Comparative Analysis of Salt and Water Fluoridation in Non-Industrialized Countries

Chelsea Elizabeth Mitchell

Follow this and additional works at: https://egrove.olemiss.edu/hon_thesis

Recommended Citation

This Undergraduate Thesis is brought to you for free and open access by the Honors College (Sally McDonnell Barksdale Honors College) at eGrove. It has been accepted for inclusion in Honors Theses by an authorized administrator of eGrove. For more information, please contact egrove@olemiss.edu.
COMPARATIVE ANALYSIS OF SALT AND WATER FLUORIDATION IN NON-INDUSTRIALIZED COUNTRIES

by
Chelsea Elizabeth Mitchell

A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of the requirements of the Sally McDonnell Barksdale Honors College.

Oxford
May 2011

Approved by

Advisor: Dr. Teresa Carithers
Reader: Dr. Robert Albritton
Reader: Dr. Sullivan-González
ABSTRACT
CHELSEA ELIZABETH MITCHELL: Comparative Analysis of Salt and Water Fluoridation in Non-Industrialized Countries
(Under the direction of Teresa Carithers)

The following paper outlines various methods of fluoridation, specifically salt and water fluoridation, and explores the implications of each in various countries. This paper identifies the factors necessary to take into account when making the decision of which method to implement in a country, as well as the main requirements of each method and steps to implementation of each. These factors include not only scientific evidence of effectiveness, but also cultural concerns, socioeconomic indicators, abundance of natural resources, as well as the political situation of the country. This paper also explores various health demographics of the non-industrialized country of Nicaragua, and identifies the current situation concerning oral health care and fluoridation in this country. Conclusions were drawn as to which method of fluoridation is better suited for Nicaragua, and other countries similar to it, and what the greatest possible benefits and set-backs of each method are. The topic of this paper was formulated based on the author’s first-hand experience in a dental clinic in Nicaragua and her observations of the health disparities seen in the area.
# TABLE OF CONTENTS

LIST OF TABLES........................................................................................................................... v

LIST OF FIGURES......................................................................................................................... vi

LIST OF ABBREVIATIONS............................................................................................................. vii

CHAPTER I: STATUS OF ORAL HEALTH IN NICARAGUA......................................................... 1

CHAPTER II: SALT AND WATER FLUORIDATION.......................................................................... 5
  Salt Fluoridation.......................................................................................................................... 6
  Water Fluoridation..................................................................................................................... 14

CHAPTER III: ASSESSMENT OF FEASIBILITY AND SUPERIORITY FOR IMPLEMENTATION IN NICARAGUA......................................................................................................................... 22
  Feasibility Assessment.............................................................................................................. 23
  Superiority Assessment............................................................................................................ 25
    Impact of Natural Resources.................................................................................................. 25
    Socioeconomic Indicators...................................................................................................... 27
    Political Environment........................................................................................................... 30

CHAPTER IV: DISCUSSION AND CONCLUSIONS.......................................................................... 33

BIBLIOGRAPHY............................................................................................................................. 37
LIST OF TABLES

Table 1 Prevalence of Fluorosis in two Communities Fluoridated by Different Methods ..........................................................9

Table 2 Comparison of Various Health Indicators in the United States vs. Nicaragua..........................................................30
LIST OF FIGURES

Figure 1  Flowchart of Steps Involved in Implementing a Salt Fluoridation System within a Country .............................................12

Figure 2  Flowchart Outlining the Process of Implementing Water Fluoridation in Victoria, Australia....................................................19

Figure 3  Map of Nicaragua Indicating Location and Size of Lakes Managua and Nicaragua..........................................................26
**LIST OF ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC</td>
<td>Center for Disease Control</td>
</tr>
<tr>
<td>CIA</td>
<td>Central Intelligence Agency</td>
</tr>
<tr>
<td>DMFT</td>
<td>Decayed, Missing and Filled Teeth</td>
</tr>
<tr>
<td>ENACAL</td>
<td>Empresa Nicaragüense de Acueductos y Alcantarillados</td>
</tr>
<tr>
<td>INAA</td>
<td>El Instituto Nicaragüense de Acueductos y Alcantarillado Sanitario</td>
</tr>
<tr>
<td>MAIS</td>
<td>Modelo de Atención Integral en Salud</td>
</tr>
<tr>
<td>MINSA</td>
<td>Ministerio De Salud</td>
</tr>
<tr>
<td>mg</td>
<td>milligrams</td>
</tr>
<tr>
<td>PAHO</td>
<td>Pan American Health Organization</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>PRB</td>
<td>Population Reference Bureau</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
CHAPTER I: STATUS OF ORAL HEALTH IN NICARAGUA
In a paper released in 2003, the World Health Organization (WHO) announced its findings that dental caries affect 60-90% of children and almost all adults worldwide (Petersen, 2004), a problem which can be greatly impacted through the implementation of fluoridation systems. Also stated in this paper was that dental caries is the most prevalent oral disease in the majority of Latin American countries (Petersen, 2004). One general and widely accepted solution to this problem that has proven to be cost-effective, worthwhile, and beneficial in all aspects is fluoridation. Fluoride is particularly effective in preventing and lowering the number of decayed, missing and filled teeth, more commonly known as DMFT, when it comes in contact with children’s developing teeth, as well as when this contact is continued throughout one’s lifetime (CDC, 2009).

