), they require quality water sources. When present even in correct amounts, fluoride and the disinfectant chloramine make water unsafe for use in kidney dialysis machines (TCEQ, 2009b). Therefore dialysis patients and caregivers should check with their water supplier or dialysis center about their water source. This further emphasizes the need for consumers to know what is included in their annual Water Quality Report.

Chlorine in combination with aluminum, fluoride, and copper has been shown to be toxic to hemodialysis patients. Even marginal amounts of these contaminants can cause dementia, osteomalacia, and gastroenteritis (Chamney & James, 2008). They can even prove to be fatal.

According to the Water Quality Association (2005):

> Chloramines also pose a risk for hemodialysis patients and can easily enter the bloodstream through dialysis membranes. Once in the blood stream, chloramines denature hemoglobin and cause hemolytic anemia. Accidental use of chloramine treated water for dialysis has been responsible for a number of patients requiring transfusion to treat resultant hemolytic anemia, and was a possible factor in an increased mortality (death) rate among the dialysis center patients during the 5 months after the chloramine exposure when compared to the 12 months before the chloramine exposure (p. 3).

Whether they are a vulnerable population or not, all consumers have a right to know the contents of their water.

Consumer's Right to Know

In the "Consumer's Right to Know" section of the EPA guidelines, the public must be provided with or at least have access to any data collected on their water, including the analyses and findings. These regulations require that community water systems organize this annual Consumer Confidence Report by providing the source of the drinking water and the levels of contaminants that are found in that water. The report is required annually, and must include the following: (1) Information on the source of the drinking water; (2) Some concise definitions of terms; (3) The Maximum Contaminant Level Goal, the MCL, and the level of regulated contaminants if any; (4) If a MCL is violated, health information and any ill effects must also be provided; and (5) Unregulated contaminant information must also be provided if required by EPA regulations (EPA, 2004).

According to the EPA (2010b):

> MCLGs consider only public health and not the limits of detection and treatment technology; sometimes they are set at a level which water systems cannot meet. When determining an MCLG, EPA considers the risk to sensitive subpopulations (infants, children, the elderly, and those with compromised immune systems) of experiencing a variety of adverse health effects (Section 6 paragraph 1).

Since water systems often cannot meet these MCLGs, they are non-enforceable public health goals. It is important to note that when setting these MCLs, the law requires that the MCL be established as close as possible to the MCLG except when the cost of a standard is not "justified by the benefit, or when certain risk-risk considerations apply" (EPA, 2004). The reports must also provide an educational statement about Cryptosporidium and the need for vulnerable populations to avoid exposure to this parasite (NSF, 2004). In support of these regulations the EPA is required to provide to the public a report that specifies populations addressed by standards and regulations, the central, upper and lower estimates of risk, any significant questions about this risk, studies that would help resolve these questions, and peer-reviewed studies that maintain or discount the said risk (EPA, 2004).

Part of the SDWA requires that consumers become more informed about their water. This requirement will support the idea that as the consumer becomes more aware and informed, they will be more involved in the process of recognizing quality water. Although awareness is important, there is the potential for consumers to misconstrue the scientific information and become concerned over items that pose no actual risk. To combat the confusion, water authorities should have an open door policy; provide better education for the public on any issues affecting their drinking water; and give public notice within 24 hours of any drinking water standard violations that have the potential to negatively affect health (Fellin & Riley, 1998). These notifications are independent of the annual Water Quality Reports.

According to the EPA (2004) they will allow smaller systems serving less than 10,000 people to publicize the annual Water Quality Reports by newspaper instead of by mail. States may also allow systems serving less than 500 people to just "notify customers that the report is available" instead of mailing it (section II paragraph 2). Each state may also adopt alternative requirements for the form and content of the consumer confidence reports through state regulations. However, the EPA must issue the determined rules within 2 years of passing those that establish the requirements for the consumer confidence reports. These regulations must be coordinated and determined in "consultation with public water systems, environmental groups, public interest groups, risk communication experts, and the States" (section II paragraph 3). The regulations must also include clearly worded definitions of MCLG, MCL, variances, and exemptions, as well as "plain-language explanations of the health concerns associated with contaminants" (section II paragraph 3). The EPA is also required to have a hotline for consumers to provide additional information on drinking water contaminants and potential health effects (EPA, 2004).

In spite of the amendments to the SDWA, the EPA is searching for new ways to not only protect the public's health, but to improve the identification of potential risks in drinking water to give consumers more confidence in their water. There are four principle focus areas the EPA is considering (EPA, 2010a). These address contaminants as groups rather than on the extended list of individual contaminants. This plan will encourage the development of new technologies to monitor contaminants and the potential for health risks posed by these contaminants. In an effort to protect drinking water, the EPA will engage multiple regulatory authorities to establish new statutes to tighten current regulations and to be able to generate any missing data. These would include such regulatory authorities as the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA), and the Toxic Substance Control Act (TSCA). The new statutes would utilize existing data and provide new insight into relevant health effects and exposure to contaminants. The final approach would be to partner with various agencies at all levels to retrieve better data as a result of monitoring public water systems (PWS). This approach would involve stakeholders at all levels, including the utilities, rural communities, the public in general, universities, technology developers, the National Drinking Water Advisory Council, the Science Advisory Board's Drinking Water Committee, and other interested parties. The EPA is also planning to hold public forums and meetings, web casts and workshops to disseminate the information more effectively (EPA, 2010a).

The EPA's determination to make changes to the Consumer Confidence Report resulted from a nationwide telephone survey performed by the Gallup Organization of 1,000 households during August and September of 2002. This survey looked at general knowledge of drinking water, water use activities, public confidence with the information already provided and the value placed on the EPA's "right to know" efforts. The results of the survey indicated that participants realized the importance of information on every aspect of their drinking water and the right to be informed.

The EPA recognized the need to improve its efforts in developing consumer trust in public water supplies. Part of this will be accomplished through more public input in decision making and stronger community efforts and awareness. Dialogues must be encouraged that raise awareness and promote confidence. Results of the Gallup survey suggested that much of the complacency in reading and a lack of satisfaction of the Consumer Confidence Report were due to a lack of efforts to publicize the report and to make consumers aware of the importance of the contents. Future efforts to increase consumer confidence include a web-based software program to simplify the reports and to provide simple English explanations. The EPA is also encouraging more accurate and timely information on violations. The EPA has created posters that highlight fresh innovative ways for water suppliers to communicate to consumers. Some of the slogans used are "healthy waters start with water quality standards" or "a river that is clean doesn't have to be a dream". There are also templates available that allow communities to insert their own logos and contact information. The EPA currently is piloting a video series entitled "Tap into Prevention: Drinking Water Information for Health Care Providers". The rationale for targeting health care providers is the finding that 79.2% of the respondents reported trust in their health care provider. The EPA is appealing to stakeholders to find other ways to increase consumer confidence and to increase awareness (EPA, 2003a).

A similar study in Canada that used a telephone survey of 1,757 respondents and two focus groups revealed that barriers to information on drinking water included inconvenience, previous acceptable water test results, complacency and a general lack of knowledge. Consumers felt more confident with information and wanted it in forms such as flyers, water bills and newspapers (Jones, 2005), which interestingly are the forms by which water suppliers in the United States supply the Consumer Confidence Report for water. There is a need for education of consumers regarding the sources and types of water contamination, the recognition of symptoms of waterborne diseases, and home methods for prevention and control of drinking water hazards (Millichap, 1995). The annual Water Quality Report for the city of Andrews, Texas, reinforces the statement that "informed consumers are our best allies" (Annual Water Quality Report, 2008).

Consumer confidence in water and the belief and the attitude of the consumer can be explained by looking at the Theory of Reasoned Action (TRA) as a way to predict intent to read such reports.

Theory of Reasoned Action

The TRA was developed by Martin Fishbein and Icek Ajzen. The TRA explores the relationship between behavior and beliefs, attitudes, and intentions (National Cancer Institute, 2005). There are three components to this theory: attitudes, subjective norms, and behavioral intent. This theory purports to actually predict behavioral intention. The subjective norm refers to the impact of the social circle on an individual's behavioral intent. If a person's behavior is strengthened by friends and family, then behavior is likely to follow suit (Theory of Reasoned Action, n.d.). The attitude toward the behavior is the individual's positive or negative feelings about performing behavior - such as reading the annual Water Quality Report. The behavioral intent and the behavior will need to be measured at the same time, because it is expected that if the attitude changes so will the behavior. Attitude is a more positive predictor of behavior than subjective data (Sheppard, Hartwick, & Warshaw, 1988; Theory of Reasoned Action, n.d.). This theory is widely used to predict consumer behavior by looking at consumer intentions as well as the behavior in question. Therefore it is useful to target consumer behavior and attempts at changing that behavior (Sheppard et al., 1988).

The TRA did not adequately convey behavioral intent among people who believed they have little to no control over their behavior. Therefore a construct (perceived behavioral control) was added to the theory and the name was changed to Theory of Planned behavior (TPB). The premise is that people will not respond when circumstantial limitations prevent them from being able to change. Again the focus is on the person's intention to perform the behavior (Ajzen, 1991; Sharma & Kanekar, 2007). The element of cognition that is a part of this theory validates the need to inform consumers of water quality (Ogden, 2003).

CHAPTER III

METHODOLOGY

Population and Sample

This research study was exploratory in nature using a mixed methods approach with both closed-ended and open-ended questions in the form of an online Psych Data survey (Addendum C). In this survey, questions were asked to collect descriptive information as well as data regarding the annual Water Quality Report and water use.

Participants for the study were volunteers who were residents of the central-northeastern section of Texas that included the area south of Oklahoma, east of Abilene, and north of Waco with many of the participants coming from Wichita and Young counties. Participants were recruited for the study through community contacts including churches, civic organizations, professional organizations, social groups, family, and friends (Addendum B). Those participants were then asked to recommend additional participants for the study and were provided a link to the online survey (Psych Data). The study was comprised of 295 respondents with two being excluded due to age, leaving a total number of participants at 293. Demographic data was requested and required on the first seven questions of the survey and are illustrated in Table 1. Findings revealed that the average age was 48.17 with a range of 19 to 76. This was similar to the demographics of Texas where 53.1% of the population is between the age of 25 and 64 (Combs, 2006). Of this number there were 213 females (72.7%) and 80 males (27.3%).

This was not representative of the general population of Texas with 49% being male and 51% being female (State of Texas Census, 2000).

