2016

The Controversy over Community Water Fluoridation : an Analysis of its Effects and Reasons Behind the Arguments

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by

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An undergraduate honors thesis submitted in partial fulfillment of the

requirements for the degree of

Bachelor of Science

in

University Honors

and

Health Studies: Health Science

Thesis Adviser

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Portland State University

2016

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Abstract

This thesis explores different viewpoints on the history of community water fluoridation and reflects on the arguments made by the pro- and anti-fluoridationists in the United States. Community water fluoridation has been controversial in the United States since it was first proposed in 1945. Since then, fluoridation has been a major factor in reducing the prevalence and severity of dental cavities in the United States (U.S.).

Fluoride safely and effectively prevents dental cavities and is available from multiple sources. Community water fluoridation is one of these sources, providing fluoride to all people regardless of their position within the community. Even so, community water fluoridation has not been universally implemented despite efforts by the Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA) to support and promote it.

Fluoridation has been declared one of the ten greatest public health achievements of the 20th century (Centers for Disease Control and Prevention, 2015). In this study, I will review the literature on the history of community water fluoridation, comprised by scientific studies on its benefits and disadvantages. I will examine how the controversy surrounding this issue began, and how the anti-fluoridationists' arguments have continued to influence some communities to vote against fluoridation. Finally, I will attempt to draw a conclusion as to why community water fluoridation has not been implemented in all cities, despite its overall health benefits.

Introduction

Why is water fluoridation so controversial even with the backing of the Centers for Disease Control and Prevention (CDC) and American Dental Association (ADA)? Why do some people oppose adding fluoride to water when it is known to benefit oral health? The purpose of this study is to examine the history of community water fluoridation and explore the possible reasons for some communities' unwillingness to fluoridate.

Community water fluoridation is the process of adjusting fluoride in the public water supply to provide health and economic benefits. Fluoridation was a major factor in reducing dental cavities during the 20th century (American Medical Association, 2000). In the 21st century, dental cavities are preventable, but they remain the most common chronic disease in children and adolescents (Centers for Disease Control and Prevention, 2013). Nationally, 74.7% of Americans have community water fluoridation, which means that over 104 million people in the United States do not have access to fluoride in their water (Center for Disease Control & Prevention, 2016). From a public health perspective, fluoridation provides prevention for oral disease to all people in a community regardless of their socioeconomic status, age, education level, or knowledge about oral health. On the other hand, the opponents of fluoridation assert that fluoridation is unconstitutional, hazardous, and ineffective (American Dental Association, 2005).

The history of fluoridation demonstrates how clinical observation led to epidemiological investigations and to a community based public health intervention (American Medical Association, 2000). By studying the history of community water fluoridation, one can understand how the controversy began and why the arguments of the anti-fluoridationists persist. These arguments sustain the controversy and leave some populations without fluoridation and its

benefits. A community's decision to support water fluoridation is not always determined by scientific studies, but is influenced by the individual values.

Overview of Literature

The Problem of Dental Cavities:

Dental cavities are the costliest and most common oral health disease affecting people of all ages (American Dental Association, 2005). This disease is caused by bacteria which adheres to and dissolves the surface of a tooth. Dental cavities are an infectious, communicable, and multifactorial disease, and severe dental cavities can cause tooth loss (American Medical Association, 2000). However, many people in industrialized and non-industrialized countries fail to recognize that oral health is a very important component for overall health and that dental cavities are a type of chronic disease. For example, a study from 1988 to 1991 showed that more than 50% of all U.S. children ages 5 to 17 had no dental cavities on their permanent teeth, but about 25% of the children in the same age group accounted for 80% of the dental cavities measured (Slavkin & Baum, 2000). Although the extent of dental cavities decreased, those who had dental cavities were disproportionately clustered among the economically disadvantaged minorities.

The Healthy People 2020 initiative, sponsored by the U.S. Department of Health and Human Services, indicated that families from impoverished communities and families of ethnic and racial minorities have higher rates of oral health problems (Dye, Li, and Thornton-Evans, 2012). Although dental cavities seemed to be decreasing throughout the years, socioeconomically disadvantaged children from minority families in the U.S. still experience

higher cavity rates than non-disadvantaged families (Slavkin & Baum, 2000). Thus, dental cavities are still a significant health problem within the United States.

In addition, with information from the records of the Centers for Medicare and Medicaid Services, the ADA reported that the nation's total bill for dental services was approximately $74.3 billion in 2003, not including indirect expenses of oral health problems (American Dental Association, 2005). One study recorded that in the U.S. about 25% of adults over age 65 have lost all of their teeth because of oral health problems such as dental cavities and gum disease (Glenn, 2014). Similarly, 24% of children ages two to four, 53% of children ages six to eight, and 56% of 15 year olds have experienced dental cavities (American Academy of Pediatrics, 2014). As a result, dentists and public health officials for preventive care recommend community water fluoridation. Fluoridation in community water supplies reduces disparities in oral health and benefits the entire population, especially those who cannot afford dental care.

Far from simply cosmetic, oral health is linked to a person's overall health. First, when a person loses a tooth, it may affect his or her nutrition, as it could limit the food he or she is able to eat. Further, recent studies show that oral bacteria that creates severe cavities can travel through the blood, causing thickening of the vessel walls and leading to heart disease. The study found that a person who had diabetes was three times more likely to have a heart attack when they also had oral disease (Glenn, 2014). In addition, there are approximately 400 pharmaceutical agents used in the U.S. that can cause dry mouth (Slavkin & Baum, 2000). The diminished salivary secretions that cause dry mouth can lead to oral health problems. Without saliva inside the mouth, harmful bacteria can thrive more easily and create cavities and other disease. People who have dry mouth due to medications may experience the same clinical consequences as Sjogren syndrome, an immune system disorder. (Slavkin & Baum, 2000). This

reflects an increase in the risk of dental diseases and resultant respiratory tract infections due to the oral bacteria (Glenn, 2014). Fluoridation work to combat this risk by controlling the oral bacteria. Finally, lack of sleep, stress, and poor physical health can lower the body's immune system, increasing the chances for oral health problems (Uwire, 2012). One study showed that the plaque build-up on teeth that causes dental cavities was associated with higher risk of pneumonia and bacteremia as well (Silva et al, 2015). In all these ways, oral hygiene and health directly affects overall wellness.