When approaching the problem of oral health care in non-industrialized countries such as Nicaragua, the variety of approaches is numerous, yet the majority of these approaches are not feasible. Though generally associated with water in most industrialized nations, fluoridation has proven to be more effective in developing countries through its use in salt.

The following paper highlights the critical importance of researching various cultural demographics in relation to current oral and overall health in countries such as Nicaragua, to determine the feasibility and superiority of salt versus water fluoridation in alleviating population based oral health concerns.

This comparative analysis study was evolved through a combination of factors. During June of 2010 a visit to the village of La Mora, Nicaragua as a member of a mission group providing services in a mission supported dental clinic provided a reality-
based exposure to the unique issues that non-industrialized countries face in addressing and solving health care concerns. This author’s interests in oral health and dentistry raised concerns and sparked an interest in finding a resolution to this basic need.

Throughout a three day time span of working in the dental clinic, which was open on average from 8:00 AM until 7:00 PM, a team of two dentists and five assistants extracted a total of 542 teeth from 254 patients. Many of the locals visiting the clinic requested to have all of their teeth extracted; others had no choice in meeting this fate. The amount of decay in each person’s mouth was astonishing, particularly in comparison to the mostly decay-free state of the average American’s mouth and the ease with which this type of problem can be fixed in the United States (U.S.) and other industrialized nations.

A passion to resolve these enormous oral health concerns evolved into an investigation of the most basic preventative oral health measures. An unexpected outcome of this investigation was a new appreciation of not just the scientific routes of improving the problems facing these people, but a broader understanding of the unique barriers found in countries, such as Nicaragua, that may make one preventive method more feasible than other methods used readily in industrialized nations. Since the oral health problems of the people of Nicaragua and other developing countries could be blamed almost entirely on their complete lack of any sort of fluoridation system, an immediate solution was envisioned, based on limited knowledge and a bias toward what already worked in the U.S. The obvious solution to the world’s oral health problems is water fluoridation.
The initial finding of the availability of salt fluoridation as an alternative to water fluoridation was quickly tossed aside due to limited knowledge and lack of understanding of how various demographic characteristics impact the answer to this question. However, further investigation revealed the need to consider this additional type of fluoridation, particularly using variables beyond strictly scientific effectiveness.

Methods

A comparative analysis research design was used to assess (1) the feasibility of each fluoridation method and (2) the superiority of one fluoridation method over another. The feasibility for implementing each method was determined using key characteristics and requirements for implementation of each. Assessment of the superiority of one method over another was determined using comparisons of the impact of natural resources, socioeconomic indicators, and a country's political environment.
CHAPTER II: SALT AND WATER FLUORIDATION
Salt Fluoridation

According to a book published by the Pan American Health Organization (PAHO) in 2005, fluoridation of table salt can reduce the prevalence of dental caries by up to 84% (Dental Watch, 2006). The book also cites the cost effectiveness of this method of fluoridation in that it saves $250 in dental care for every $1 spent on these fluoridation systems at a cost of only 6 cents per person per year (Dental Watch, 2006), as opposed to 50 cents per person per year for water fluoridation (Horowitz, 2000). Recent studies have shown the continuing effectiveness of this method up to adulthood, yet it is important to ensure the complete effect of the salt fluoridation method (Marthaler and Petersen, 2005). This would involve the fluoridation of all forms of salt, including that used for household consumption, school meals, as well as what is used in bakeries and larger scale manufacturing of various products. Various studies, a notable one completed in Hungary, have determined the appropriate concentration of fluoride necessary to be deemed effective. It was found that the most effective concentrations of fluoride in salt were 250ppm and 350ppm (Marthaler and Petersen, 2005). Other studies, such as one completed in Switzerland, confirm the effectiveness of the 250ppm concentration (Marthaler and Petersen, 2005), and salt fluoridated at this level is currently available in Austria, Costa Rica, France, Germany, Mexico, Switzerland, and 30 additional countries (Sagheri, McLoughlin and Clarkson, 2005). In Germany it was found that this level of fluoridation has the ability to double the fluoride intake of the consumer in areas where natural water fluoride levels are 0.13ppm or lower, resulting in an overall level of fluoride intake that is still lower than is deemed adequate, though close to being acceptable (Bergmann, 1995).
The two methods for incorporating fluoride into a salt supply are batch processing and continuous processing (Marthaler and Petersen, 2005). In batch processing, a fixed amount of fluoride is added to a fixed amount of salt, resulting in the desired 250ppm fluoride concentration, whereas in continuous processing a dosage of measured concentration of fluoride is sprayed onto the salt as it passes by on a conveyor belt (Marthaler and Petersen, 2005). The latter process often results in a greater number of problems and less continuously consistent production than the prior (Marthaler and Petersen, 2005). In order for fluoride to be effective through its addition to salt, it must be present in the ionic form when the salt is dissolved in water (Marthaler and Petersen, 2005). It is also necessary to decrease humidity levels and ensure the reduction of the presence of calcium carbonate, as well as any heavy metals, because their presence reduces the ionic form of fluoride (Marthaler and Petersen, 2005).