Table 1
Categorical Demographics

Category	Response	Frequency	%
Age	18-30 years	48	16.4%
	31-40 years	40	13.7%
	41-50 years	60	20.5%
	71+ years	10	34%
	Total N	293	100%
Gender			
	Female	213	72.7%
	Male	80	27.3%
	Total N	293	100%
Race			
	White Non-Hispanic	239	81.6%
	Hispanic/Mexican/Spanish	26	9.0%
	African American/ Black	15	5.1%
	Asian/Oriental	1	0.3%
	Pacific Islander	1	0.3%
	Native American	6	2.0%
	Other	5	1.7%
	Total N	293	100%

Table Continued

Table 1 Continued

Category	Response	Frequency	%
Employment	Employed	242	82.6%
	Unemployed	8	2.7%
	Retired	25	8.5%
	Other	18	6.2%
	Total N	293	100%
Education	Less than high school	14	4.8%
	Diploma or GED	32	10.9%
	Technical school	20	6.8%
	Some college no-degree	71	24.2%
	Associates degree	40	13.7%
	Bachelor's degree	57	19.5%
	Master's degree	37	12.6%
	Doctorate degree	22	7.5%
	Total N	293	100%
Population Size	Less than 10,000	125	42.7
	10,000-50,000	51	17.4%
	50,000-100,000	28	9.5%
	>100,000	89	30.4%
	Total N	293	100%

The distribution of race as seen in Table 1 indicates that 81.6% of the respondents were white non-Hispanic with representation from Hispanic/Mexican/Spanish, African American/black, Asian, Pacific Islander, Native Americans, and those who listed their race as other. Since the general population in North Central Texas accounts for 17% of the 35.7% of the total Hispanic population in Texas or 6.1%, the sample is representative of that population. And since 72.6% of the total population in Texas is white non-Hispanic, and 0.3% of the total population in Texas is Asian; the responses by the respondents on the survey were representative of the general population in regards to those races (State of Texas Census, 2000).

In regards to education as seen in Table 1, 4.8% of the respondents had less than a high school education while 17.7% were high school graduates, had a GED, or were technical school graduates. Over half of the respondents graduated with a degree at some level, while 24.2% of the respondents stated they had attended some college. These percentages indicated that there was some variation in representation with regard to educational level. In populations ages 25 and over in the general population of Texas, only 3.1% have an associate's degree, 4.6% have obtained a bachelor's degree, and 1.8% have obtained a graduate or professional degree. However another 20.7% of Texans have less than a high school education (State of Texas Census, 2000).

Concerning population settings, as seen in Table 1, the diversity of sizes of the communities in North Central Texas was evident in the representation of respondents. Of the respondents, 42.7% indicated they lived in an area with 10,000 people or less indicating a good representation of vulnerable rural areas. In regard to employment as seen in Table 1, 82.6% of the respondents were employed and 8.5% were listed as retired. Among the employed respondents, a variety of occupations were reported (see Table 2). This further validated the diversity of the population studied and was representative of occupations in the general population.

To determine "at risk" populations, participants were asked about certain health conditions among persons residing in their household (see Table 3). These included members in the household undergoing chemotherapy, members of the household that have undergone an organ transplant, have an immune disorder which may include autoimmune diseases such as lupus, rheumatoid arthritis or are HIV/AIDS positive, or are elderly or infants. Over half of the participants reported that there were no "at risk" or "vulnerable" members in their household. Approximately 39% of the participants selected one of the risk factors, thus offering adequate representation of the "at risk" populations as referred to on the required warnings of the annual Water Quality Report.

Table 2

Frequencies and Percentages for Occupations Represented

Category	Response	Frequency	%
Occupation	Administration/ management	14	4.8%
	Air Force	4	1.4%
	Bank tellers/manager/owner	2	1.3%
	Business manager/owner	5	1.7%
	Clerks/secretaries/office representatives	15	5.1%
	Construction/carpenter/roofer, etc	5	1.7%
	Collections/customer service	2	0.6%
	Community volunteer/coaches	3	1.0%
	Computer techs/analysts	3	1.0%
	Criminal justice/police/attorneys	6	2.0%
	Custodian/maintenance/animal caretaker	3	1.0%
	Dietary/ food services/cooks, etc	9	3.1%
	Disabled	5	1.7%
	Disaster management /underwriter	1	0.3%
	Educators/ professors /teachers	36	12.3%
	Electrical superintendent/ engineer	2	0.6%
	Homemakers/ moms	16	5.5%
	Inspectors/supervisors	3	1.0%
	Insurance agents/adjusters/underwriters	4	1.3%
	Inventory control /Case management	2	0.6%
	IT consultant/managers/networking	3	1.0%
	Lab technicians/ medical technologist	5	1.7%
	Lawn service operators	2	0.7%
	Licensed professional counselors	3	1.0%
	Licensed realtor /sales	5	2.0%
	Mechanics /technicians/repairs	8	2.6%
	Nurse/nurse practitioners	35	11.9%

Continued

Table 2 Continued

Category	Response	Frequency	%
Occupation	Oil/natural gas/well service	6	2.1%
	Paramedics	3	1.0%
	Patient care advocates/support staff/aides	7	2.4%
	Physical therapy/respiratory therapy	5	1.7%
	Physicians/surgeons	6	2.0%
	Plant operator/public utilities	3	1.0%
	Public information officer/PR	3	1.0%
	Radiology techs/sonographers	4	1.3%
	Retired	25	8.5%
	Self-employed	1	0.3%
	Students	6	2.0%
	Textile operator/seamstress	2	0.6%
	Tire manufacturer/truck drivers	4	1.3%
	Unemployed	9	3.0%
	Total N	293	100%

Table 3

Frequencies and Percentages for Health Conditions or Risk Factors

Category	Frequency	%
Cancer Undergoing Chemotherapy	8	2.6%
Have undergone Organ Transplants	2	0.6%
Immune System Disorders	34	11.1%
Elderly (age 65 and older)	55	17.9%
Infants (age 1 year old or younger)	20	6.5%
Uncertain	2	0.6%
None of these	187	60.7%
Total N	308	100%

Protection of Human Participants

Institutional Review Board approval was obtained from Midwestern State University and Texas Woman's University (see Appendix A). Participants were given information regarding the purpose of the study, potential risks and benefits as well as assurance of anonymity. Participants who participated in the study were given the opportunity to opt out of the study at any time regardless of the reason without penalty.

Data Collection Procedures

Instrumentation

A 26-item survey that took no more than 30 minutes to complete was used to collect data (see Appendix B). Participation was completely voluntary and anonymous. Prior to administering the survey, several focus groups were formed from respondents who did not live in the North Central Texas area and were not eligible to participate in the survey. They were administered the survey to determine if the questions were easy to understand in an independent online setting. Questions were modified and re-administered to the focus group and modified again prior to administering the survey based on suggestions from these groups.

The following statement was provided before participants began the survey: "Participants realize that there is a potential risk of loss of confidentiality in all internet transactions; however the providers of Psych Data have addressed these concerns by placing all surveys in a secure survey environment" (Psych Data, 2010). The following statement was included at the beginning of the survey: "Completion of this survey will imply your informed consent to participate and will grant the use of the anonymous information for this study." At the end of the survey, participants were then given the opportunity to decide whether to submit the survey as consent for its use in the study.

Data Analysis

Since this was an exploratory mixed-methods study, data was divided into qualitative and quantitative information. Measures of central tendency were used to assess the descriptive covariates (age, gender, race, education, size of population, and health condition or "risk" factor), respondents reading and/or understanding of the Water Quality Report, including understanding water contaminants, MCL, fluoridation, and water softening. Respondents overall confidence in tap water was assessed including some qualitative data that was gathered concerning their consumption of tap water, use of filters, and hesitancy to drink the water. All data were uploaded into EXCEL and SPSS formats. The data were further evaluated by running statistical analyses using Predictive Analytics SoftWare (PASW) to answer the three research questions and to test the five null hypotheses.

Independent- samples *t*-tests were used to compare consumer confidence and use of water between respondents who read and those who did not read the annual Water Quality Report; between those who acknowledged an understanding and those who did not acknowledge an understanding of the information in the report; and to determine if age affected understanding of the report. Pearson's χ^2 tests were used for the other descriptive covariates when determining if they played a role in understanding the Water Quality Report.

Multinomial logistic regressions were employed to gauge the predictability of the descriptive covariates in regards to understanding water contaminants, the presence of fluoride, and the use of water softeners. Binary logistic regressions were also used to assess the predictability of descriptive covariates in relation to drinking tap water, being hesitant to drink tap water, and changing habits related to tap water consumption and to assess the predictability of descriptive covariates as they related to reading and understanding the water report. Binary logistic regressions were also used for understanding the term MCL and the descriptive covariates. After these statistical testes were run, data were further analyzed to answer other questions that contributed to the research and offered insight for further research in this area. Qualitative data were then compiled and evaluated for additional information and for recurring and common themes.

Follow up Pearson's χ^2 were used, and to ensure the reliability of these statistics, the categories of the descriptive covariates were combined and recoded as needed. Age was re-coded into a categorical variable with the categories 18 to

40, 41 to 60, 61 and over. Race categories were combined so that the respondents were either categorized as Non-Caucasian or Caucasian. Education was re-coded into those with no college degree or those with an associate's degree, a bachelor's degree, a master's degree or a doctorate degree. Population size was recoded to indicate that respondents were from areas with less than 10,000 people or 10,000 people and over. Health conditions or "risk" factors were combined to indicate whether a participant had someone in the home that had a health condition or did not have an at risk health condition.

Summary

This exploratory study was approved by the MSU Human Subjects in Research Committees and was granted exempt status by the TWU Institutional Review Board. A 26- item survey that included both quantitative and qualitative questions was used to determine demographics, water consumption habits, consumer confidence, reading of the annual Water Quality Report, and an understanding of its contents. The first seven questions of the survey included descriptive covariates that gave the reader a sense of the population that was represented in the study. While this study consisted of volunteers from central-northeastern section of Texas, it was a good representation of the general population of Texas. There were a total of 295 participants that completed the report with 2 being excluded due to age restrictions. The study was based on the

Theory of Reasoned Action (TRA) used by health educators to explore the relationship between behavior and beliefs, attitudes, and intentions.

CHAPTER IV

RESULTS

Statistical analyses were utilized to answer the research questions and to address the hypotheses for the study, as well as to look for correlations among the variables.

Research Question 1

The first research questions asked "What proportion of participants actually read and acknowledge an understanding of the information on the annual Water Quality Report?" When answering this research question hypothesis two H_{02}, hypothesis three H_{03}, and hypothesis four H_{04} were used to compare those who read and understood the water report to individuals who did not read and understand the report based on the descriptive covariates and to use descriptive covariates to gauge predictability of understanding water contaminants, MCL, fluoridation, and the use of water softeners and filters.

Reading and Understanding the Report.

Of the respondents, 155 (52.9%) indicated that they did not remember receiving or seeing an annual Water Quality Report, 114 (38.9%) reported they had read the report and 41 (14.0%) answered they had not read the report. In regards to understanding the information, 149 individuals responded with 64 (43.0%) indicating they did understand the information contained in the water report while 85 (57.0%) people did not understand the water report.