Natural vs. Artificial Fluoride:

Fluoride is an ion which comes from the element fluorine and occurs naturally in the atmosphere, soil, and water. Fluorine is a gas abundant in the earth's crust and only exists with the combination of other elements. Once it becomes a fluoride compound, it is found in sedimentary rocks like fluorspar (CaF_2), and igneous rocks such as cryolite (Na_3AlF_6) (Mohapatra et al, 2009). Volcanic granites also contain sources of soil fluoride, because volcanic activity creates fluoride (McClure, 1970). Rock weathering releases fluoride into water sources, including oceans. Hence, all water contains naturally occurring fluoride. Fluoride concentrations vary and may be either too low or high, however. The concentration depends on the geological, chemical, and physical characteristics of the aquifer and the pH of the rocks. For instance, fluoride levels for ground water can range from under 1.0mg/L to more than 35.0mg/L and surface water levels are less than 0.3mg/L (Maheshwari, 2006). Fluorine is a highly electronegative element, attracted to positively charged ions like calcium. This characteristic of fluorine causes fluoride from any source to be attracted to bone and teeth and bond with these mineralized tissues (Maheshwari, 2006). When fluoride comes into contact with teeth, it

provides protection from demineralization and strengthens enamel. Fluoride also interferes with the metabolism of bacteria into the acid which causes cavities (Morabia, 2016).

Fluoride is used to help protect teeth in topical and systemic forms, as three additives: sodium fluoride, sodium fluorosilicate, and fluorosilicic acid (American Dental Association, 2005). The topical form of fluoride is found in toothpastes, mouthwashes, and professional gels. Topical use means that the fluoride is placed directly on the dental surface and incorporated to strengthen established adult teeth. Systemic fluoride is used to strengthen developing teeth. This form is ingested so that fluoride is deposited throughout the entire tooth structure. Systemic fluoride is found in water, dietary fluoride supplements, food, and beverages (American Dental Association, 2005). When the systemic form is used by drinking fluoridated water, the ingested fluoride is incorporated into the tissue enamel of the teeth (Maheshwari, 2006). Community water fluoridation is also considered to be a topical form, however, because when people drink the fluoridated water, it passes through the teeth and is taken up by bacteria on the surface of the tooth, reducing overall bacterial acid production (American Medical Association, 2000). Therefore, community water fluoridation is a systemic and topical form of fluoride, where the fluoride concentration in the public water supply is adjusted to the optimal level to improve dental health for all people of all ages.

History of Fluoridation:

The study of fluoride in water began in the early 1900s with Dr. J.M. Eager, an American dentist of the Public Health Service stationed in Italy, and Dr. Fredrick McKay, a dentist in the United States. While Eager was stationed in Italy, he recorded dental-clinical reports of his examination of the deteriorated conditions of oral health among Italian emigrants. He found fine

black horizontal lines on the teeth, which he described as a dental disease called "denti di Chiaie" (McClure, 1970). He noted the areas where he saw this unusual disease were near Naples, a region with volcanic formations. In 1901, he reported that local geological conditions had an impact on the Italian emigrants' teeth, as they drank water from nearby springs. At the same time, McKay noticed the same problem in the United States and devoted his time to resolving this disease. Though McKay was not aware of Eager's findings until ten years later, the report on Italian conditions was identical to what McKay saw in Colorado (Crain, Katz, & Rosenthal, 1969).

McKay opened a dental office in Colorado in 1908 and noticed that many of his patients had brown, mottling stains on permanent teeth, which he called "Colorado Brown Stains" (McClure, 1970). As McKay looked into this matter, he first learned that the stain was widespread in many Rocky Mountain communities, but he could not find a cause (Crain, Katz, & Rosenthal, 1969). As McKay investigated these occurrences, he garnered the interest of Dr. Greene Vardiman Black, Dean of the Northwestern University Dental School in Chicago and a leading dental histologist. Working together in 1916, the two men described the mottle as a developmental disease that only affected the color of the teeth. They suspected that water was the cause, calling this the "waterborne hypothesis" (McClure, 1970). By this time, McKay had published his observation that mottled teeth also showed less tooth decay. However, he was so intent in finding the cause of the staining, he had ignored the significance of this discovery (Crain, Katz, & Rosenthal, 1969).

In 1909, shallow wells in Bauxite, Arkansas were replaced with three deep wells, changing the water supply. Local dentist, Dr. F. L. Robertson noticed that children born after 1909 had stained teeth, whereas those born prior to1909 did not (McClure, 1970). In 1926,

Robertson asked the U.S. Public Health Service to investigate and in 1928 McKay and Dr. Grover A. Kempf started a survey. During this investigation, McKay traveled to Italy to observe the environs in which Eager had reported the same stains. He began his research around Naples and examined new cases of severe mottling on adult teeth in the city of Resina. McKay's research in Resina revealed that community members were drinking water piped from a mountain nearby, where previously they had been drinking water from a well. McKay conducted further research in rural districts and identified that people drinking out of private wells did not have the dental disease. Hence, his research provided some evidence for a waterborne contaminant forming within the earth and causing the staining (McClure, 1970). McKay had not yet determined what the stain-causing agent was. Because fluorine is a very active element, the ordinary chemical analysis that McKay performed was not able to isolate it (Crain, Katz, & Rosenthal, 1969).

While McKay failed to find the agent, Bauxite's water supply research caught the attention of H.V. Churchill, a chemist with the Aluminum Company of America (ALCOA). Churchill started researching the Bauxite water supply, believing there was a relationship between the staining on patients' teeth and aluminum. He ordered a sample of Bauxite's water from McKay and tested for rare elements that would go undetected in the usual chemical analysis (McNeil, 1985). The results spectrographically identified the presence of fluorine in Bauxite's water instead of aluminum (McClure, 1970). To confirm the presence of fluorine, Churchill requested various water samples from McKay's research of areas with endemic mottling. With this research, Churchill and ALCOA reported that there were high fluoride levels, measured at 13.7 parts per million (ppm), in Bauxite's water supply (Mullen, 2005). Churchill also analyzed 26 samples from large cities within the United States and found less than 1.0ppm

fluoride in all of them. Twenty-nine years after McKay began his research, Churchill concluded that fluoride was the cause of the stains and McKay published the findings in 1931 (McNeil, 1985).

Until this discovery was reported, the U.S. Public Health Service ignored McKay's pleas for assistance. Even so, once McKay published Churchill's research as evidence that fluoride was the stain-causing agent, the U.S. Public Health Service ordered the National Institutes of Health (NIH) to start government-sponsored dental research to verify the relationship between waterborne fluoride and the endemic mottling of teeth. Dr. H. Trendley Dean, the first director of the NIH, conducted an epidemiological study to confirm the correlation between fluoride levels and severe staining. The NIH first noted some communities had naturally higher levels of fluoride in their water and hoped for a solution to reduce these elevated levels. For this reason, several researchers started a project designing filters to adjust the levels of waterborne fluoride (Carstairs, 2015). Dean first published his systemic surveys in 1933, soliciting each state dental society for information on the occurrence and extent of the teeth mottling (McClure, 1970). In Dean's studies, McKay's 1916 report and other past research were used to develop standards of classification for mottled teeth. The water history of all the places Dean surveyed and the amount of fluoride in the water were thoroughly examined. Altogether, Dean and his associates established that fluoride levels up to 1.0ppm did not cause severe staining. This meant that discoloration of the tooth began when there were more than 1.0ppm fluoride in the water supply.