It should be noted that the distribution of fluoridated salt should be limited to areas where fluoridated water is less prevalent, though this problem does not apply to non-industrialized countries lacking adequate water supplies (Marthaler and Petersen, 2005). Experts recommend only one form of systemic fluoride supplementation to the individual, which may include, but is not limited to, salt fluoridation, water fluoridation and fluoride tablets or drops, except during the first two years of an individual’s life (Bergmann, 1995). During this critical time of tooth development, up to 2 methods of fluoridation are deemed acceptable without invoking future harm to the child, due to the minimal salt intake experienced at this stage in one’s life (Bergmann, 1995). It has been found that infants retain 90% of all the fluoride they intake, which is directed toward critical tooth and bone development (Bergmann, 1995).
The top concern of the majority of populations in all countries implementing some type of fluoridation system has been the issue of fluorosis (Horowitz, 2000). Fluorosis can be defined as the hypermineralization of the enamel of teeth, caused by ingestion of excessive amounts of fluoride, particularly during the period when teeth are forming in the jaw (Horowitz, 2000). Fluorosis does not affect the overall health of the individual or the health of that individual’s teeth, rather it can be classified as a cosmetic concern, and it has been found to have a higher prevalence in water fluoridated communities than salt (Horowitz, 2000). This point was demonstrated in a study completed by the Department of Public and Child Dental Health, Dublin Dental School and Hospital, Trinity College, and the Republic of Ireland. This study compares the prevalence of fluorosis in two communities with different fluoridation systems: Dublin, Ireland, practicing water fluoridation, and Freiburg, Germany, practicing salt fluoridation (Sagheri, McLoughlin and Clarkson, 2007). The results of this study are displayed below in Table 1 (Sagheri, McLoughlin and Clarkson, 2007).
“Mild” and “Moderate” levels of dental fluorosis are considered to be cosmetic concerns, and though these numbers are similar in the two communities, the prevalence of “Very Mild” dental fluorosis more than doubled in Dublin, as opposed to Freiburg (Sagheri, McLoughlin and Clarkson, 2007). Upon analysis of the results, the difference in dental fluorosis levels in the two communities was found to be statistically significant, as is visible in the higher prevalence of fluorosis at all stages in the water fluoridated community of Dublin over the salt fluoridated community of Freiburg, which demonstrates the effectiveness of the salt fluoridation method at maintaining a low prevalence of fluorosis among those populations affected (Sagheri, McLoughlin and Clarkson, 2007). This study also took into account the times at which children began brushing their teeth. It was found that in Dublin children began brushing their
teeth at an older age than in Freiburg, however differences in fluorosis levels among the “early” and “late” children were not found to be considered significant (Sagheri, McLoughlin and Clarkson, 2007).

The following presents an outline of characteristics and requirements to be taken into account in a given nation in order for the feasibility of a salt fluoridation program to be determined (Marthaler and Petersen, 2005):

- Identification of the main producers, exporters and importers of salt within the nation
- Identification of all packaging and distribution routes of salt
- Identification of all forms of salt available to the public
  - Including (but not limited to) large kitchens, restaurants, hospitals, bakeries, food industries, markets/grocery stores
- Location of available data concerning salt consumption within the nation – must include all forms of salt previously mentioned
- Gather information concerning salt iodization processes within the nation
- Assess the ability of each form of salt to be fluoridated, taking into account grain size, humidity, additives, etc.
- Determine the number of fluoridation instillations necessary to make fluoridated salt available to 60-80% of the population
  - Repeat this assessment to include 90% of the population
- Assess the legal situation and current legislature concerning the regulations on additives to the salt supply
- Ensure coordination and cooperation with medical systems (including overall health care as well as oral health care) and food control systems
- Assess the possible methods of analyzing and monitoring fluoride intake
  - Including (but not limited to) urine analysis, fingernail samples, salt and water sample analysis
- Check for regions of the nation supplied with water containing natural levels of fluoride of 0.7ppm or greater – fluoridated salt is not to be used in these regions
- Ensure the ability to monitor fluoride addition at the salt production level
- Ensure the ability to monitor fluoride intake via urine samples from children for at least the first two years of implementation
- Calculate specific costs of implementation for that nation
- Calculate anticipated costs of campaigning the idea of implementing the system to the public
  - It is necessary to convince the public of the importance of switching to fluoridated salt from normal salt, while informing them of the benefits and eliminating the question of increased price and cultural concerns over freedom of choice

The following flowchart, Figure 1, outlines the steps necessary to implement a salt fluoridation system within a country. Additional, more specific steps may be
Salt fluoridation systems have many advantages over water fluoridation systems. Salt, itself, is a supplement necessary in controlled amounts in an individual’s diet, therefore the benefits of this system are two-fold (Bergmann, 1995). In a study
completed in Germany, daily salt intake at all ages, including preschool, school, male and female adults, was recorded and found to be higher than the minimum recommended intake (Bergmann, 1995). These results demonstrate the feasibility of salt as a vehicle for fluoride based on its already popular consumption at all ages (Bergmann, 1995). Salt is also advantageous in that it allows the consumer freedom of choice, whereas water fluoridation does not. In Germany, for example, this advantage, alone, was the deciding factor to implement a salt fluoridation system in the early 1990s over a water fluoridation system due to strong objections from a minority group complaining that water fluoridation does not respect the decision of the individual not to consume more fluoride than is naturally present in the water supply (Bergmann, 1995).