Descriptive covariates and reading and understanding the report. H_{02} was tested using binary logistic regressions to evaluate if descriptive covariates were potential barriers as related to reading and understanding the annual Water Quality Report. The limited number of individuals in many of the health condition "risk" factor categories also made it necessary to consider this variable as one dichotomous variable so that those with any health condition or "risk" factor were compared to those with no health condition or "no risk" factor.

While these regression analyses revealed the descriptive covariates could not significantly predict reading the water report (χ^2 (6) = 8.493, p = .204), they did prove predictive of understanding the water report (χ^2 (6) = 22.733, p = .001). Population size (Wald = 10.250, p = .001, Exp (B) = 1.648) was a significant contributing factor, and gender (Wald = 3.761, p = .052, Exp (B) = 2.350) approached significance. Further independent statistics were completed to address $H_{03.}$ These revealed significant differences for education with no significance for age, race or risk factors.

Understanding these results may be enhanced by using follow-up statistics to consider the significant contributing variables individually. This consideration shows that population size (see Table 4) has a significant difference (χ^2 (3) = 13.930, p = .003) with a moderate effect size (V = .306) with those from an area with more than 100,000 people having a majority (66.7%) indicating that they understood the report while all other population sizes had a majority indicating they did not understand the report. Due to the lack of participants in the 50-100,000 population group and to ensure reliability of the results, an additional comparison was done on the population group. Population was recoded to a dichotomous variable consisting of the categories less than 10,000 and greater than 10,000 residents. This test revealed a significant difference (χ^2 (1) = 6.271, p = .012), with a majority of those residing in areas of less than 10,000 residents reporting they did not understand the report (see Table 5).

Table 4

Understanding Report and Population Size

	Understand Report				
Size	No	Yes	Total	χ^2	*P*
<10,000	44 (68.8%)	20 (31.3%)	64 (100%)		
10,000-50,000	20 (64.5%)	11 (35.5%)	31 (100%)		
50,000-100,000	7 (58.3%)	5 (41.7%)	12 (100%)		
>100,000	14 (33.3%)	28 (66.7%)	42 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	13.930	.003

Table 5

Understanding Report and Population Size as Dichotomous Variable

	Understand Report				
Size	No	Yes	Total	χ^2	*P*
< 10,000	44(68.8%)	20(31.2%)	64(100%)		
> 10,000	41(48.2%)	44(51.8%)	85(100%)		
Total	85 (57%)	64 (43%)	149 (100%)	6.271	.012

While gender was a predictive factor that approached significance, additional testing of gender alone revealed no significant differences (χ^2 (1) = 1.794, p = .180).

However, 18 of the 34 men (52.9%) indicated they understood the report while only 46 of the 115 women (40.0%) indicated they understood (see Table 6).

Table 6

Understanding Report and Gender

	Understand Report				
Gender	No	Yes	Total	χ^2	*P*
Female	69 (60.0%)	46 (40.0%)	115 (100%)		
Male	16 (47.1%)	18 (52.9%)	34 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	1.794	.180

The testing of H_{03} was further accomplished using a *t*-test for the variable age, as well as Pearson's χ^2 tests for the other demographic variables to compare between individuals who understood the report and those who did not understand the report. Results indicated that the *t*-test comparing the ages between the group who understood and the group who did not understand the report was not significant ($t = -1.590, p = .114$). Additional testing of the variable age in relation to understanding the report was done to address concerns with low cell numbers in the χ^2 analysis. After recoding the variables and running the χ^2, a significant difference (χ^2 (2) = 6.272, $p = .043$) was revealed with a majority of those between the ages of 18 and 40 and those 61 and over reporting they did not understand the report (see Table 7).

Also, race and education were recoded to dichotomous variables to address the same issues of low cell sizes in the χ^2 analysis. Analysis revealed significant differences in understanding of the report based on education (χ^2 (7) = 15.990, $p = .025$) and population size (χ^2 (3) = 13.930, p = .003). Education had a moderate effect size (see Table 8) as measured by Cramer's V (V = .328) indicating those with a master's or doctoral degree were more likely to report an understanding of the Water Quality Report; specifically, 14 of the 22 individuals (63.6%) with a master's indicated they understood the report, and 7 of the 11 participants (63.6%) with a doctorate indicated they understood the report. To further check for reliability, education was recoded into a dichotomous variable where one group consisted of those without a degree and the other group consisted of those with an associate's degree, a bachelor's degree, a master's degree and a doctorate degree. After recoding, the results indicated that education (having a degree) had no effect on understanding the Water Quality Report (χ^2 (1) = 1.711, p = .191) (see Table 9).

Additionally, the χ^2 tests were not significant for risk factors (χ^2 (1) = .310, p = .578) as shown in Table 10 or for race (χ^2 (5) = 7.813, p = .167) as shown in Table 11. To validate the findings for race, race was recoded to Caucasian and Non-Caucasian. The results indicated no significant difference (χ^2 (1) = 3.763, p = .052) as seen in Table 12. Ultimately, a majority of both groups reported they did not understand the report.

Table 7

Understanding Report and Age Categories After Recoding the Variables

	Understand Report				
Age	No	Yes	Total	χ^2	*P*
18-40	26 (72.2%)	10 (27.8%)	36 (100%)		
41-60	38 (48.1%)	41 (51.9%)	79 (100%)		
61 and over	21 (61.8%)	13 (38.2%)	34 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	6.272	.043

Table 8

Understanding Report and Education

	Understand Report				
Education	No	Yes	Total	χ^2	*P*
<High School	7 (100%)	0 (0%)	7 (100%)		
High School	9 (50%)	9 (50%)	18 (100%)		
Tech School	5 (83.3%)	1 (16.7%)	6 (100%)		
Some College	20 (58.8%)	13 (38.2%)	34 (100%)		
Associate	10 (50%)	10 (50%)	20 (100%)		
Bachelor	22 (71%)	9 (29%)	31 (100%)		
Master	8 (36.4%)	14 (63.6%)	22 (100%)		
Doctorate	4 (36.4%)	7 (63.6%)	11 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	15.990	.025

Table 9

Understanding Report and Education as Dichotomous Variable

	Understand Report				
Education	No	Yes	Total	χ^2	*P*
No Degree	41 (63.1%)	24 (37.9%)	65 (100%)		
Degree	44 (52.4%)	40 (47.6%)	84 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	1.711	.191

Table 10

Understanding Water Quality Report and Risk Factors

	Understand Information				
Risk Factors	No	Yes	Total	χ^2	*P*
No	33 (60%)	22 (40%)	55 (100%)		
Yes	52 (55.3%)	42 (44.7%)	94 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	.310	.578

Table 11

Understanding Water Quality Report and Race

	Understand Information				
Race	No	Yes	Total	χ^2	*P*
White	67 (53.6%)	58 (46.4%)	125 (100%)		
Hispanic	10 (76.9%)	3 (23.1%)	13 (100%)		
African American	4 (100%)	0 (0%)	4 (100%)		
Other	4 (57.1%)	3 (42.9%)	7 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	7.813	.167

Table 12

Understanding Report and Race as Dichotomous Variable

	Understand Information				
Race	No	Yes	Total	χ^2	*P*
Not Caucasian	18 (75%)	6 (25%)	24 (100%)		
Caucasian	67 (53.6%)	58 (46.4%)	125 (100%)		
Total	85 (57%)	64 (43%)	149 (100%)	3.763	0.52

Descriptive Covariates and Understanding Contaminants, MCL, Fluoride, Water Softeners

Pertaining to H_{04}, multinomial logistic regressions were employed to gauge the predictability of the descriptive covariates in regards to understanding water contaminants, the presence of fluoride, and the use of water softeners. Again, re-coding was necessary for the variables age, race, and risk factors using the same coding as for the binary logistic analyses.

Descriptive covariates and understanding water contaminants. In regards to understanding the contaminants, a significant equation was found (χ^2 (40) = 63.909, p = .010) with education (χ^2 (14) = 31.670, p = .004), age (χ^2 (10) = 21.574, p = .017), and risk factors (χ^2 (2) = 6.464, p = .039) contributing significantly to the predictive equation. Pertaining to education, significant differences could be seen between the comparison group (individuals with a doctorate) and individuals with less than a high school education (Wald = 7.151, p = .007, Exp (B) = .034), those with a degree from a technical school (Wald = 7.332, p = .007, Exp (B) = .055), and participants who completed some college (Wald = 6.879, p = .009, Exp (B) = .152). The difference between the "risk factor" groups was also supported by the Wald statistic being significant (Wald = 5.006, p = .025, Exp (B) = 2.361). However, there were no significant differences between the individual groups comprising the variable age or gender.

In considering these variables individually with follow-up Pearson's χ^2 statistics, there was a significant difference in reported understanding of water contaminants by education (χ^2 (14) =26.349, p = .023; see Table 13). Specifically, 7.1% of participants with less than a high school education, 26.7% of high school graduates, 10.0% of technical school graduates, 14.3% of individuals with some college, 30.0% of participants with an associate's degree, 32.7% of people with a bachelor's degree, 33.3% of those with a master's degree, and 36.4% of participants with a doctorate understood the contaminants. Concerns about cell size led to education being recoded to a dichotomous variable of college degree/no college degree (Table 14). This additional analysis revealed a significant difference (χ^2 (2) =12.282, p = .002) by education; those without a college degree were more likely to report a lack of understanding of water contaminants.

Table 13

Understanding Contaminants and Education

	Understand Contaminants					
Education	Yes	No	Uncertain	Total	χ^2	*P*
<High School	1 (7.1%)	2 (14.3%)	11 (78.6%)	14 (100%)		
High School	8 (26.7%)	9 (30%)	13 (43.3%)	30 (100%)		
Tech School	2 (10%)	3 (15%)	15 (75%)	20 (100%)		
Some College	10 (14.3%)	24 (34.3%)	36 (51.4%)	70 (100%)		
Associate	12 (30%)	11 (27.5%)	17 (42.5%)	40 (100%)		
Bachelor	18 (32.7%)	15 (27.3%)	22 (40%)	55 (100%)		
Master	12 (33.3%)	7 (19.4%)	17 (47.3%)	36 (100%)		
Doctorate	8 (36.4%)	9 (40.9%)	5 (22.7%)	22 (100%)		
Total	71(25%)	80 (28%)	136 (47%)	287(100%)	26.349	.023

Table 14

Understanding Contaminants and Education as Dichotomous Variable

	Understand Contaminants					
Education	Yes	No	Uncertain	Total	χ^2	*p*
No Degree	21 (15.8%)	38 (28.4%)	75 (56%)	134 (100%)		
Degree	50 (32.7%)	42 (27.5%)	61 (39.9%)	153 (100%)		
Total	71 (25%)	80 (28%)	136 (47%)	287 (100%)	12.282	.002

Analysis of understanding of contaminants by age revealed no significant difference (χ^2 (10) = 16.464, p = .087; see Table 15). Due to low individual cell counts, further statistics were completed using condensed categories for age: 18-40, 41-60, and 61 and over. These results as can be seen in Table 16 and further support the previous finding of no significant difference in understanding of contaminants by age (χ^2 (4) =

7.558, $p = .109$). In comparison of the risk and no risk groups (Table 17), there was no significant difference in the understanding of contaminants (χ^2 (2) = 3.638, $p = .162$); thus, the variable contributes significantly to the function but is not significant on its own.