Furthermore, Dean surveyed the physiological effects of fluoride in drinking water and whether it caused dental cavities (McClure,1970). In addition to the endemic staining, the study of the physiological effects revealed a concomitant reduction in dental cavities. Gradually, this research led to further epidemiological studies establishing the relationship between water

fluoridation and the reduction of dental cavities, and exposing the benefits of fluoride in water. In 1938, Dean published an article based on his research, showing children living in areas with fluoride of 1.0ppm had lower incidence of dental cavities compared to children without fluoride in their water (Carstairs, 2015). In 1942, Dean published additional research suggesting that the addition of artificial fluoride to community water supplies with natural fluoride levels lower than 1.0ppm was safe and effective for preventing dental cavities (Mullen, 2005). This led to effective community water fluoridation, which in turn predicated a decline in dental cavities during the second half of 20th century.

Beginning of Organized Community Water Fluoridation:

On January 25,1945 in Grand Rapids, Michigan, the U.S. Public Health Service began an experimental program under Dean's administration. Sodium fluoride was added to Grand Rapids' public water supply, making it the first in the world to undergo organized community water fluoridation. A nearby city, Muskegon, did not have fluoride added to the water supply, thereby serving as the control for Dean's experimental program (McNeil, 1985). The objectives of this experimental study were:

> …To secure evidence of a significant reduction in caries by artificially controlled fluoridation of drinking water, to demonstrate the technical as well as the financial feasibility of the procedure, and to continue observations on the development of dental fluorosis as well as non-dental physiological effects possibly concomitant with the addition of this trace quantity of fluoride to various types of drinking waters (McClure, 1970).

Grand Rapids' drinking water came from Lake Michigan and was treated in a filtration plant. In 1944, the water was analyzed to have 0.05ppm of fluoride. A total of 107 barrels, each containing 375 pounds of sodium fluoride, were added to the water on January 25, 1945 (McClure, 1970).

W. L. Harris, the Chief Chemist of Grand Rapids, then completed a fluoridation analysis. Harris surveyed the tooth decay levels in children by comparing the results from Grand Rapids with Muskegon, the control city, and with Aurora, Illinois, where the water contained fluoride levels of 1.2ppm. The total examinations performed were 28,614 in Grand Rapids, 7,786 in Muskegon, and 8,312 in Aurora (McClure, 1970). Soon after, Newburgh, New York and Brantford, Ontario followed suit and became some of the first areas to adjust their drinking water using organized community water fluoridation.

In communities involved in this project, the public raised concerns about whether artificial fluoride had the same effect as the natural fluoride. Some even believed sodium fluoride to be highly toxic (Carstairs, 2015). However, this experiment was approved by public health official, as well as medical and dental authorities (McClure, 1970). Fluoride was recognized as a trace element found in plants, foods, tissues, and organs of human and animals, and therefore compatible with health and unavoidable in nutrition (McClure, 1970).

For many years, hundreds of thousands of individuals have consumed fluoride via natural drinking water in many places around the globe. The only resulting health problems noted by the U.S. Public Health Service was tooth staining experienced by those who consumed water with fluoride quantities greater than 1.0ppm. Community water fluoridation is controlled so that people will have the optimal concentration of fluoride to prevent cavities.

Scientific Studies of the Harm Caused by Fluoride:

Despite the benefits of fluoride, the adverse effects have also been studied in other countries before water fluoridation began. Two Copenhagen physicians, P. Flemming Moller and Sk. V. Gudjonsson, first observed harm from fluoride in Denmark in 1931 (McClure, 1970). They noticed incidences of silicosis among workers in dust-producing industries. Silicosis is a lung disease in which the lung tissues are scarred by inhalation of the dust particles containing silicon dioxide or silica (Leung, Yu, & Chen 2012). Moller and Gudjonsson found that half of the employees working in mineral cryolite factories showed symptoms of silicosis (Carstairs, 2015). Through their physical examinations, the physicians learned that cryolite contained a rare fluoride mineral and concluded that, when swallowed, cryolite dust introduced fluorine to the alimentary tract and triggered silicosis (McClure, 1970).

Hypothesizing that fluoride could be harmful, Dr. Kaj Roholm began to study fluoride intoxication in 1932 (McClure, 1970). Roholm measured quantities of fluoride in the bodies of cryolite factory workers by obtaining dry bone tissue. The tissues were tested and found to contain 0.99 and 1.12% fluoride, where the tissues of normal individuals only contained 0.048 to 0.210% (McClure, 1970). Roholm also measured urine specimens from the cryolite workers for fluoride excretion, resulting in amounts 10 to 20 times greater than normal (McClure, 1970). Next, Roholm began experimentation on animals: he fed excessive amounts of cryolite, sodium fluoride, and sodium fluosilicate to rats, swine, calves, and dogs to test the effects of these chemicals on bones and teeth. He found that consuming large quantities of fluoride was toxic and that inhaling cryolite had the same effect due to the fluoride therein (McClure, 1970). By 1948, Roholm discovered that exposure to fluoride could be hazardous for bones, enzyme levels, and thyroid health (Carstairs, 2015).

As Rohom observed, the hazardous effects of excessive exposures to fluoride in industrial fluoride environment was also prevalent in endemic fluoride areas. Researchers discovered large amount of fluoride in the drinking water in Madras Presidency, India. The Madras water supply had 2.0 to 10.0ppm of fluoride in 1937 and 10 individuals who had been exposed to the drinking water for 30 years or more showed signs of skeletal fluorosis, such as immobility and stiffness in the spine, joints, and ribs (McClure, 1970). In 1940, researchers Singh, Jolly, Bansal, and Mathur studied the correlation between high levels of fluoride in drinking water and urinary fluoride. In the drinking water of Madras Presidency, these scientists measured average drinking water fluoride levels of 1.0 to 2.0ppm, with some as high as 16.2ppm. The urinary fluoride levels of people drinking this water ranged from 2.3 to 13.5ppm (McClure, 1970). The study revealed that farmers working in extremely warm areas were drinking an average of 5.0 liters of water daily, thereby consuming as much as 6.5 to 8.1mg of fluoride (McClure, 1970). The researchers were concerned that these farmers could be consuming excessive amounts of the highly fluoridated water because they used the water in their cooking and food processing as well. After studying the people in Madras Presidency, the researchers found 42 people with neurological complications out of the 409 cases of skeletal fluorosis (McClure, 1970).