Other advantages of salt as a vehicle for fluoride include that it requires no attention to lifelong daily compliance, as opposed to fluoride drops or tablets, the very low cost of consumption, as well as that it can be ingested in small amounts throughout the day (Bergmann, 1995). Addition of fluoride to salt does not raise costs higher than that of iodized salt, which costs the individual an average of 55 cents per year for consumption rates at 2 grams per day (Bergmann, 1995).

One major disadvantage of salt intake in general is the risk of hypertension, commonly referred to as high blood pressure, however this concern is present with or without the addition of fluoride to the salt supply (Bergmann, 1995). Increased salt consumption is not required to reap the benefits of fluoridated salt, and it was found in a study completed in Germany that levels of salt consumption did not actually increase with the introduction of fluoridated salt, in large part due to the release of critical consumer education concerning the basics of fluoride and salt intake in general
Given that adults excrete 90% of all fluoride they consume, urine samples have proven to be an effective method of analyzing and monitoring fluoride ingestion (Bergmann, 1995).

**Water Fluoridation**

On the other hand, with the addition of fluoride to the water sources in a country virtually all consumers within range of the affected water supply will be reached unquestionably (Marthaler and Petersen, 2005).

All sources of water naturally contain a minimal amount of fluoride, yet water fluoridation is still necessary to adjust this level to an optimal amount in each given community so as to prevent fluorosis (CDC, 2009). It should be noted that in general, communities with higher levels of fluorosis tend to have naturally fluoridated water supplies rather than artificially treated water with optimal fluoride levels via fluoridation systems that have been implemented (Petersen, 2004). It has been estimated that 350 million people worldwide drink artificially fluoridated water via water fluoridation systems, and at least 50 million people drink naturally fluoridated water with fluoride levels of about 1ppm (Sagheri, McLoughlin and Clarkson, 2007).

Water fluoridation was implemented in the United States in 1945, and as of 2008 an astounding 72.4% of the entire population had access to these fluoridated water sources (CDC, 2009). Similarly, mandatory water fluoridation was introduced in Ireland in 1964, and currently 74% of the population lives in fluoridated areas (Sagheri, McLoughlin and Clarkson, 2007). As opposed to the cost of 6 cents per person per year for salt fluoridation, water fluoridation costs range from 50 cents in larger communities
to $3.00 in smaller communities per person per year (CDC, 2009). Though this drastic
difference in cost is less of a problem in developed countries, such as the United States,
this presents a problem in non-industrialized countries desiring to implement this type
of system. Any additional costs involved in the process of implementing either salt or
water fluoridation are similar in both circumstances, and therefore should not affect the
decision as to which system is more feasible in a given country.

Water fluoridation is done on a community based level, which is often
inconsistent across communities in a given state (CDC, 2009). Many communities of a
given population are required by law to fluoridate their public water sources, and this
presents yet another problem in developing countries due to lack of centralized water
sources (CDC, 2009).

The WHO has deemed 1.5ppm to be the maximum concentration of fluoride
allowable in drinking water so as to minimize the prevalence of fluorosis (Newbrun,
1992), and optimal fluoride concentrations in the United States have been set between
0.7ppm and 1.2ppm depending on natural levels of fluoride present in a given source
(Newbrun, 1992). These numbers, however, do not apply to all other countries.
Particularly in areas of extremely hot and dry climates where residents are subject to
more outside work, excessive sweating, and therefore greater water intake, appropriate
fluoride concentrations are lower (Newbrun, 1992).

One major advantage of water fluoridation is the ability of the set concentration
to benefit all individuals in the affected area without taking into account weight, height
or age, which are necessary when using other prescribed fluoride supplements, such as
drops and tablets (Newbrun, 1992). It has been concluded through the analysis of 50
epidemiological studies completed in various countries that no adverse health risks are associated with intake of water treated to have optimal levels of fluoride (Newbrun, 1992).