Table 15

Understanding Contaminants and Age

	Understand Contaminants					
Age	Yes	No	Uncertain	Total	χ^2	p
18-30	10 (21.7%)	11 (23.9%)	25 (54.4%)	46 (100%)		
31-40	7 (17.5%)	10 (25%)	23 (57.5%)	40 (100%)		
41-50	12 (20%)	24 (40%)	24 (40%)	60 (100%)		
51-60	29 (37.2%)	19 (24.4%)	30 (38.5%)	78 (100%)		
61-70	11 (20.8%)	15 (28.3%)	27 (50.9%)	53 (100%)		
70+	2 (20%)	1 (10%)	7 (70%)	10 (100%)		
Total	71 (25%)	80 (28%)	136 (47%)	287 (100%)	16.464	.087

Table 16

Understanding Contaminants and Age After Recoding the Variables

	Understand Contaminants					
Age	Yes	No	Uncertain	Total	χ^2	p
18-40	17 (19.8%)	21 (24.4%)	48 (55.8%)	86 (100%)		
41-60	41 (29.7%)	43 (31.2%)	54 (39.1%)	138 (100%)		
61 and over	13 (20.6%)	16 (25.4%)	34 (54.4%)	63 (100%)		
Total	71 (25%)	80 (28%)	136 (47%)	287 (100%)	7.558	.109

Table 17

Understanding Contaminants and Risk Factors

	Understand Contaminants					
Risk Factor	Yes	No	Uncertain	Total	χ^2	*p*
No	31 (30.1%)	23 (22.3%)	49 (47.6%)	103 (100%)		
Yes	40 (21.7%)	57 (31.0%)	87 (47.3%)	184 (100%)		
Total	71 (25%)	80 (28%)	136 (47%)	287 (100%)	3.638	.162

Descriptive covariates and understanding MCL. A binary logistic regression was used to assess the predictability of the descriptive covariates on understanding the term Maximum Contaminant Level (MCL). This analysis revealed a significant prediction equation (χ^2 (5) = 36.542, *p* = .000), with significant contributions from gender (Wald = 4.353, *p* = .037, Exp (B) = 1.853) and education (Wald = 22.738, *p* = .000, Exp (B) = 1.433).

The follow-up analysis of descriptive covariates independently revealed a difference which was not significant by gender (χ^2 (1) = 1.785, *p* = .182); nevertheless, this variable contributes significantly to the predictive model with men being more likely to respond "yes" when asked if they understood the term Max Contaminant Level (Table 18).

Education, however, did reveal a significant difference (χ^2 (7) = 32.499, *p* = .000) between the groups. The general trend of the figures provided in Table 19 indicates that understanding increased as education increased. An additional χ^2 statistic was used with education since there were a few cells in the original analyses with low counts. The additional analysis of education (Table 20) as a dichotomous variable (college degree or no college degree) showed a significant difference between groups in their understanding of MCL (χ^2 (1) = 23.592, p = .000). Participants with a college degree were more likely to report they understood the term Max Contaminant Level.

Table 18

Understanding MCL and Gender

	Understand MCL				
Gender	No	Yes	Total	χ^2	p
Female	116 (55.0%)	95 (45.0%)	211 (100%)		
Male	35 (46.1%)	41 (53.9%)	76 (100%)		
Total	151 (53%)	136 (47%)	287 (100%)	1.785	.182

Table 19

Understanding MCL and Education

	Understand MCL				
Education	No	Yes	Total	χ^2	p
< High School	12 (85.7%)	2 (14.3%)	14 (100%)		
High School	20 (66.7%)	10 (33.3%)	30 (100%)		
Technical	17 (85.0%)	3 (15.0%)	20 (100%)		
Some College	42 (60.0%)	28 (40.0%)	70 (100%)		
Associate	19 (47.54%)	21 (52.5%)	40 (100%)		
Bachelor	23 (41.8%)	32 (58.2%)	55 (100%)		
Master	12 (33.3%)	24 (66.7%)	36 (100%)		
Doctorate	6 (27.3%)	16 (72.7%)	22 (100%)		
Total	151 (53%)	136 (47%)	287 (100%)	32.499	.000

Table 20

Understanding MCL and Education as Dichotomous Variable

	Understand MCL				
Education	No	Yes	Total	χ^2	*P*
No Degree	91 (67.9%)	43 (32.1%)	134 (100%)		
Degree	60 (39.2%)	93 (60.8%)	153 (100%)		
Total	151 (53%)	136 (47%)	287 (100%)	23.592	.000

Descriptive covariates and fluoride knowledge. Regarding the knowledge of the presence of fluoride, a significant equation was found (χ^2 (40) = 101.844, p =.000) with education (χ^2 (14) = 41.078, p = .000) and age (χ^2 (10) = 20.406, p = .026) contributing significantly while race (χ^2 (6) = 12.499, p = .052) and population (χ^2 (6) = 11.123, p = .085) approached significance.

In considering the results related to education, significant differences were present between the comparison group (individuals with a doctorate) and participants with less than a high school education (Wald = 5.417, p = .020, Exp (B) = .101), a high school diploma (Wald = 5.647, p = .017, Exp (B) = .127), and a technical school degree (Wald = 6.668, p = .010, Exp (B) = .038). These findings may be called into question due to the low number of participants in several cells; for example, individuals with less than a high school education and technical school graduates had fewer than 5 individuals in the "yes" category for fluoride knowledge while individuals with a master's degree or doctorate had fewer than 5 individuals in the "no" category. Therefore, education was recoded to a dichotomous variable (Table 21) which further validated the significant difference (χ^2 (2)

= 25.697, p = .000). A majority of participants with a college degree knew fluoride was in the water while the highest percentage of participants without a degree was uncertain.

Analyses of fluoride knowledge by age, race, gender, and population did not reveal any significant differences. Follow-up statistics were again used to assess these variables individually. This assessment revealed that there was a significant difference (χ^2 (10) = 23.111, p = .010) by age (Table 22) in regards to knowledge of fluoride presence in the water. This significant difference, even in the absence of a significant difference based on the Wald statistics, is probably due to the Wald statistic being more conservative. To further get a sense of these statistics a χ^2 was done using a more condensed grouping for age (Table 23) since the 70 and over group had too few people to supply reliable results. This assessment showed a difference which was not significant (χ^2 (4) = 6.313, p = .177).

Table 21

Fluoride Knowledge and Education as Dichotomous Variable

	Fluoride Knowledge					
Education	Yes	No	Uncertain	Total	χ^2	*P*
No Degree	42 (31.3%)	40 (29.9%)	52 (38.8%)	134 (100%)		
Degree	94 (61.4%)	25 (16.3%)	34 (22.2%)	153 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	25.697	.000

Table 22

Fluoride Knowledge and Age

	Fluoride Knowledge					
Age	Yes	No	Uncertain	Total	χ^2	*p*
18-30	20 (43.5%)	10 (21.7%)	16 (34.8%)	46 (100%)		
31-40	17 (42.5%)	6 (15.0%)	17 (42.5%)	40 (100%)		
41-50	20 (33.3%)	24 (40.0%)	16 (26.7%)	60 (100%)		
51-60	48 (61.5%)	13 (16.7%)	17 (21.8%)	78 (100%)		
61-70	28 (52.8%)	9 (17.0%)	16 (30.2%)	53 (100%)		
70+	3 (30.0%)	3 (30.0%)	4 (40.0%)	10 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	23.11	.010

Table 23

Fluoride Knowledge and Age After Recoding the Variables

	Fluoride Knowledge					
Age	Yes	No	Uncertain	Total	χ^2	*P*
18-40	37 (43%)	16 (18.6%)	33 (38.4%)	86 (100%)		
41-60	68 (49.3%)	37 (26.8%)	33 (23.9%)	138 (100%)		
61 and over	31 (49.2%)	12 (19.0%)	20 (31.7%)	63 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	6.313	.177

Analysis of fluoride knowledge by race revealed a significant difference (χ^2 (6) = 19.290, p = .004; Table 24). While a majority of Caucasian participants indicated an understanding of fluoride presence in the water, a majority of Hispanic and African American participants responded they were uncertain. Recoding race to Caucasian/not Caucasian further revealed a significant difference (χ^2 (2) = 15.949, p = .000; Table 25).

Analysis of fluoride knowledge by population revealed a significant difference (χ^2 (6) = 18.719, p = .005). Participants were more likely to know if fluoride was present in the water if they lived in a more populated area (Table 26). Recoding population to a dichotomous variable supported the findings by indicating that persons who resided in an area of 10,000 or more were more likely to know fluoride is present in the water compared with those who lived in an area of fewer than 10,000 (χ^2 (2) = 6.135, p = .047; Table 27).

Table 24

Fluoride Knowledge and Race

	Fluoride Knowledge					
Race	Yes	No	Uncertain	Total	χ^2	*P*
White	124 (52.8%)	50 (21.3%)	61 (26%)	235 (100%)		
Hispanic	5 (20%)	6 (24%)	14 (56%)	25 (100%)		
African American	2 (14.3%)	5 (35.7%)	7 (50%)	14 (100%)		
Other	5 (38.5%)	4 (30.8%)	4 (30.8%)	13 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	19.290	.004

Table 25

Fluoride Knowledge and Race as Dichotomous Variable

	Fluoride Knowledge					
Race	Yes	No	Uncertain	Total	χ^2	*P*
Not Caucasian	12 (23.1%)	15 (28.8%)	25 (48.1%)	52 (100%)		
Caucasian	124 (52.8%)	50 (21.3%)	61 (26%)	235 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	15.949	.000

Table 26

Fluoride Knowledge and Population Size

	Fluoride Knowledge					
Size	Yes	No	Uncertain	Total	χ^2	*P*
<10,000	49 (39.2%)	34 (27.2%)	42 (33.6%)	125 (100%)		
10,000-50,000	16 (33.3%)	14 (29.2%)	18 (38.1%)	48 (100%)		
50,000-100,000	15 (53.6%)	5 (17.9%)	8 (28.6%)	28 (100%)		
>100,000	56 (65.1%)	12 (13.9%)	18 (21.0%)	86 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	18.719	.005

Table 27

Fluoride Knowledge and Population as Dichotomous Variable

	Fluoride Knowledge					
Size	Yes	No	Uncertain	Total	χ^2	*P*
< 10,000	49 (39.2%)	34 (27.2%)	42 (33.6%)	125 (100%)		
> 10,000	87 (53.7%)	31(19.1%)	44 (27.2%)	162 (100%)		
Total	136 (47%)	65 (23%)	86 (30%)	287 (100%)	6.135	.047

Descriptive covariates and water softeners. The final multinomial logistic regression involved knowing if water softeners were used, and a significant equation was only found (χ^2 (40) = 67.209, p = .005) for education (χ^2 (14) = 27.327, p = .017). Significant differences were present between the comparison group (individuals with a doctorate) and participants with less than a high school education (Wald = 4.901, p = .027, Exp (B) = .086), a high school diploma (Wald = 3.793, p = .051, Exp (B) = .147), some college (Wald = 4.266, p = .039, Exp (B) = .191), and a bachelor's degree (Wald = 3.430, p = .064, Exp (B) = .226). Examining the impact of education alone on knowing if water contains a softener revealed a significant difference (χ^2 (14) = 31.876, p = .004).