Similarly, from 1939 to 1942, Dr. T. Ockerse of the Department of Public Health of the Union of South Africa investigated endemic fluorosis in the children of the country (McClure, 1970). He saw similar results to those in Madras. Ockerse gathered fluoride data via a time consuming procedure by which he noted that areas with elevated temperatures contained 11.78ppm of fluoride (McClure, 1970). He observed that children who lived near the waters sources with high levels of fluoride had dark stains on their teeth, lower incidence of dental

cavities, and higher rates of severe dental fluorosis. Ockerse also reported that some area natives complained of stiff backs and painful joints which he predicted were caused by fluoride in the water (McClure, 1970).

Scientific Studies of the Benefits:

Weighing the benefits and the drawbacks of water fluoridation, a group of dentists led by John Frisch and the state dental-health officers in Madison, Wisconsin, called for mass water fluoridation. Their rationale for the campaign was that people had already been drinking naturally fluoridated water without any health problems (McNeil, 1985). After some debate, Madison began fluoridation in 1947, and other cities followed suit. Senator Robert M. LaFollette Sr. encouraged academics, lawyers, doctors, and politicians to contribute to positive developments in public services, such as fluoridation, for the communities of Wisconsin. By consolidating the support of experts, LaFollette gained the public's trust in the authorities' decision to fluoridate (McNeil, 1985). Though many scientists, including those at the U.S. Public Health Service, disapproved and withheld their support of mass fluoridation until the final results of Grand Rapids experiment were revealed, Frisch and his organization saw the almost immediate positive effects of the experiments and continued to demand action on fluoridation.

After just three years of fluoridation in Newburg and other cities, the U.S. Public Health Service had reported a one-third drop in tooth decay rates, with the final results showing a 59% decay in Newburg (Crain, Katz, & Rosenthal, 1969). Once these results were publicized, Frisch received approval for fluoridation from the U.S. Public Health Service and the American Dental Association (Crain, Katz, & Rosenthal, 1969). By January 1, 1950, half of the cities of Wisconsin, 50 communities, including Madison, had their water fluoridated (McNeil, 1985). In

the same year, Dean and his colleagues published data from the study in Grand Rapids. The results of the five-year study showed that the number of cavities among the children of Grand Rapids had diminished by half. Sixty percent of local children did not have cavities on their baby teeth and dental cavities in adult teeth had decreased by 35% with fluoridation (American Dental Association, 2005). Based on these discoveries, the neighboring town decided to add fluoride to its water supply in 1951 (Mullen, 2005). The studies above consistently proved that there was no difference between the effects of the natural and artificial fluoride (Crain, Katz, & Rosenthal, 1969). Public-health professionals were excited to learn that mass fluoridation in community water resulted in fewer dental cavities, reduced dental bills for community residents, and no harm to the human body.

By the end of 1992, 56% of the U.S. population had community water fluoridation: over 10,000 public water systems serving 135 million persons in 8,573 U.S. communities. This means that about 70% of all U.S. cities with more than 100,000 people used artificial fluoridation, and ten million persons in 1,924 communities used natural fluoride at a concentration around 0.7ppm. That said, about 42,000 public water systems in 153 U.S. cities with more than 50,000 people still did not have any fluoridation (American Medical Association, 2000).

In 2010, Dr. Matthew Neidell, Dr. Sherry Glied, and Karin Herzog of Columbia University completed a study to determine whether community water fluoridation benefits had changed in the years since 1990. The researchers compared the number of cavities in people who had community water fluoridation 20 years previous and those with fluoridation at the time of the study. They also studied whether individuals exposed to community water fluoridation from birth experienced different rates of tooth loss in adulthood (Neidell, Glied, & Herzog, 2010). Neidell and his colleagues conducted their study by gathering data from the 1992 Water

Fluoridation Census and the 1995 to 1999 Behavior Risk Factor Surveillance System. The 1992 Water Fluoridation Census reflected data complied by the CDC to provide information on fluoridation for every public water system in the United States in 1990 (Neidell, Glied, & Herzog, 2010). From this data, the team computed the total number of people with access to community water fluoridation and the county fluoridation rates in 1900.

Next, the data from 1995 to 1999 Behavior Risk Factor Surveillance System were used to gather information on more than 350,000 adults born between 1950 and 1969 and living with community water fluoridation. Researchers used this information to compare their oral health information and demographic variables (Neidell, Glied, & Herzog, 2010). Although these studies represented the most accurate data to date, Neidell noted some limitations since these results were compiled from surveys and therefore may reflect some unobserved factors, such as respondent moves within the survey period. Nevertheless, statistical analyses conducted using this information helped establish the prevalence of dental caries and periodontal disease among adults.

Finally, Neidell estimated interval regression models for community water fluoridation exposure at various times in life and its relation to tooth loss from severe cavities. The results from the study indicated that those who were exposed to community water fluoridation from birth experienced significantly less tooth loss from cavities compared to those who were not. Neidell also noticed that community water fluoridation exposure was less important after permanent tooth formation and had a larger impact for individuals of a lower socioeconomic status (Neidell, Glied, & Herzog, 2010). The researchers surmised that individuals with lower socioeconomic status might be less able to receive treatment for dental cavities due to financial issues compared to those of higher socioeconomic status. Further, the rate of annual preventative

dental visits was higher among individuals of higher socioeconomic status (Neidell, Glied, & Herzog, 2010).

Laboratory and epidemiological research has proven that water fluoridation prevents dental cavities and decreases the chances of tooth loss. The benefits of community water fluoridation were greater for those exposed to it from birth and those from a lower socioeconomic background.

The Controversy:

Though the controversy over mass fluoridation began the same year the practice was endorsed by the U.S. Public Health Service, opposition to community water fluoridation continues to this day. While many public health officials believed fluoridation would improve the quality of life for citizens, not all agreed. When Frisch and his allies were visiting cities in Wisconsin with their plans to fluoridate all of the state's water, opponents of fluoridation, the anti-fluoridationists, also appeared.

Alexander Y. Wallace, a 67-year old part-time politician, poet, and writer, became the first anti-fluoridationist leader. He denounced fluoridation as poisonous and wrote letters protesting and antagonizing Frisch and the Wisconsin council (Hicks, 2011). With pressure from Wallace's anti-fluoridation campaigns, the city council voted down community water fluoridation in 1949 because of its experimental state, as the results from Grand Rapids had been released only a few months before (McNeil, 1985). Wallace's protest drew attention from both activists on both sides of the fluoridation issue. Frisch and his allies, the pro-fluoridationists, did not give up; they gathered groups of supporters to urge the city council to reconsider. Frisch's campaigning was successful and although the proposal was first rejected, the city council

eventually authorized fluoridation. Wallace responded by collecting 1,300 signatures, forcing a referendum on fluoridation on November 21, 1949 (Crain, Katz, & Rosenthal, 1969). Even so, the city council assumed Frisch would win over Wallace's protest and, in May, secretly ordered fluoridation to begin. Wallace discovered the subterfuge, denounced the council, and framed the issue as if outsiders were experimenting on the people of Stevens Point. He incited mistrust among citizens by handing out flyers demanding to "Get the Poison Out of our Drinking Water" (Hicks, 2011).