The following outlines a checklist of necessary factors to take into consideration when planning and implementing a water fluoridation system in a country (WHO, 2004):

- Identification of chemicals already present in the given water supply; establish which of these chemicals poses key concerns to the affected population
  - It is necessary to primarily assess the four priority chemicals (arsenic, fluoride, selenium and nitrate) before assessing other chemicals of specific local concern
- Establish and implement a management policy for continued monitoring of these chemicals; implementing systems to alter their levels (only if necessary)
- Assess the current legal situation concerning drinking-water standards and guidelines; this includes the knowledge of whether these regulations are set at the national, state, or community based level
- Standards developed by countries should be applicable to the largest urban areas, as well as smaller community piped systems and non-piped systems in the smallest communities
- Ensure the existence of legal documentation allowing a fluoridation system to be implemented
○ Development of a water safety plan that ensures control of water production, treatment and distribution to all affected areas

○ Identify specific community health-based targets in order to establish adequate levels of fluoride necessary (it is also necessary to establish acceptable amounts of other naturally present chemicals)

○ Ensure consent of all parties involved in order to justify the water fluoridation system
  - Those affected by the fluoridated water supply will have virtually no choice but to use the aforementioned water supply; their personal opinions and biases will be deemed null

○ Consideration of the balance of risks and benefits, potential alternatives, and all possible health outcomes

○ Establish whether fluoridating the water supply constitutes a forced medical intervention for that given nation

○ Assess cost-effectiveness of the fluoridation system for that nation/state/community
  - Costs must include fluoride storage equipment, dosing system, instrumentation and control systems, electrical control system, safety equipment for managing fluorine, spill management system, testing and commissioning of fluoride levels

○ Assign a monetary value to medical procedures that would be avoided if the water fluoridation system were implemented
Have all fluoridation plant designs and methods approved by the appropriate governmental sector before implementation.

The following flow chart, Figure 2, outlines a generic plan of the key steps involved in starting a water fluoridation system. This specific outline proved effective through its use in Victoria, Australia, however the generic layout is applicable to other countries as well (Victorian State Government, 2008).
Authority directed by Secretary of the department or resolves to fluoridate under Health (Fluoridation) Act 1973

Step 1: Initial Procedure

Step 1a: Authority discusses proposal with the department
Step 1b: Authority conducts feasibility study

Step 2: Plans and specifications

Step 2a: Authority submits plans and specifications
Step 2b: Authority commences tender process for fluoride plant
Step 2c: Authority submits work program and commences plant

Step 3: Commissioning

Step 3a: Authority commences commissioning
Step 3b: Department provides written approval for addition of fluoride
Step 3c: Authority completes commissioning and commences production

Step 4: Operation

Authority operates in accordance with approved submission, and integrates into risk management plan as required under Safe Drinking Water Act 2003; Audit undertaken by the department within 12 months after commencement of operation.
Aside from the technical implications of each system, socio-economic factors must also be taken into account. In an effort to examine this aspect of fluoridation systems, a study comparing social classes under the water fluoridation system in Dublin, Ireland and the salt fluoridation system in Freiburg, Germany was performed. The results of this study, which compared DMFT of 12 year olds in both communities, showed a great disparity between social class 1, the highest class, and social classes 2 and 3 (Sagheri, McLaughlin and Clarkson, 2007). The study also revealed a lesser disparity between classes 2 and 3 than between class 1 and either of the other two (Sagheri, McLaughlin and Clarkson, 2007). These results were mirrored in both communities, however the disparity between classes 2 and 3 was less in the water fluoridated community of Dublin than in the salt fluoridated community of Freiburg (Sagheri, McLaughlin and Clarkson, 2007). The average DMFT in social class 1 was lower in both communities than social class 2, and in both situations class 3 had the highest average DMFT (Sagheri, McLaughlin and Clarkson, 2007). These results suggest the ability of water fluoridation systems to bridge the gap between social classes, as well as the important role of salt fluoridation particularly in areas where water is not feasible (Sagheri, McLaughlin and Clarkson, 2007).
The same study was further conducted in Freiburg during which fluoridated and non-fluoridated salt consumers were analyzed. Of the fluoridated salt users that were involved, 147 had DMFT of 0 and 59 had DMFT higher than 0 (Sangheri, McLaughlin and Clarkson, 2007). In the non-fluoridated salt use group, only 50 had DMFT of 0 while 44 had DMFT higher than 0, again suggesting the impact salt fluoridation, or any fluoridation system in general, can have on the individual as well as the community level (Sangheri, McLaughlin and Clarkson, 2007).
CHAPTER III: ASSESSMENT OF FEASIBILITY AND SUPERIORITY FOR 
IMPLEMENTATION IN NICARAGUA
Feasibility Assessment

Fluoridated salt may be the answer to the problems facing non-industrialized countries for many reasons aside from its economic feasibility. The maximum daily fluorine intake for adults has been established as 4mg (Marthaler and Petersen, 2005), so not only have fluorosis and fluoride overdose via salt intake been virtually excluded as concerns, this type of system is also easy to implement, sustain and monitor (Baez, 2010). The implementation of a salt fluoridation system over a water fluoridation system allows the consumer an extended amount of freedom of choice, given that fluoridated and non-fluoridated products are available to the consumer (British Medical Association, 2010). In reality, all humans are exposed to some amount of fluoride naturally, however the consumer’s ability to choose the extent of this exposure relieves many cultural concerns, as well as serving to appease the individual’s perception of his/her freedom of choice (Bergmann, 1995). This eliminates the need to obtain complete community consent when implementing the system, which would be required in a water fluoridated system where virtually all consumers are affected regardless of personal convictions or opinions (British Medical Association, 2010).