However, as multiple cells had fewer than 5 cases, further analysis was conducted with education recoded to college degree/no college degree (Table 28). A significant difference was found (χ^2 (2) = 14.285, p = .001) indicating those with a college degree were more likely to know if their water contained a softener. Despite the significant finding, it's important to note that a large percentage of participants from both groups were uncertain as to whether their water contained a softener.

Table 28

Understanding The Use of Water Softeners and Education

	Water Softened					
Education	Yes	No	Uncertain	Total	χ^2	*P*
<High School	2 (14.3%)	3 (21.4%)	9 (64.3%)	14 (100%)		
High School	3(10.0%)	14 (46.7%)	13 (43.3%)	30 (100%)		
Tech School	0 (0.0%)	8 (40.0%)	12 (60.0%)	20 (100%)		
Some College	9 (12.9%)	36 (51.4%)	25 (35.7%)	70 (100%)		
Associate	10 (25.0%)	11 (27.5%)	19 (47.5%)	40 (100%)		
Bachelor	12 (21.8%)	19 (34.5%)	24 (43.6%)	55 (100%)		
Master	12 (33.3%)	12 (33.3%)	12 (33.3%)	36 (100%)		
Doctorate	9 (41.0%)	10 (45.4%)	3 (13.6%)	22 (100%)		
Total	57 (20%)	113 (39%)	117 (41%)	287 (100%)	31.876	.004

Table 29

Understanding The Use of Water Softeners and Education as Dichotomous Variable

	Water Softened					
Education	Yes	No	Uncertain	Total	χ^2	*P*
No Degree	14 (10.4%)	61 (45.6%)	59 (44.0%)	134 (100%)		
Degree	43 (28.1%)	52 (34.0%)	58 (37.9%)	153 (100%)		
Total	57 (20%)	113 (39%)	117 (41%)	287 (100%)	14.285	.001

Research Question 2

The second research question asked "Does reading the annual Water Quality Report influence decisions to drink the water?" In regards to answering this question, Hypothesis one H_{01} and Hypothesis five H_{05} were tested to answer this question. This question addressed whether reading the report served as a determinant of drinking the water. Further analysis was done to see if understanding the report affected consumer confidence and the decision to drink water and if this consumer confidence was affected by the descriptive covariates.

Consumer Confidence and Reading/Acknowledging an Understanding of the Report

When testing $H_{01,}$ independent *t*-tests were used to compare consumer confidence and use of water among consumers who read/acknowledged an understanding of the annual Water Quality Report and those who did not read/acknowledge an understanding of the report. These analyses revealed there were no significant differences between the group that read the report and the group that did not read the report in being hesitant to drink tap water (t = -.735, p = .463), being confident in the safety of the water (t = .208, p = .835), adding a filter (t = -.463, p = .644), or consumption of tap water (t = 1.621, p =

.107). However, participants who had read the report (M = .20, SD = .402) were more likely to change their water drinking habits compared to individuals who did not read the report (M = .03, SD = .171; t = -2.396, p = .018).

Analysis of those who understood the Water Quality Report and those who did not revealed no significant differences by being hesitant to drink water (t = .880, p = .381), drinking the water (t = .375, p = .708), or changing habits related to the consumption of tap water (t = -1.328, p = .186).

Consumer Confidence and Use of Water Filters

Analyses of consumer confidence revealed significant differences in feeling confident to drink the water (t = -3.200, p = .002). To expound upon these findings, participants who did not feel they understood the information (M = .41, SD = .495) were less likely to feel confident in their water source compared with individuals who felt they understood the information (M = .67, SD = .473). Thus, the individuals who felt they understood the information had a higher probability of feeling the water was safe to drink. Although no significant difference between groups was found on use of water filtration, qualitative data revealed some interesting reasons (Table 30).

Table 30

Reasons for Filter Usage (N=119)

Reason	Frequency	%
Improves Taste	78	65.5%
Reduces odor	69	58.8%
Came with the new refrigerator	32	26.9%
Eliminates chemicals in the water	31	26.1%
Improves confidence level about using the water	29	24.4%
Worry about contaminants	8	6.7%
Fish were dying	4	3.4%
Family member on dialysis	4	3.4%
Water company told them to filter their water	4	3.4%

Note: Participants could offer more than one reason for filter usage.

Descriptive Covariates and Hesitancy to Drink Water and Tap Water Consumption

For research question number two using H_{05}, binary logistic regressions were used to assess the predictability of descriptive covariates in relation to drinking tap water, being hesitant to drink tap water, and changing habits related to tap water consumption. These regression analyses revealed there was a significant regression (χ^2 (5) = 33.912, p = .000) for individuals being hesitant to drink water based on descriptive covariates. Specifically, the variables of gender (Wald = 11.144, p = .001), education (Wald = 4.760, p = .029), and population size (Wald = 9.119, p = .003) significantly contributed to distinguishing between individuals who were hesitant and those who were not hesitant to drink the water.

Additionally, a significant regression (χ^2 (5) = 18.181, p = .003) was found for drinking tap water by descriptive covariate of population (Wald = 8.777, p = .003). Moreover, a significant difference (χ^2 (5) = 33.665, p = .000) was found when considering the confidence individuals had in the safety of the water by age (Wald = 3.597, p = .058), gender (Wald = 6.501, p = .011), and population size (Wald = 16.188, p = .000).

Descriptive covariates and hesitancy to drink water. Analysis of hesitancy to drink the water by gender revealed a significant difference (χ^2 (1) = 9.194, p = .002). Women were more likely to report a hesitancy to drink the water (59.2%) while a majority of the men (60.8%) were not hesitant to drink the water (Table 31). Moreover, a significant difference (χ^2 (7) = 14.712, p = .040) was found by education (Table 32), revealing less hesitancy to drink the water as education level increased. Due to low cell sizes, education was recoded to college degree/no college degree (Table 33). Results indicated no significant difference in hesitancy to drink the water based on college degree (χ^2 (1) = 2.618, p = .106).

Table 31
Hesitancy to Drink Water and Gender

	Hesitant to Drink Water				
Gender	No	Yes	Total	χ^2	*P*
Female	87 (40.8%)	126 (59.2%)	213 (100%)		
Male	48 (60.8%)	31 (39.2%)	79 (100%)		
Total	135 (46%)	157 (54%)	292 (100%)	9.194	.002

Table 32

Hesitancy to Drink Water and Education

	Hesitancy to Drink Water				
Education	No	Yes	Total	χ^2	*P*
<High School	5 (35.7%)	9 (64.3%)	14 (100%)		
High School	10 (31.3%)	22 (68.8%)	32 (100%)		
Technical School	6 (30.0%)	14 (70.0%)	20 (100%)		
Some College	35 (50.0%)	35 (50.0%)	70 (100%)		
Associate	14 (35.0%)	26 (65.0%)	40 (100%)		
Bachelor	28 (49.1%)	29 (50.9%)	57 (100%)		
Master	23 (62.2%)	14 (37.8%)	37 (100%)		
Doctorate	14 (63.6%)	8 (36.4%)	22 (100%)		
Total	135 (46%)	157 (54%)	292 (100%)	14.712	.040

Table 33

Hesitancy to Drink Water and Education as Dichotomous Variable

	Hesitant to Drink Water				
Education	No	Yes	Total	χ^2	*P*
No Degree	56 (41.2%)	80 (58.8%)	136 (100%)		
Degree	79 (50.6%)	77 (49.4%)	156 (100%)		
Total	135 (46%)	157 (54%)	292 (100%)	2.618	.106

Analysis of hesitancy to drink the water by population (Table 34) revealed a significant difference (χ^2 (3) = 17.628, p = .001). Individuals from more populated areas were less likely to report a hesitancy to drink the water. The dichotomous grouping was used here also to address the reliability of the findings, and a significant difference (χ^2 (1) = 6.553, p = .010) was found with those residing in areas of fewer than 10,000 persons being more likely to report a hesitancy to drink their water (Table 35).

Table 34

Hesitancy to Drink Water and Population Size

	Hesitancy to Drink Water				
Size	No	Yes	Total	χ^2	*P*
<10,000	47 (37.6%)	78 (62.4%)	125 (100%)		
10,000-50,000	17 (33.3%)	34 (66.7%)	51 (100%)		
50,000-100,000	17 (60.7%)	11 (39.3%)	28 (100%)		
>100,000	54 (61.4%)	34 (38.6%)	88 (100%)		
Total	135 (46%)	157 (54%)	292 100%)	17.628	.001

Table 35

Hesitancy to Drink Water and Population Size as Dichotomous Variable

	Hesitant to Drink Water				
Size	No	Yes	Total	χ^2	*P*
< 10,000	47 (37.6%)	78 (62.4%)	125 (100%)		
> 10,000	88 (52.7%)	79 (47.3%)	167 (100%)		
Total	135 (46%)	157 (54%)	292 (100%)	6.553	.010

Descriptive covariates and tap water consumption. Further exploration of the significant contributing factors related to tap water consumption showed a significant difference (χ^2 (3) = 14.747, p = .002) in consumption of tap water based on population size. Individuals from more populated areas were more likely to report they drank the tap water (Table 36). Recoding population to a dichotomous variable revealed similar findings (χ^2 (1) = 4.227, p = .040; Table 37). Despite the significance, it's important to note that a majority of residents in all population size groups reported they drank the tap water. Analysis of tap water consumption by age revealed no significant differences (χ^2

(5) = 11.024, p = .051; Table 38). Additional analysis of age by dichotomous variable supported the prior finding of no significance (χ^2 (2) = 5.238, p = .073; Table 39).