With such conflict among residents, the council could not decide whether or not to add fluoridation to the public water supply and decided instead that the public was to vote on September 19, 1950. The water fluoridation proposal was rejected by the citizens of Stevens Point, Wisconsin by a vote of 3,705 to 2,166 (Hicks, 2011). Having successfully quashed their opponents in this instance, anti-fluoridationist leaders realized that creating fear in the public was an effective strategy to gather votes against community water fluoridation. Wallace became a popular figure on national media and his influence soon spread the anti-fluoridationists movement to other cities. Anti-fluoridationists publicized that the scientific research done on community water fluoridation was still at an experimental stage. As expected, community members responded with a sense of doubt about public safety and became uncomfortable with the unknown potential harm that community water fluoridation could create (Hicks, 2011).

Politics & Values of Fluoridation:

The arguments made against fluoridation demonstrate fear about the quality of fluoridated water, but the question has also been linked to other social and political issues. These concerns have brought constitutional challenges against community water fluoridation, with

arguments including possible violations of the First Amendment right to freedom of religion, and Fourteenth Amendment protections of liberty, against abridgement of privileges and immunities, and denial of equal protection (Balog, 1997). The pertinent part of the Fourteenth Amendment to the United States Constitution provides that:

> …no State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws (U.S. Senate, 1994).

This means that every individual has a personal liberty right to decide what is best for their health and happiness; and, each individual have the right to determine what to consume.

Throughout the years, researchers have also noticed that the most progressive form of government, the city management system, had the highest adoption rate on fluoridation, though no form of government was uniformly willing to adopt fluoridation (Crain, Katz, & Rosenthal, 1969). Since the controversy on fluoridation began, the number of doctors and scientists in the opposition gradually diminished. However, many individuals and groups supporting vitamins, natural foods, and drug-free therapy remained vocally opposed to fluoridation in local referendum battles (McNeil, 1985). These anti-fluoridationists believed that fluoridation violated the Fourteenth Amendment.

An early contributor to the anti-fluoridation movement was Royal Lee of Milwaukee, Wisconsin. He actively opposed governmental health intervention. In the 1930s, Lee owned his own vitamin products company. Later, the Food and Drug Administration declared that Lee was making false and illicit claims for his company's products, and a federal court found him guilty of the violation. Despite this, he established the Lee Foundation for Nutritional Research in

Milwaukee. Lee declared that his foundation was created to protect the public against "vicious commercial interests that were busy selling the public down the river" and he continued his vigorous activism until his death in 1971 (McNeil, 1985). Lee claimed that water fluoridation amounted to forcing the public to take drugs and didn't allow the individual to determine what to consume (Balog, 1997). At the same time, another anti-fluoridationist, Dr. Charles Betts emerged in Toledo, Ohio. Betts was a licensed dentist who had never graduated from dental school. Betts denounced those who supported fluoride as "checkbook charlatans" who "spew forth their Munchausen scientific muck," and then asked his audiences if they wanted "those Mexicans, Negroes, and Puerto Ricans in your water department" to put "drugs in your water" (McNeil, 1985).

Amongst such claims, public health officials found that fluoridation referenda were regularly being defeated and worried that many people were voting on this issue without proper knowledge. Researchers Bernard and Judith Mausner surveyed voters in Northampton, Massachusetts, where fluoridation was defeated by vote and found that opposition votes came mostly from the elderly, who were often uneducated, low income, and did not have children under 12 years old. The Mausners explained that many of these voters reflected values of anti-intellectualism, including suspicion of the scientists and the belief that a conspiracy was being created by the government (McNeil, 1985). The Mausners also explained that these elderly voters did not want any social change, and that some may have believed science was bad because science was for fluoridation (Crain, Katz, & Rosenthal, 1969). In addition to feeling increased suspicion and fear, uneducated adults were less trained in evaluating scientific evidence, which led them to support opposition forces in fluoridation referendums (Crain, Katz, & Rosenthal, 1969).

Another constitutional challenge made against fluoridation was based on religious beliefs. The pertinent part of First Amendment to the United States Constitution provides that, "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof" (U.S. Senate, 1994).

In 1951, the president-elect of the California Dental Association realized there was a lot of opposition to fluoridation from Christian Scientists. Although the leaders of the Christian Science Church headquarters in Boston were vague about their position on fluoridation, many state committees of the church declared fluoridation was forced "mass medication" (McNeil, 1985). In fact, some religious anti-fluoridationists turned to litigation and sued to stop the process of fluoridation because they believed it violated their rights under the First Amendment. Their religion prohibited them from taking medication for any disease (Balog, 1997), but no court ruled that fluoride was a medication. Still, some anti-fluoridationists believed that fluoridation was a conspiracy and produced "moronic, atheistic slaves" (McNeil, 1985). The editor of an anti-Semitic publication described water fluoridation was a "plot to "weaken the Aryan race" by "paralyzing the functions of the frontal lobe"" (McNeil, 1985).

During the late 1970s, John Y. Yiamouyiannis, a biochemist from the University of Chicago and the University of Rhode Island, emerged as a new anti-fluoridationist leader. Yiamouyiannis was a Science Director for the National Health Federation. Besides fluoridation, the organization also opposed polio vaccination and the pasteurization of milk. Though Yiamouyiannis helped create various remedies, such as electrical therapy and medications to treat cancer, none of these treatments were tested. On the contrary, the National Health Federation was well known to the federal Food and Drug Administration for its quackery (McNeil, 1985). Meanwhile, Yiamouyiannis was on radio and TV shows throughout U.S., and

conceived of several local lawsuits to stop community water fluoridation, claiming that fluoride caused cancer. He later wrote a book, *Fluoride: The Aging Factor*, stating fluoride was responsible for lowering the immune system, making the body more susceptible to colds, premature aging, arthritis, birth defects, cancer, and AIDS, along with damaging the body's natural enzymes (Balog, 1997). He also courted attention from environmentalist groups, who prized organic and natural foods and didn't want any chemicals added into their waters.