Salt fluoridation has been deemed most effective in developing nations, such as Nicaragua, because of the benefits it offers the community regardless of socioeconomic status, demographics of the country, and access to dental service (Cathcart, 2006). The WHO, as well, recommends salt fluoridation in areas where water isn’t feasible for technical, financial, or socio-economic reasons (Sagheri, McLaughlin and Clarkson, 2007).
Although water fluoridation systems can also be in the form of bottled or mineral water, this is not practical in a non-industrialized country given the lack of financial and geographic ability to access these sources (Marthaler and Petersen, 2005). Water fluoridation is also not feasible in these developing countries due to the lack of a centralized water supply and inadequate distribution of water to rural areas of the countries (Estupiñán-Day, 2005). In other parts of the world, Central and Eastern Europe for example, water fluoridation systems that were previously either in schematic form or already in place have stopped due to a political transition in the 1990s, and the amount of dental caries has significantly increased due to this, which serves as an indicator of the importance of governmental cooperation when implementing such a system (Marthaler and Petersen, 2005).

Hypothetically speaking, even if the water sources in Nicaragua or other third world countries were expansive enough to supply a major portion of the population, insufficient governmental support concerning this matter would present problems in further implementation of such a system (Webster, Waite and Markley, 2001). As it is only ideal for stable countries and large cities, water fluoridation is currently only considered popular and successful in the United States, Spain, Australia, Singapore, Hong Kong, the United Kingdom and Ireland, and is making little progress elsewhere (Marthaler and Petersen, 2005).
Superiority Assessment

Impact of Natural Resources

Water quality and sources in the country are not only a problem for effective oral health care, they also hinder the country's agricultural production by lack of irrigation systems, as well as overall infrastructure (USDA, 2010). It can be inferred from these data that if agricultural production is struggling, the people of the country are also in trouble. Groundwater is the main source of fresh water throughout the country of Nicaragua, and sufficient supplies of it are available in most areas (Webster, Waite and Markley, 2001). Surface water is heavily polluted due to deforestation and a lack of water sanitation regulations, causing the country to resort to groundwater for nearly all sources of water (Webster, Waite and Markley, 2001). Average daily water use in developed countries is 40 liters per person per day, whereas this number drops to only 15 liters per person per day in developing countries in which water sources are not only contaminated, but are more importantly far away from immediate use in the home (Webster, Waite and Markley, 2001). The major source of water quantity and quality problems in Nicaragua relates to the lack of a single governmental sector to deal with this, rather a collection of agencies and organizations share this responsibility (Webster, Waite and Markley, 2001). The uneven distribution of the population throughout the country, as well as the various amounts of rainfall, results in a lack of ability to adequately distribute water sources, despite the fact that Nicaragua has two of the largest fresh water lakes in all of Central America (Webster, Waite and Markley, 2001). The sizes of these lakes, Lake Managua and Lake Nicaragua, are pictured below in
Figure 3 in order to allow comparison of their size relative to the overall size of the country (Language Schools Worldwide).

[Figure 3: Map of Nicaragua Indicating Location and Size of Lakes Managua and Nicaragua]


ENACAL, an organization under supervision of the INAA, is a national government agency responsible for water supply and sanitation services within Nicaragua (Webster, Waite and Markley, 2001). It has been estimated that this service covers 77% of the urban population, yet only 31% of the rural population (Webster, Waite and Markley, 2001). An estimate of 42% of the entire water supply sources lack
in quantity, especially during the country’s dry season between the months of November and April (Webster, Waite and Markley, 2001). As far as water treatment is concerned, 97% of the urban population’s water supply is chlorinated, yet other forms of water treatment are currently skeptical (Webster, Waite and Markley, 2001).

Socioeconomic indicators

Nicaragua is the largest, and sadly the poorest, country in all of Central America (CIA, 2010). It was estimated in 2005 that 45% of the entire population lives below the poverty level, and this is mainly observed in the villages farthest from Managua, the central capitol of the country (CIA, 2010). In a population of 5,669,500, life expectancy of both sexes is at an average of 71 years of age (PRB, 2010). Approximately 60% of this population lives in the western part of the country, with the other 40% living on the east side much more spread out and away from the convenience of resources and what little of the country’s infrastructure there is (Webster, Waite and Markley, 2001). It has been estimated that roughly half of the country’s workforce is unemployed or underemployed, serving as a major contributing factor to the poor economy of the country (Webster, Waite and Markley, 2001).

Nicaragua stands in the 77th percentile for the highest birth rate of all countries, with 22.77 births per every 1,000 people (CIA, 2010). The CIA World Factbook classifies Nicaragua as a country with a “high” degree of risk of infectious diseases (CIA, 2010). This classification is in large part due the fact that only 48% of the population has access to adequate sanitation facilities, and some of these diseases, for example leptospirosis, are transferred through water contact (CIA, 2010). Vaccinations are given as a course of prevention and first line of defense for many of these problems,
however depending on one’s social class, availability becomes an issue. Only 64% of the poorest fifth of children are fully vaccinated, while this number jumps to 78% for the middle fifth and 71% for the richest fifth (PRB, 2010).