Table 36

Tap Water Consumption and Population Size

	Drink Tap Water				
Size	No	Yes	Total	χ^2	P
<10,000	42 (33.6%)	83 (66.4%)	125 (100%)		
10,000-50,000	19 (37.3%)	32 (62.7%)	51 (100%)		
50,000-100,000	8 (28.6%)	20 (71.4%)	28 (100%)		
>100,000	11 (12.5%)	77 (87.5%)	88 (100%)		
Total	80 (27%)	212 (73%)	292 (100%)	14.747	.002

Table 37

Tap Water Use and Population Size as Dichotomous Variable

	Drink Tap Water				
Size	No	Yes	Total	χ^2	P
< 10,000	42 (33.6%)	83 (66.4%)	125 (100%)		
10,000 or more	38 (22.8%)	129 (77.2%)	167 (100%)		
Total	80 (27%)	212 (73%)	292 (100%)	4.227	.040

Table 38

Tap Water Consumption and Age

	Drink Tap Water				
Age	No	Yes	Total	χ^2	*P*
18-30	20 (42.6%)	27 (57.4%)	47 (100%)		
31-40	11 (27.5%)	29 (72.5%)	40 (100%)		
41-50	18 (30.0%)	42 (70.0%)	60 (100%)		
51-60	18 (23.1%)	60 (76.9%)	78 (100%)		
61-70	9 (15.8%)	48 (84.2%)	57 (100%)		
70+	4 (40.0%)	6 (60.0%)	10 (100%)		
Total	80 (27%)	212 (73%)	292 (100%)	11.024	.051

Table 39

Tap Water Use and Age After Recoding the Variables

	Drink Tap Water				
Age	No	Yes	Total	χ^2	*P*
18-40	31 (35.6%)	56 (64.4%)	87 (100%)		
41-60	36 (26.1%)	102 (73.9%)	138 (100%)		
61 and over	13 (19.4%)	54 (80.6%)	67 (100%)		
Total	80 (27%)	212 (73%)	292 (100%)	5.238	.073

Descriptive Covariates and Confidence in the Safety of Tap Water

Analysis of confidence in safety of tap water by gender revealed a significant difference (χ^2 (1) = 5.591, p = .018; Table 40) with men being more likely to report confidence in the safety of the water (62.8%); a majority of the women reported they were not confident in the safety of the water (52.8%). Participants from highly populated areas were more likely to report confidence in the safety of the drinking water (χ^2 (3) =

21.150, $p = .000$; Table 41). Recoding population to dichotomous variable supported the prior finding, revealing that participants from areas of fewer than 10,000 persons were less confident in the safety of the drinking water (χ^2 (1) = 13.045, $p = .000$; Table 42). Analysis of confidence in safety of the drinking water by age showed no significant difference (χ^2 (5) = 8.836, $p = .116$).

Table 40

Confidence in Safety of Tap Water and Gender

	Confidence in Safety of Tap Water				
Gender	No	Yes	Total	χ^2	*P*
Female	112 (52.8%)	100 (47.2%)	212 (100%)		
Male	29 (37.2%)	49 (62.8%)	78 (100%)		
Total	141 (49%)	149 (51%)	290 (100%)	5.591	.018

Table 41

Confidence in Safety of Tap Water and Population Size

	Confidence in Safety of Tap Water				
Size	No	Yes	Total	χ^2	*P*
<10,000	76 (60.8%)	49 (39.2%)	125 (100%)		
10,000-50,000	28 (56.0%)	22 (44.0%)	50 (100%)		
50,000-100,000	10 (35.7%)	18 (64.3%)	28 (100%)		
>100,000	27 (31.0%)	60 (69.0%)	87 (100%)		
Total	141 (49%)	149 (51%)	290 (100%)	21.150	.000

Table 42

Confidence in Safety of Tap Water and Population Size as Dichotomous Variable

	Confident in Safety of Tap Water				
Size	No	Yes	Total	χ^2	*P*
< 10,000	76 (60.8%)	49 (39.2%)	125 (100%)		
> 10,000	65 (39.4%)	100 (60.6%)	165 (100%)		
Total	141 (49%)	149 (51%)	290 (100%)	13.045	.000

Descriptive Covariates and Changes in Tap Water Consumption

The final binary regression analysis was related to changes in tap water consumption habits and was further evaluated using follow-up Pearson χ^2 statistics which revealed a significant difference (χ^2 (1) = 4.727, p = .030) between males and females in regards to changing their tap water consumption habits (Table 43). Women were more likely to change their tap water consumption after being apprised of the information contained in the Water Quality Report.

Table 43

Changes in Tap Water Consumption and Gender

	Changed Tap Water Consumption				
Gender	No	Yes	Total	χ^2	*P*
Female	83 (80.6%)	20 (19.4%)	103 (100%)		
Male	30 (96.8%)	1 (3.2%)	31 (100%)		
Total	113	21	134	4.727	.030

Research Question 3

The third research question asked "Among the participants who are hesitant to drink the water, what are the barriers?" This question was addressed using qualitative data from question 11 on the survey "If you are hesitant in drinking the water within your community, why?" Of the respondents, 150 (51.1%) answered "yes" that they were hesitant to drink the water within their community. Of these, 147 (98%) qualified this answer with a reason; many cited several reasons for their hesitancy. The total number of reasons for hesitancy identified by the 147 who responded with reasons was 31. Similar concepts were placed in groups with frequency tabulations, and the frequency of the concepts was tabulated and converted to percentages. Many of the responses had common themes for their hesitancy and are identified in Table 44.

Further descriptive statistics were done to determine if any additional barriers were identified. Of the 150 who were hesitant to drink the water, 95 (63.3%) indicated that despite having hesitations, they drink the tap water in the community. Of the individuals who were hesitant to drink the water and chose an alternate source of water, 98 (65.3%) drank bottled water. Of those hesitant to drink the water, 93 (62%) marked that they do not read the annual Water Quality Report. Of those who read the report, 48 (92.3%) reported that they do not understand the contents of the report. Of the 102 who stated that they understood the report, 61 (59.8%) marked that there were no warnings on the report or they were uncertain if there were any warnings. This indicated that despite their response that they understood the annual Water Quality Report, they did not recognize the required warnings on all reports for vulnerable populations and certain diseases such as Cryptosporidium. These indicates an additional barrier that could contribute to hesitancy which is a lack of reading of the report and a lack of knowledge and understanding of the annual Water Quality Report among those who read it.

Table 44

Common Reasons for Hesitancy to Drink the Water

Reason	Frequency	%
Lack of trust for the quality of the water	41	20.5%
High incidence of cancer in the community	28	14.0%
Taste of the water	27	13.5%
Smell of the water	23	11.5%
Lack of the trust for the treatment process	19	9.5%
Color and clarity of the water	16	8.0%
Uncertainty of knowing what is in the water	9	4.5%
Number of chemicals, bacteria, etc. in the water	9	4.5%
Uncertainty of how it is treated	8	4.0%
Fear of not knowing enough about the water	8	4.0%
Lack of trust for the Water Quality Report	6	3.0%
Fear for their kids	6	3.0%
Total	200	100%
N=147		

Summary

Analyses evaluated the contributing variables separately to compare the individuals who read the Water Quality Report with those who did not read the report, as well as the individuals who understood the water report to individuals who did not understand the report. Results indicated that the descriptive covariates were not predictive of participants reading the water report; however population size, age, and education were predictive of understanding the report. Respondents from areas with more than 10,000 people were more likely to respond that they understood the report in comparison with smaller population sizes.

When looking at age and understanding the report, a majority of respondents between the ages of 18 and 40 and those 61 and over reported that they did not understand the report. When looking at education and understanding, those with a master's degree and a doctorate degree were more likely to report understanding. However, when the data was recoded into degree and no degree, the fact that a respondent just had a degree was not a significant finding on understanding.

Analysis of understanding the term contaminant revealed a significant difference by education with those without a college degree being more likely to report a lack of understanding of the term. When looking at understanding the term MCL, gender played a role with men more likely to respond "yes" to understanding the term. Participants with a college degree were also more likely to report that they understood the term MCL.

A majority of participants with a college education knew fluoride was in the water with the highest percentage of those without a degree being uncertain. Race played a role in the knowledge of fluoride also with a majority of non Caucasians not knowing or being uncertain. Population size was also a factor with persons who resided in an area of 10,000 or more being more likely to know if fluoride is present in their water.

There was also a significant difference in regards to education and knowing if the water was softened. Those with a college degree were more likely to know this information compared to those without a college degree. Despite this finding, it is interesting to note that a large percentage of participants from both groups reported uncertainty as to whether their water was softened.

Analysis of consumer confidence and reading the report revealed that respondents had no hesitancy in drinking the water, being confident in the safety of the water or adding a water filter. However, participants who read the report were more likely to change their water drinking habits than those who did not read the report. Analysis of those who acknowledged an understanding of the report also revealed no difference in hesitancy to drink the water, drinking the water or changing habits related to tap water consumption. However, there was a significant effect in feeling confident to drink the water and adding a water filter. Participants who did not understand the water report were less likely to feel confident in their water source. Individuals who reported they understood the information had a higher probability of believing the water was safe to drink, but they also had a higher chance of installing additional filters for their water. Taste and odor control were the top reasons given for using additional filters.

Women were more likely to report a hesitancy to drink the water, while a majority of the men were not hesitant to drink the water. When looking at education, again the fact that a respondent had a college degree was not significant in itself. Those participants with a master's or doctorate were less hesitant to drink the water.

Participants who resided in areas of less than 10,000 persons were more likely to report hesitancy to drink the water. When looking at tap water consumption, individuals from more populated areas were more likely to drink the tap water. However, a majority of residents from all population size areas reported that they drank the water. When looking at confidence in the safety of the water, men and respondents from highly populated areas were more likely to report confidence in the safety of the water. Women were more likely to change their tap water consumption after being apprised of the information contained in the Water Quality Report.

Common and recurring themes were identified to address hesitancy to drink the water and associated barriers. The top themes identified were a "lack of trust for the quality of the water", a "high incidence of cancer in the community", and the "taste" and "smell" of the water. Not reading the report and a lack of knowledge and understanding of the annual Water Quality Report were identified as barriers to drinking the water. If an alternate source of water was chosen, a majority drank bottled water. Despite the fact that respondents stated that they understood the report, they identified on their survey that they did not have warnings on their report or were uncertain if there were any warnings in the report.

CHAPTER V

DISCUSSION

Summary

While most individuals will agree that water is essential for life, many take for granted that the water they consume is clean and safe for consumption. The EPA enforces standards that apply to public water systems to protect the public's health and well being by limiting contaminants in the water and ensuring the safety of water treatment to make it potable. To keep the public informed as to the quality of tap water, a Consumer Confidence Report (CCR) is communicated through an annual Water Quality Report (EPA, 2008). This annual Water Quality Report comes in a written report, but for smaller communities with less than 10,000 residents, the water system only has to make communities aware that there is a report available or can publicize the information through venues such as the newspaper. The report contains required information such as contaminants, the Maximum Contaminant Levels (MCL), the amount of fluoride used, selected water borne diseases, and warnings to certain at risk populations about the safety of drinking the water (EPA, 2004).