One of Yiamouyiannis' greatest victories was the 1975 Los Angeles referendum to stop fluoridation. To strengthen his position, he gathered chiropractors, health food advocates, and radical environmentalists and claimed that studies done by the CDC, National Cancer Institute, and the National Academy of Sciences lacked credibility in their denial of a link between fluoride and cancer. Yiamouyiannis declared that there was a higher rate of cancer in communities that were fluoridated (McNeil, 1985). As such, he asserted that fluoridation was an invasion of each person's constitutional right to protect his or her own health (Balog, 1997). Many voters in Los Angeles were swayed by this and the anti-fluoridationists successfully passed their referendum.

In the 1980s, political consultant Paul Robbins found that voters who opposed fluoridation came from all social and economic classes and education levels. Robbins noticed that the well-educated opponents were swayed by constitutional arguments about freedom of choice, whereas uneducated people voted against fluoride due to the fear of health problems (McNeil, 1985). In a 1984 survey by the Opinion Research Corporation, only 2% of those polled knew fluoride was important to prevent dental cavities. This survey also showed that very few people were aware that cavities are a serious oral disease, and that not many dentists were informing their patients about the benefits of fluoride treatment and fluoridation in general

(McNeil, 1985). Due to this, not many people were aware that cavities are a serious oral disease and that it is a problem.

During the referendums, the anti-fluoridationists had synthesized concerns against fluoridation, such as equating fluoridation to "mass medication". This tactic helped negatively frame the debate in voters' minds. Framing is the simplest and the obvious thing in everyday life because it is based on what you know. For example, you have a conceptual mental structure for a cup because if you have a cup, you understand it and that it is a small object. Hence, every time you hear the word "cup", you are most likely to think of it as a container which you typically put liquids in it and drink out of (University of California Television, 2008, 4:10). The word "cup" is evoking a frame which means that it is in your brain. Similarity, the phrase "mass medication" creates a conceptual mental structure that encourages mistrust, paranoia, and confusion. This and similar framing and language continues to be used by anti-fluoridationists today. For example, the organization Fluoride Action Network (FAN), founded in 2000, is a group of anti-fluoridationists who strongly believe in the toxicity of fluoride. FAN claims fluoride is accepted as a drug by the Food and Drug Administration and that, therefore, community water fluoridation is a form of mass medication that is unnecessary when there are voluntary fluoride sources such as toothpaste to use instead (Fluoride Action Network, 2016).

Safety of water fluoridation:

Early research done on the physiological effects of fluoride did show some unwanted effects on the bones of animals. Since 1950 when Wallace gathered his anti-fluoridationists, the opponents of community water fluoridation have claimed that fluoridation increases the risk for many other diseases and health problems. In 1997, Douglas A. Balog from Pace University

School of Law wrote about existing scientific knowledge of the risks fluoride could have. Balog stated that there is a difference between natural and artificial fluorides, since the former is calcium fluoride whereas the latter is sodium fluoride. Sodium fluoride is known for its use as poison in insecticide, rodenticide, wood preservative, fungicide, ceramics, and light metal production whereas sodium fluoride has been recognized for its toxicity in pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Balog, 1997). He also states that the Environmental Protection Agency (EPA) lists fluoride in its table of water-borne contaminants. FAN continues to believe that fluoridation is not a safe practice due to these assertions. Their arguments against fluoride are that fluoride is known to cause discoloration of the teeth for many children, as well as increasing the risk for bones disease, and possibly contributing to serious health issues like arthritis, brain damage, thyroid function, and bone cancer (Fluoride Action Network, 2016). These concerns about the safety of water fluoridation have been similar since the 1950s.

In response to such concerns, the U.S. Public Health Service reevaluated the safety of water fluoridation, but found that problems with fluoride will only occur if a human drinks water with a fluoride concentration of 8 milligrams per liter or more over many years (National Research Council, 2006). This concentration is vastly higher than the optimal fluoride concentration used in community water fluoridation, which is 0.7ppm (American Dental Association, 2015). There was no credible evidence supporting the harms of community water fluoridation. Conversely, the topical forms advocated by anti-fluoridationists hold higher levels of fluoride, and therefore higher risk. In toothpastes, the concentration of fluoride is around 850ppm to 1150ppm and in mouth rinses, between 0.01 to 0.05% of the solution (Balog, 1997). Due to the large concentration of fluoride in these topical treatments, there is a potential for harm

if these are swallowed. As a result, the government required a warning label on all products containing fluoride so ingestion would be avoided (Public Health Reports, 2015).

In 2015, the CDC gathered scientists with expertise in various health and scientific disciplines from the U.S. and other countries to form a panel. These scientists considered the available evidence in peer-reviewed literature about the harmful health effects of community water fluoridation, but did not find any link between fluoridation and any "risk for cancer, down syndrome, heart disease, osteoporosis, bone fractures, immune disorders, low intelligence, renal disorders, Alzheimer disease, or allergic reactions" (Weno, 2015). The only confirmed risk in community water fluoridation was dental fluorosis, the discoloration of teeth. However, in the U.S. today, dental fluorosis does not pose a serious problem, as its mildest form is a barely visible, lacy white marking on the tooth. Also, fluorosis occurs most among children eight years or younger, and this will have no effect on their permanent teeth (Weno, 2015).

Effectiveness of water fluoridation:

Fluoride works by inhibiting demineralization and the bacterial activities that build up plaque on teeth, while enhancing remineralization. When fluoride is present in dental plaque, it can inhibit the bacterial acid that dissolves the minerals which form the surface of the tooth. Also, fluoride strengthens the tooth surface and attracts calcium ions present in saliva (American Medical Association, 2000). Early studies on community water fluoridation showed a reduction of 50 to 70% in dental cavities, but by the mid-1980s, the prevalence of dental cavities in permanent teeth among children living in fluoridated communities was only 18% lower than that of children without fluoridated water. A review of studies on the effectiveness of community water fluoridation found that there was an 8 to 37% reduction in cavities among adolescents

(American Medical Association, 2000). In adults, community water fluoridation reduced cavities by 20 to 40% and has been effective to prevent dental cavities on the exposed root surfaces of teeth (American Medical Association, 2000). When community water fluoridation was first introduced in the U.S., the prevalence of cavities declined dramatically, however, prevalence of cavities declined at about the same rate in communities with and without fluoridation.

FAN believes that this is because fluoride is not effective when it is being ingested and that, rather, its benefits come from topical contact. In addition, the organization maintains that there have been no randomized, controlled trials of community water fluoridation (Connett, 2012). The American Dental Association, however, believes that the prevalence of dental cavities declined in both fluoridated and non-fluoridated communities because of the development of topical forms of fluoride and the diffusion of fluoridated water through processed foods and bottled beverages originating in areas with fluoridated water (American Dental Association, 2005). Indeed, it was the knowledge from studies on community water fluoridation that led to the development of fluoridated topical treatments such as toothpastes, mouthwash, and professional gels (Centers for Disease Control and Prevention, 2000).