The structure of the health care system in Nicaragua suffers as well, which can be inferred from the statistical evidence describing the vast number of health problems among the people. The health system is organized through the “Modelo de Atención Integral en Salud”, more commonly known as MAIS (“Nicaragua’s Health System”). The three components of this system include provision, management, and financing of health care throughout the country (“Nicaragua’s Health System”). This organization is responsible for determining the extent to which health care is needed in various geographic areas of the country and is moving toward a more decentralized form of operation where individual hospitals will have more freedom to assess the use of their resources (“Nicaragua’s Health System”).

The Social Security system in the country is making progress, as well, toward coverage of a larger portion of the population (“Nicaragua’s Health System”). The 2006 budget as set by the government for the Ministry of Health, or MINSA, was $182,371,695 US dollars, roughly averaging out to $35 per person (“Nicaragua’s Health System”). There are a total of thirty two hospitals (“Nicaragua’s Health System”) and 4,337 hospital beds in the country (Health Care Gran Pacífica Nicaragua, 2009), 2,001 of which are located in Managua (“Nicaragua’s Health System”). This presents a vast disparity in the outer edges of the country, and averages out to 1 bed per 968 people (Health Care Gran Pacífica Nicaragua, 2009). Not only is there a problem with a shortage of medical personnel, there are estimates of 6.2 physicians per 10,000
inhabitants, but these hospitals also lack supplies and appropriate equipment ("Nicaragua’s Health System"). It is formally stated in Nicaragua’s General Law on Health that those residing in vulnerable sectors of the population will receive free healthcare, however it is difficult and often impossible for these people to access these services ("Nicaragua’s Health System"). Only 13% of the residents of Managua are little more than 30 minutes walking distance from a health unit, which is in stark contrast to the 33% of the rural populations that live more than two hours walking distance from health care units ("Nicaragua’s Health System"). The dental health care system is in an even graver situation than the overall health care system, with only 243 total dentistry personnel in the country, which averages out to less than 0.5 dentistry personnel per 10,000 people (WHO, 2011).

The following table presents a comparison of various health statistics in Nicaragua versus those observed in the United States (WHO, 2011) in an attempt to demonstrate the disparities, as well as two similarities, seen in the overall health care system of the country.
Table 2: Comparison of Various Health Indicators in the United States vs. Nicaragua

<table>
<thead>
<tr>
<th>Health Indicator</th>
<th>United States</th>
<th>Nicaragua</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>311,666,000</td>
<td>5,669,500</td>
</tr>
<tr>
<td>Population living below poverty level</td>
<td>12%</td>
<td>45%</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>M: 76 F: 81</td>
<td>M: 71 F: 71</td>
</tr>
<tr>
<td>Percent of children receiving vaccinations</td>
<td>76% of all children in the United States</td>
<td>64% of poorest fifth, 78% middle fifth, 71% richest fifth</td>
</tr>
<tr>
<td>Number of Hospital beds</td>
<td>31 beds per 10,000 people</td>
<td>9 beds per 10,000 people</td>
</tr>
<tr>
<td>Total number of dentistry personnel</td>
<td>463,663</td>
<td>243</td>
</tr>
<tr>
<td>Dentistry personnel density</td>
<td>16.3 per 10,000 people</td>
<td>&lt;0.5 per 10,000 people</td>
</tr>
</tbody>
</table>

Political Environment

The decision to start a system of salt fluoridation resides in the power of the nation or state, and as of 2005 approximately 15 countries in Europe and the Americas were implementing salt fluoridation systems (Marthaler and Petersen, 2005). An initial decision must also be made by the nation of whether to fluoridate the entire country immediately, given that the feasibility of the system has been assessed entirely, or to
present the population with the choice of fluoridated and non-fluoridated salt, which has in many instances proved to be the more publicly appreciated choice (Marthaler and Petersen, 2005). Nicaragua’s system is considered to be in its initial stages of implementation, as opposed to Mexico and various countries in South America, which are in the advanced stages of their program and are already reaping its benefits (Estupiñán-Day, 2005).

Preliminary studies concerning salt fluoridation in Nicaragua were initiated in 1997 (Baez, 2010). As of November 2001 Nicaragua was listed by PAHO as a country that needed to “modify” rather than “strengthen” its legislation in the area of salt fluoridation in order to further pursue implementation of this system, whereas those countries in the “strengthen” category are closer to implementation than those in the “modify” category (Estupiñán-Day, 2001). It was also stated that no changes need be made to their areas of legislation concerning salt iodization, however no formal statement was made concerning fluoridation legislature (Estupiñán-Day, 2001). As of 2004 the country was in its beginning stages of implementing a salt fluoridation system (Estupiñán-Day, 2005), and as of 2009 this system was questionably initiated, however further updates on this situation are unavailable (Baez, 2010).