The purpose of this study was to determine whether the annual Water Quality Report was effective as a consumer confidence tool. Snowball sampling techniques recruited 293 participants from the central Northeastern section of Texas. Respondents participated in a brief 26 question on line survey to determine if they read the report, acknowledged an understanding of the information on the report, and used information in the report to make informed decisions about consumption of their tap water.

The survey included demographic information, information on whether respondents used a filter, the uses of the tap water, any hesitancy and barriers to consuming the water, and whether the information in the report affected their tap water consumption. Information about descriptive covariates (age, gender, race, education, occupation, size of population and health condition or risk factors) was assessed to determine if they were either predictive or protective of the respondent's reading of the report, acknowledging an understanding of the report, understanding water contaminants, understanding Maximum Contaminant Levels (MCL), having knowledge as to whether the water was fluoridated or softened, and having confidence in the safety of the drinking water.

The results indicated that the average age of respondents was 48 years, with the largest percentage being white non-Hispanic women with at least a high school education or the equivalent. A majority of the respondents were employed, were represented by a variety of occupations, and lived in areas with less than 50,000 people. While a majority of the respondents identified that there was no at risk populations in their household, almost 40% responded that at least one member of the household had an at risk health condition that made them more vulnerable to potential contaminants in the tap water.

A majority of the respondents indicated they did not remember receiving or seeing an annual Water Quality Report. Of those who did receive the report, a majority indicated that they read the report, however of those, a majority indicated they did not understand the report. While the descriptive covariates could not significantly predict reading of the water report, they did have an impact on an understanding of the annual Water Quality Report.

Conclusions

The annual Water Quality Report is a tool that the EPA considers important in providing information to consumers on the quality of their water. Consumers are to take that information and decide whether to consume the water, use additional filtration, or to take precautions for at risk populations. In this study, statistics showed that reading the report was not affected by the descriptive covariates, and that just reading the report did not make participants more or less hesitant to drink the water. Reading the report also did not affect their confidence in the safety of the water, or influence decision to use additional filtration on the water. Despite the lack of significant findings, a higher percentage of those who read the report were more hesitant to drink the water, less likely to drink the water and more apt to change their tap water consumption compared with those who did not read the report.

Of the respondents, 155 (52.9%) indicated they did not remember receiving or seeing an annual Water Quality Report, with 114 (38.9%) reported they had read the report and 41 (14.0%) answered they had not read the report. In regards to understanding the information, 149 individuals responded with 64 (42.9%) indicating they did understand the information contained in the water report while 85 (57.1%) people did not understand the information in the report.

Even though the descriptive covariates were not predictive of reading the water report, they did have an effect on an understanding of the report. Respondents from more populated areas were more likely to report an understanding of the report. Specifically understanding increased as population size increased with the least understanding in the group residing in an area of fewer than 10,000 persons.

Analysis of the effect of age on understanding of the report revealed that those between the ages of 18 and 40 and those 61 and over were more likely to not understand the report. Although no significant effect was found by gender, a majority of the male participants expressed an understanding of the water quality report. Health condition contributed significantly to the overall predictive model of understanding the Water Quality Report, but was not significant when analyzed independently.

While education had a moderate impact on understanding the report, just having the degree was not a significant finding in understanding the report. Those respondents with more education were also more likely to express understanding of the report. This was more than just being identified as having a degree. Those individuals identified as having a master's degree or doctorate degree were the only category where more than half acknowledged that they actually understood the report. There was no significant effect by race, with a majority in each category acknowledging a lack of understanding of the information in the report. However, the percentage was much higher among the non-Caucasian group.

Respondents who acknowledged understanding the report were also more likely to feel confident in their water source as compared with individuals who did not understand the information in the report. Those who understood the report were also more likely to use additional filtration on their water source. This could be related to understanding the potential for contaminants and adding the filtration, or the fact that they have the filtration might be related to their reporting an understanding and an increase in confidence in the water. When asked why they used the filters, the majority indicated that it was for "taste and odor control".

Further analyses related to understanding the report evaluated the terms contaminants and MCL. In regards to contaminants, higher levels of education were associated with higher percentages of people understanding water contaminants. Despite this finding, a higher percentage of participants with (39.9%) and without (56%) a college degree reported uncertainty as to their understanding of water contaminants. As for understanding of MCL, there was a definite trend of increasing understanding as educational level increased. Those with a college degree were much more likely to note an understanding of MCLs compared with participants without a college degree.

Gender and having a person in the home with an at-risk condition contributed significantly to the overall predictive model but were not significant as individual variables in evaluating participant understanding of contaminants and MCL, and fluoride. In regards to understanding the term MCL, a majority of the men responded affirmatively (54%) while a majority of the women responded in the negative (55%).

When determining if fluoride was in the water, again education was a significant part of the equation. Respondents with a college degree were more likely to know if fluoride was in the water. Using the multiple age groupings, a significant effect was found by age on knowledge of fluoride use; but when recoded to three age groups, no significant effect was found by age. By race, Caucasian participants were much more likely to report knowledge of fluoride in the water when compared with non-Caucasian participants. A majority of the Hispanic and African American participants indicated they were uncertain of the presence of fluoride in their water. Lastly, participants who resided in more populated areas had an increased likelihood of reporting knowledge of fluoride in the water.

When asked whether their water is softened, results indicated a significant effect by education. Those with higher education levels answered affirmatively that they knew if softeners were used. Even with the recoding of this group due to low cell sizes, results revealed that participants with a college degree were much more likely to know this information.

There were not any significant differences between the group that read the report and the group that did not read the report in being hesitant to drink tap water or being confident in the safety of the water. Interestingly, a majority of the men reported no hesitancy in drinking the tap water, while a majority of the women reported they were hesitant to drink the tap water. No significant effect was found for hesitancy to drink the water by education, but percentages of those less hesitant to drink the water increased as education increased. A higher percentage of persons hesitant to drink the tap water came from less populated areas.

When considering changing tap water consumption habits, those who read the report were more likely to change their habits than the individuals who did not read the report. Participants who did not perceive they understood the information in the annual Water Quality Report were less likely to feel confident in their water source as compared with individuals who perceived they understood the information. Participants who did not understand the report were less likely to install an additional water filtration system than individuals who did understand the report. Thus, the individuals who felt they understood the information had a higher probability of feeling the water was safe to drink and a higher chance of installing additional filters for their water.

Finally when looking at confidence in water safety, a majority of men indicated that they believed the water was safe while a majority of the women indicated they were not confident in the safety of the water. Participants from more highly populated areas were also more likely to be confident in the safety of their water. A majority of the reasons for a lack of confidence or hesitancy were a "lack of trust of the quality of the water", "concerns for high levels of cancer," and an overall "poor quality of the water".

After all of the analyses were done and the findings were reviewed and evaluated, the disposition of the null hypotheses (Table 45) was determined. The findings suggested that each of the null hypotheses should be rejected with the exception of the relationship between the descriptive covariates and reading the annual Water Quality Report in H_{02}.

Table 45

Deposition of Study Hypothesis

Hypothesis	Deposition
H_{01}- There will be no statistically significant difference in consumer confidence and use of water among consumers who read the annual Water Quality Report or those who acknowledged an understanding of the information in the report and those who did not read the report or did not acknowledge an understanding of the information.	Rejected
H_{02}- Descriptive covariates (age, gender, race, education, occupation, size of population, health condition) will be neither predictive nor protective of participants reading and acknowledging an understanding of the Water Quality Report.	Rejected (Understanding) Accepted (Reading)
H_{03}- There will be no statistically significant difference between those who reported an understanding and those who did not report an understanding of the annual Water Quality Report based on descriptive covariates (age, gender, race, education, occupation, size of population, health condition).	Rejected

Continued

Table 45 Continued

Deposition of Study Hypothesis

Hypothesis	Deposition
H_{04}- Descriptive covariates (age, gender, race, education, occupation, size of population, health condition) will be neither predictive nor protective of participant understanding of water contaminants, maximum contaminant levels (MCL), fluoridation, and softening of their water.	Rejected
H_{05} - There will be no statistically significant difference between those who report confidence and those who report no confidence in the safety of the drinking water based on descriptive covariates (age, gender, race, education, occupation, size of population and health condition).	Rejected

Discussion and Implications

Research Question 1

What proportions of participants actually read and acknowledged an understanding of the information on the annual Water Quality Report? Reading the report was not affected by demographic information. When asked about reading the report, a majority of the respondents who answered this question indicated that they did not remember seeing the report. Of those who saw the report, a majority stated they read it. Respondents were asked to skip the question about understanding the report if they indicated that they had not read the report. However, some respondents answered the question. Despite the fact that these answers were not used in the statistical analyses, it was interesting to note that, of the respondents who stated they did not see or read the report, 97.2% stated they did not understand the information. This finding may relate to the constructs of the Theory of Reasoned Action (TRA) which outlines beliefs, attitudes, and intent to read the report. In this theory, attitude is more predictive of intent to behave. In this case, those participants may have had a preconceived notion they wouldn't understand the information in the report. The respondents with more education were more likely to report an understanding of the report. This could further substantiate the fact that the participants may be less likely to read the report if they perceive they do not have the education or tools necessary to understand it.

Of those respondents who answered the question on understanding, a majority indicated they did not understand the information in the report. Those participants from rural areas of less than 10,000 residents were more likely to indicate they did not understand the report. Rural populations represent 94% of all systems in the United States. Additionally, this population is more vulnerable due to less stringent and latent changes on requirements for treatment of the water (EPA, 2006; Millichap, 1995; National Academy of Science, 2010).

Rural water system providers also have fewer restrictions on how the report is delivered and often lack the resources to publish reports that are more aesthetically appealing (EPA, 2004). This was confirmed when the researcher reviewed reports from over 100 cities in Texas. A majority of the reports from smaller populations were usually one to two pages in size, had no color on them, and had little or no educational information included. The reports from larger communities were more visually appealing, inviting, and informative. Often the reports from the larger systems were also available online with additional resources.

Although no effect in the understanding of the report was found by gender, a majority of the men stated they understood the information while a majority of the women responded in the negative. As information included on the report is more technical in nature, men may have been more interested in the content or they may have been reluctant to acknowledge a lack of understanding. Understanding and age also had some relationship with a majority of those between the ages of 18 and 40 and those 61 and over stating that they did not understand the report. This only left the group between 41 and 60 having a majority expressing an understanding of the report. While it is unclear why these age groups expressed a lack of understanding, it should be further evaluated in the context of health education and health literacy

This understanding was further assessed by determining if the respondents understood contaminants, MCL, whether their water had fluoride or had softener. Again the degree of education made understanding that information easier. There was also a trend for a lack of understanding or uncertainty of the term contaminant in the previous mentioned age groups but not the fluoride information.