There are some low socioeconomic groups who are less informed and have less access to dental care. Unfortunately, these demographic groups are also less likely to be educated in when and how to start brushing their teeth or how to properly care for their oral health. Though the use of topical forms of fluoride is effective in preventing cavities, their efficacy depends on the frequency of use and proper technique. As such, Centers for Disease Control and Prevention believe that community water fluoridation provides the most effective oral disease prevention to all residents, including socioeconomically disadvantaged children, because everyone consumes water (Centers for Disease Control and Prevention, 2000).

Cost Effectiveness of Water Fluoridation:

Compared to other methods of providing dental care and cavity prevention, such as toothpaste, mouthwash, gels, and supplements, community water fluoridation is the most cost effective fluoride delivery method for all members in the community regardless of age, socio-economic status, and education (Weno, 2015). Water fluoridation provides primary prevention of oral disease like dental cavities, and reduces overall health care expenditures. On the other hand, the anti-fluoridationists group FAN declared that low-income families cannot afford the fluoride in the public water, alternative water without fluoride, or treatment for dental fluorosis (Connett, 2012). In 1992, Americans spent more than $700 million on in-home water filters and $2 billion on bottled waters to avoid fluoride (Balog, 1997).

When community water fluoridation first began in 1945, the addition of sodium fluoride for five years amounted to an estimated total cost of $57,760, which the Public Health Service absorbed (McClure, 1970). To put this into perspective, in 1988 dollars, the cost for water fluoridation was around $.31 per year per person in large communities of more than 50,000 persons and about $2.12 per year per person in small communities of less than 10,000 persons (American Medical Association, 2000). From 1979 to 1989, one economic analysis estimated that community water fluoridation had saved $39 billion in dental treatments (American Medical Association, 2000). In today's dollars, the cost to fluoridate water is estimated at approximately $.50 per year per person in large communities and about $3.00 per year per person in small communities. Every $1.00 invested in community water fluoridation saves between $8 and $49 in dental treatments, which accounts for more than $4.6 billion in annual dental costs (Centers for Disease Control and Prevention, 2013). Further, a study was conducted in Colorado to compare community water fluoridation costs with treatment savings achieved through reduced

dental cavities. Researchers analyzed 172 public water systems, each serving more than 1,000 individuals. The analysis found that one year of exposure to community water fluoridation provided about $60 worth of savings per person, with even lower cavity rates in children. This saved each individual $28 to $67 annually in their children's treatment costs (Weno, 2015).

Summary:

	Pro-Fluoridationists	**Anti-Fluoridationists**
Values & Political View	Noted the constitutional claim made by the anti-fluoridationists were not accurate	Unconstitutional: violation of the First Amendment & Fourteenth Amendment
Scientific View	Scientifically proven for its use and safety	Unclear, not enough to prove its safety, still at an experimental stage

Pro-Fluoridation	**Anti-Fluoridation**
Only unsafe to drink water with fluoride concentration of 8 milligrams per liter or more over many years	Artificial fluoride is toxic and could cause possible harms in the body
Fluoridation provides prevention of dental cavities and are more effective towards the socioeconomically disadvantaged children	Fluoride is not effective when it is ingested and topical forms are enough to prevent cavities
Fluoridation saves a lot of dental costs and treatments to treat cavities	Low-income families cannot afford fluoride in the water and they cannot pay for alternative water even if they want to

Discussion:

The controversy about community water fluoridation has been a divisive one since fluoridation began. As of last year, only six of the 50 largest cities in the U.S. did not have fluoridated water, including Portland, Oregon (Hersch & Pelkowski, 2014). Fluoridation was passed by the Portland City Council, but was voted down by the public in 2013. Hence, one child in every five in Portland suffers from dental cavities and local children are experiencing 40 % more dental cavities than children with fluoridated water (Krisberg, 2013).

Tooth loss from dental cavities is no longer a major problem in oral health due to fluoridation. Between the mid-1940s and the 1970s, water fluoridation spread fairly quickly, but in the recent years the rate of increase has slowed. The American Medical Association attributes this change to several factors: people does not realize that dental cavities are a public health problem and believe that fluoridation is not necessary anymore; the political process of adopting water fluoridation is making this public health measure difficult; the anti-fluoridationists are making unsubstantiated claims to influence the public opinion; and there are many public water systems that serve small populations which increases the cost of fluoridation (American Medical Association, 2000).

The history of community water fluoridation clearly reveals how the controversy began and sheds light on the further scientific investigations that provide evidence for fluoride's safety, effectiveness, and cost-effectiveness in reducing dental cavities. It is difficult to examine directly what the individual attitudes and values are for those who oppose fluoridation. However, it is clear that concerns about fluoridation are linked to individual issues within political issues. Opponents argue that the fluoridation violates the constitutional protections of freedom of choice and religion. These concerns may stem from a distrust of government and scientists, or a cultural

value in being natural and drug-free. Anti-fluoridationists continue to point out how artificial fluoride could be toxic and often cite foreign cases of the diseases caused by fluoride poisoning. The opposition also points out an increased risk of bone cancer linked to fluoride, which accumulates over time. Scientific findings about these claims have been unclear, but the current community water fluoridation level is 0.7ppm, and amount scientifically confirmed as not enough to cause fluoride poisoning.

Method:

The method used for this study was an intensive literature review. To begin, I compiled literature on topics of fluoridation, community water fluoridation, fluoride, dental cavities, controversy on fluoridation, and opposition to fluoride through online database research, professional internet searches, and the Portland State University library. I first reviewed what dental cavities are, what fluoride is, the differences between artificial and natural fluoridation, the benefits and problems of fluoride, and the history of community water fluoridation. Next, I examined scientific studies exploring the risks and benefits of fluoride. Finally, I addressed what made community water fluoridation a controversy and the arguments between pro- and the anti-fluoridationists.

Conclusion:

Fluoride acts to protect teeth from demineralization by strengthening the enamels and interfering with the metabolism of bacteria that cause cavities. When fluoride is used appropriately, it can help prevent and control dental cavities and maintain a healthy community. In the 20th century, numerous scientific studies provided supporting evidence for fluoride's

safety, effectiveness, and cost-effectiveness in reducing dental cavities, and fluoridation has been favored by many health-related organizations. However, the controversy still remains and some communities are still without water fluoridation. Although knowledge and research can provide scientific evidence to inform the public about fluoridation, people have different values that influence how they integrate science and make their decision on the issue. Therefore, because this issue is decided by public vote, scientific evidence alone cannot determine whether or not a community will support fluoride in the water.