Many of the issues that arise at the governmental level during the approval and implementation of some fluoridation system within the country can be blamed on its unstable system of democracy (Johnson, 2005). It was stated in 2005 that the country had been experimenting with democracy for 15 years, and as of 2005 it was failing due to a rapidly approaching government coup (Johnson, 2005). Despite these issues, salt fluoridation is still considered the ideal approach in Nicaragua due to its limited water
supplies and widespread population, and in future years it will be important that the governmental sectors in control of monitoring and ensuring continued implementation of salt fluoridation prevent any democratic issues from standing in the way of enabling the country to experience the maximum possible results from this system.
CHAPTER IV: DISCUSSION AND CONCLUSIONS
A number of countries have implemented salt and/or water fluoridation systems since the 1950s, with Switzerland, Hungary and Colombia being some of the forerunners in programs involving salt (Marthaler and Petersen, 2005). In Switzerland, for example, salt fluoridation has been used since 1955, and this system has proven to be equally effective as fluoridated water (Marthaler and Petersen, 2005). As of 2005, 15 countries, mainly in Europe and the Americas, had begun the use of salt fluoridation as well (Marthaler and Petersen, 2005). Since 1987 all salt destined for human consumption in Jamaica has been fluoridated, resulting in a dramatic decline in DMFT of an outstanding 84% (Marthaler and Petersen, 2005). The average DMFT in 12 year old children as of 1984 was 6.7, and this number dropped to 1.1 in 1995 in a follow-up study to the implementation of their salt fluoridation program (Estupiñán-Day, 2007). It was also observed that though there was a significant presence of fluoridated tooth paste in Jamaica prior to 1984, the drastic decline of DMFT after this date indicates that it was clearly a result of salt fluoridation, though obviously fortified by the use of fluoridated tooth paste (Marthaler and Petersen, 2005). Fluoridated milk has also been experimented with briefly, however it is only available in the countries of Chile and Peru and still requires extensive experimentation and observation (Baez, 2010). Initial decisions must be made by any country as to whether or not the choice between fluoridated and non-fluoridated salt will be allowed, however this generally only applies to the initial stages of implementing the system in the country, which would later ideally progress to complete salt fluoridation, regardless (Marthaler and Petersen, 2005).
Nicaragua was considered as having "Emergent DMFT" of greater than 5 per person up to the year 1996, however as of 2004 they have shifted to the "Consolidation DMFT" category of less than 3 per person due to the slow implementation of their salt fluoridation system (Estupiñán-Day, 2007). Between the years of 1986 and 1992, the same time Jamaica implemented its salt fluoridation system, Costa Rica, Mexico and Uruguay introduced nationwide salt fluoridation as well (Gillespie, 2005). Reductions in DMFT of children age 12 were seen in each of these countries and further developments to the system have been observed, for example legislative advances requiring certain levels of salt fluoridation throughout the countries (Gillespie, 2005).

Water fluoridation, as well, has proven to be effective more so in developed countries such as the United States and Canada (Gillespie, 2005). Water fluoridation has been the dominant source of fluoride in the United States since 1945 when the country first participated in trials experimenting with this system (Gillespie, 2005). Upon experiencing the benefits of this method, implementation throughout the country began shortly after (Gillespie, 2005). Grand Rapids, Michigan was the starting place for this system, which has now successfully been in place for over 50 years, and the benefits of the consumers have been observed and well documented (CDC, 2009).

Through this comparative analysis, the author has learned not only the extent to which fluoridation of any type is critical to the oral, and therefore the overall, health of a population, but also of the various factors that need be taken into account when implementing such a system. Not only are scientific aspects of great importance, cultural perspectives and socioeconomic indicators of the given nation must be taken into account, as well. It has become strongly apparent that fluoridation systems and
required fluoride levels within these systems are highly country-sensitive in that one set of requirements can not be set for all. Upon completion of this analysis the author has been able to make many conclusions, and has formulated future questions as to why developed nations, the United States in particular, do not move more in the direction of salt fluoridation, especially given the popularity of bottled water consumption over fluoridated tap water, as well as the current economic struggles facing the country as a whole. Final conclusions are listed below.

CONCLUSIONS:

(1) Both salt and water fluoridation are optimal fluoridation methods for improving oral health.

(2) Implementation of a sustainable national fluoridation system requires complex assessment of criteria in order to assure sustainability, including scientific, cultural, economic/political, as well as demographic aspects.

(3) Salt fluoridation has economic, social and cultural benefits that greatly outweigh those of water fluoridation, therefore it is recommended over water fluoridation to those developing nations struggling economically, politically or geographically.
Bibliography


Cathcart, Ginny. "Promoting Oral Health: The Use of Salt Fluoridation to Prevent Dental Caries" *The Free Library* 01 March 2006. 03 March 2011

<http://www.thefreelibrary.com/Promoting Oral Health: The Use of Salt Fluoridation to Prevent Dental...-a0156005188>.


"Country Page -- Nicaragua." *USDA Foreign Agricultural Service (FAS) - Homepage.*