Another dimension was added with respect to race, with a majority of Caucasians being more aware if fluoride is in their water, and a majority of Hispanic and African

American participants being uncertain of this information. More than half of blacks and Hispanics are more likely to live in cities compared to 21% of non-Hispanic whites (U.S. Census Bureau, 2003). Most large cities fluoridate the public water supply (CDC, 2009), and African American children are at a greater risk for dental fluorosis (National Academy of Science, 2006). This would emphasize the need for educators to focus on understanding and considering race as an important factor in that understanding.

Research Question 2

Does reading the annual Water Quality Report influence decisions to drink the water? There was no difference in reading the report and being hesitant to drink the water, being confident in the safety of the water, or adding a filter. This was an almost "out of sight out of mind" mentality. If they did not read the report they did not own the information and were not accountable for the information, despite important warnings and information being included in the report. However, those who read the report were more apt to take the information and change their tap water consumption habits. Ideally this would be reflected in not drinking the water when the information warranted this change and enjoying the water when the water was deemed safe to drink.

Interestingly, understanding did not factor into the equation here when it came to tap water consumption or being hesitant to drink the water. However adding a filter was affected by understanding. Respondents were less likely to use filters when they didn't understand the report. However, of those who did use additional filters on their water source, 26.9% said they only did so because their new refrigerator came with it. Filters need to be changed as per manufacturer guidelines. While most respondents said that they used the filter for taste and odor control over 50% stated that they used the filter to "increase their confidence level" and to "eliminate contaminants in the water". This certainly shows that health education is needed in this area.

Research Question 3

Among the participants who are hesitant to drink the water, what are the barriers? Over half of the respondents stated that they were hesitant to drink the water, but 63.3% of them indicated that despite having hesitations, they drink the tap water in the community. If they chose an alternate source of water, 65.3% chose bottled water suggesting that they felt confident that the bottled water was safer to drink. As stated in the review of the literature, health educators need to make communities aware that bottled water is not necessarily a safer alternative to their tap water.

When indicating why they were hesitant to drink the water, over 37% indicated that it was "fear" or a "lack of trust". The biggest barrier that could contribute to hesitancy is a lack of reading the report and a lack of knowledge and understanding of the annual Water Quality Report. Even with the respondents who identified that they understood the report, 59.8% stated that there were no warnings on the report or they were uncertain if there were any warnings on the report.

This further substantiates the need for health educators to use theories such as the TRA to target consumer behavior and attempt to change that behavior to reflect healthy choices. Health educators could strengthen the attitudes that encourage the consumer to read the annual Water Quality Report by increasing their motivation to read it by educating them to assist in understanding the report. People who feel that they have little or no control over the situation would not change. If they feel that they can not understand the report anyway, they would not read it. That would eliminate the limitation of a lack of control and understanding that they place on themselves (Ajzen, 1991; Sharma & Kanekar, 2007). Again, the element of cognitive process behind the intent to behave is a part of this theory validates the need to inform consumers of water quality and to make the information readable and understandable (Ogden, 2003).

Limitations of the Study

This study had several limitations. One of the limitations was the survey itself. Many respondents commented in the final open-ended question that the survey made them more aware of the annual Water Quality report and were more likely to look at it or read it prior to answering the questions on the survey. Another limitation was that the survey was only available online. This limited the participants to those who had access to the survey and to those who knew how to use the computer to answer the questions. Another limitation was that since this study was a non-probability convenience sample using a snowball sampling technique; thus no generalizations of the results can be made beyond the scope of this study.

Recommendations for Future Research

Additional research is needed in the area of health education to ensure that the annual Water Quality Report is the Consumer Confidence Report that it was intended to be. Recommendations for future research include:

- Accessing the readability of the report and the effect on understanding.
- Identifying the accessibility of the report especially in smaller populated areas.
- Evaluating the effect of an advocacy campaign on the reading and understanding of the Water Quality Report; similar to that used to alert communities about the Census.
- The effect of understanding the report when utilizing a uniform and consistent format for the content in the report.
- The effect on understanding of the report when enlisting community support for follow up education on the contents and questions about the annual Water Quality Report.

Recommendations

The annual Water Quality Report is an important tool to keep the consumer informed about the quality of their tap water. Health educators, water treatment companies, the EPA, and community leaders should become more involved with efforts to make communities aware of the importance of clean water and to assist communities to be alert when the annual Water Quality report will be made available. The report should be written in formats that allow all consumers the opportunity to understand the content regardless of their education level.

To compensate for educational differences, health educators should assist water suppliers in checking the report for readability and educating the community on the meaning of technical terms such as contaminants and MCL. They should also educate consumers on the importance of reading the report, including the warnings that are listed on the report and educate the public on how to protect at risk populations, including children and the elderly. They should also be made aware of the importance of this information even when traveling to other communities.

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APPENDIX A

Midwestern State University Human Subjects in Research Committee /Texas Woman's University Institutional Review Board

Human Subjects In Research Committee

Institutional Review Board in Compliance with 45 CFR 46

MSU Policy 2.37

MEMORANDUM

TO: Martha Gibson

RE: The Effect of Water Quality Reporting on Consumer's Confidence and Use of Water in North Texas

DATE: March 11, 2010

Your proposal for research utilizing human subjects has been reviewed and approved by the above named committee.

The number assigned this project is 10031101

Please include this file number in any presentation or publication arising from this research. You may be required to place a copy of this letter within the thesis or other class, department, or college documentation. This approval is valid for one calendar year following granting of approval status. Your may request an extension by submitting a letter requesting such to the HSRC committee chair.

Respectfully,

Chair, Human Subjects in Research Committee (IRB)

TWU
TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378 Fax 940-898-3416
e-mail: IRB@twu.edu

April 29, 2010

Ms. Martha L. Gibson
116 Wolf Circle
Graham, TX 76450

Dear Ms. Gibson:

Re: Water Quality Reporting and Its Association with Consumer Confidence and Use of Water in North Texas

The above referenced study has been reviewed by the TWU Institutional Review Board (IRB) and was determined to be exempt from further review.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. Because a signed consent form is not required for exempt studies, the filing of signatures of participants with the TWU IRB is not necessary.

Another review by the IRB is required if your project changes in any way, and the IRB must be notified immediately regarding any adverse events. If you have any questions, feel free to call the TWU Institutional Review Board.

Sincerely,

Kathy DeOrnellas, PhD.

Dr. Kathy DeOrnellas, Chair
Institutional Review Board - Denton

cc. Dr. Gay James, Department of Health Studies
Dr. Kristin L. Wiginton, Department of Health Studies
Graduate School

APPENDIX B

Water Quality Report Data Collection Instrument

Addendum B: Water Quality Report Data Collection Instrument

Water Quality Report Data Collection Instrument

The purpose of this study is to explore whether the annual Water Quality Report gives information that if read is understood and allows decisions to be made about drinking water.

As part of the Safe Drinking Water Act, drinking water suppliers provide reports that inform consumers of the drinking water's origin and any possible contaminants. This Consumer Confidence Report is communicated through annual drinking Water Quality Reports (EPA, 2008). For this study tap water will be water that is supplied by a water company.

Participation in this survey gives informed consent and is strictly voluntary. You may exit the survey and have the right to not participate at any time prior to submitting it.

There is a potential risk of loss of confidentiality in all email, downloading, and internet transactions. While there is always a potential risk of loss of confidentiality in all Internet transactions, the providers of Psych Data have addressed these concerns by placing surveys in a secure survey environment.

Please answer the questions to the best of your knowledge and ability. All questions with a * must be answered in order to submit the survey. If they do not apply to you, please mark N/A.

The return of your completed questionnaire constitutes your informed consent to act as a participant in this research.

Section 1: Demographics

***1) Age:** ____

***2) Gender:** ___male ___female

***3) Race:**

- White Non-Hispanic
- Hispanic/Mexican/Spanish
- African American/Black
- Asian/Oriental
- Pacific Islander
- Native American
- Other

***4) Education:**

- Less than high school graduate
- High school diploma or GED
- Technical school graduate
- Some college but no degree
- Associates degree
- Bachelor's degree
- Master's degree
- Doctorate degree

***5) Occupation: ____**

***6) Size of the population where you live:**

- less than 10,000
- between 10,000 and 50,000
- between 50,000 and 100,000
- more than 100,000

***7) Questions about Health Conditions: Do you have any of the following persons living in your household? (Mark all that apply).**

___ Persons with cancer undergoing chemotherapy

___ Persons who have undergone organ transplants

___ Persons with immune system disorders which may include autoimmune diseases (e.g., lupus, rheumatoid arthritis, etc.) or HIV/AIDS.

___ Persons who are elderly (age 65 and over)

___ Persons who are infants (age 1 year old or younger)

___ Uncertain

___ None of these

Section 2: Questions about water use

*8) **Do you drink tap water in your community?** ____ yes ___no

*9) **If you do not drink tap water in your community, what is your source of water?**

- well water
- bottled water
- N/A

*10) **Are you ever hesitant in drinking the water in your community?** ___yes ___no

11) **If you are hesitant in drinking the water within your community why?**

____

*12) **Do you remember receiving or seeing an annual Water Quality Report for your tap water in the last year?** ____ yes ____ no ____

(If you answered "no" to #12, please skip to # 18).

13) **Did you read the Annual Water Quality Report?** ____ yes ____ no

14) **Did your Water Quality Report include any warnings?**
____ yes ____ no ____uncertain

15) **Do you feel that you understand the information that is in your Water Quality Report?** ____ yes ____ no ____

16) **Did the information on the Water Quality Report change your habits in drinking that tap water?**
____ yes ____ no ____ N/A(because I never drank the tap water)

17). **If the Water Quality Report altered your habits in drinking the tap water, Please check the correct response:**
______ I only drink tap water now
______ I don't drink tap water as much now
______ I never drink the tap water now

*18) **Are you confident that the tap water in your community is safe?**
____ yes ____ no ____

***19) What other ways do you use tap water? (Please mark all that apply).**

- bathing/showering
- bathing pets
- washing clothes
- washing dishes
- washing car
- cooking
- swimming
- sprinklers
- other
- N/A

***20) Do you know if the water you drink (in any form) contains contaminants?**
____ yes ____ no ____uncertain

***21) Do you understand what the term Maximum Contaminant Level (MCL) means?** ____ yes ____ no

***22) Do you know if the water you drink (in any form) contains fluoride?**
____ yes ____ no ____uncertain

***23) Do you know if the water you drink (in any form) is softened?**
____ yes ____ no ____uncertain

***24) Do you use additional filtering on your water?** ____ yes ____ no

25) If you use additional filtering on your water, why? ____________________________

26) Is there anything that you would like to add to this survey about water quality and/or the Water Quality Report or anything that you would like to see changed or included in the annual Water Quality Report?

____
____
____
____

Thank you!

This concludes the survey questionnaire. By clicking submit below you are acknowledging that you have voluntarily participated in the above survey and are allowing the answers to be included in the data set.

Submit