References:

American Academy of Pediatrics. (2014). Maintaining and Improving the Oral Health of Young Children. *Organizational Principles to Guide and Define the Child Health Care System And/or Improve the Health of All Children,* (134), 1224-1229.

American Dental Association. (2005). Centers for Disease Control Celebrate 60th Anniversary of Community Water Fluoridation. *Ascribe Health News Service*. Retrieved April 3, 2016, from http://ascribe.org

American Dental Association. (2005). Fluoridation Facts. 1-69.

American Dental Association. (2015, April 27). ADA Applauds Final Announcement on Optimal Fluoride Level in Drinking Water. Retrieved March 27, 2016, from http://www.ada.org/en/press-room/news-releases/2015-archive/april/hhs-announcement-on-optimal-fluoride-level-in-drinking-water

American Medical Association. (2000). Achievements in Public Health, 1900 - 1999: Fluoridation of Drinking Water to Prevent Dental Caries. *Morbidity and Mortality Weekly Report, 283*(10), 1283-1286.

Balog, D. A. (1997). Fluoridation of Public Water Systems: Valid Exercise of State Police Power or Constitutional Violation. *Pace Environmental Law Review, 14*(2), 645-691. Retrieved February 25, 2016.

Carstairs, C. (2015). Debating Water Fluoridation Before Dr. Strangelove. *American Journal of Public Health*, *105*(8), 1559-1569. Print.

Centers for Disease Control and Prevention. (2013, July 10). Preventing Dental Caries with Community Programs. Retrieved April 2, 2016, from http://www.cdc.gov/oralhealth/publications/factsheets/dental_caries.htm

Centers for Disease Control and Prevention. (2013). *2012 Water Fluoridation Statistics.* U.S. Census Bureau. Retrieved from http://www.cdc.gov/fluoridation/statistics/2012stats.htm

Centers for Disease Control and Prevention. (2015, July 29). Community Water Fluoridation. Retrieved from http://www.cdc.gov/fluoridation/

Centers for Disease Control and Prevention. (2016, March 23). Water Fluoridation Data & Statistics. Retrieved from http://www.cdc.gov/fluoridation/statistics/

Connett, P. (2012). 50 REASONS TO OPPOSE FLUORIDATION. *Fluoride Action Network*. Retrieved February 15, 2016, from http://fluoridealert.org/articles/50-reasons/

Crain, R. L., Katz, E., & Rosenthal, D. B. (1969). *The Politics of Community Conflict: The Fluoridation Decision*. Indianapolis and New York: The Bobbs-Merrill Company.

Dye, B. A., Li, X., & Thornton-Evans, G. (2012). Oral Health Disparities as Determined by Selected Healthy People 2020 Oral Health Objectives for the United States, 2009 - 2010. *NCHS Data Brief,* (104), 1-8.

Fluoridation Action Network. (2016). Water Fluoridation - Fluoride Action Network. Retrieved February 16, 2016, Retrieved from http://fluoridealert.org/issues/water/

Fluoride Action Network. (2016). ABOUT FAN. *Fluoride Action Network*. Retrieved February 15, 2016, Retrieved from http://fluoridealert.org/about/

Glenn, E. (2014). Oral health affects overall health. *ProQuest.* Retrieved from http://www.bibme.org/citation-guide/apa/journal-article

Hersch, P., Pelkowski, J. (2014). Voter demand for fluoridated water: a tale of two c(av)ities. *Applied Economics Letters, 21*(1), 51 – 54.

Hicks, J. (2011). Pipe Dreams: America's Fluoride Controversy | Chemical Heritage Foundation. Retrieved April 7, 2016, from http://www.chemheritage.org/discover/media/magazine/articles/29-2-pipe-dreams-americas-fluoride-controversy.aspx?page=3

Krisberg, K. (2013, August). Sates collect, analyze public drinking water data. *The Nation's Health*.

Leung, C., Yu, I., Chen, W. (2012). Silicosis. *The Lancet Journal, 379*(9830), 2008 – 2018.

Maheshwari, M. (2006). Fluoride in drinking water and its removal. *Journal of Hazardous Materials, 137,* 456-463.

McClure, F. J. (1970). *Water Fluoridation: The Search and the Victory*. Bethesda, MD: National Institute of Dental Research.

McNeil, D. R. (1985). America's Longest War: The Fight over Fluoridation, 1950-. *The Wilson Quarterly, 9*(3), 140-153.

Mohapatra, M. et al. (2009). Review of fluoride removal from drinking water. *Journal of Environmental Management, 91,* 67-77

Morabia, A. (2016). Cmmunity Water Fluoridation: Open Discussions Strengthen Public Health. *American Journal of Public Health, 106*(2), 209 – 210

Mullen, J. (2005). History of Water Fluoridation. *British Dental Journal*, 199, 1-4. Print.

National Research Council. (2006). *Fluoride in drinking water: A scientific review of EPA's standards*. Washington, D.C.: National Academies Press.

Neidell, M., Herzog, K., & Glied, S. (2010). The Association Between Community Water Fluoridation and Adult Tooth Loss. *American Journal of Public Health*, *100*(10), 1980-1985.

Public Health Reports. (2015). U.S. Public Health Service Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries**.** *U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation, 130.* 1-14

Sapolsky, H. M. (1969). The Fluoridation Controversy: An Alternative Explanation. *The Public Opinion Quarterly, 33*(2), 240-248.

Silva, M. et al. (2015). Oral hygiene protocols in intensive care units in a large Brazilian city. *American Journal of Infection Control, 43*(3), 303-304

Slavkin, H. C., & Baum, B. J. (2000). Relationship of Dental and Oral Pathology to Systemic Illness. *Contempo Updates: Linking Evidence and Experience, 284*(10), 1215-1217.

University of California Television. (2008, January 31). *George Lakoff: Moral Politics.* [Video File]. Retrieved from https://www.youtube.com/watch?v=5f9R9MtkpqM

U.S. Senate. Charters of Freedom. (1994). Retrieved May 04, 2016, Retrieved from http://www.senate.gov/civics/constitution_item/constitution.htm#amdt_1_(1791)

UWIRE. (2012). Oral health linked to overall health. *UWIRE Text*. Retrieved from http://go.galegroup.com.proxy.lib.pdx.edu/ps/i.do?id=GALE%7CA284974841&v=2.1&u=s1185784&it=r&p=AONE&sw=w&asid=aed4e5f43006c245b77bb3010278b58d

Weno, K. (2015). Statement on the Evidence supporting the safety and effectiveness of community water fluoridation. *Department of Health & Human Services*. Retrieved April 5, 2016.

Zipkin, I., Likins, R. C., McClure, F. J., & Steere, A. C. (1956). Urinary Fluoride Levels Associated with Use of Fluoridated Waters. *Public Health Reports, 71*(8), 767-772.