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Consequences of Community Water Fluoridation Cessation for Medicaid Eligible Children and Adolescents

Jennifer Meyer
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Jennifer Meyer

has been found to be complete and satisfactory in all respects,
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Review Committee
Dr. Vasileios Margaritis, Committee Chairperson, Public Health Faculty
Dr. Aaron Mendelsohn, Committee Member, Public Health Faculty
Dr. James Rohrer, University Reviewer, Public Health Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
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Abstract

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by

Jennifer Meyer

MPH, University of Washington, 2004

BSN, Johns Hopkins University, 2000

BS, University of California Davis, 1994

Dissertation Submitted in Partial Fulfillment

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Abstract

Oral health impacts general health and well-being throughout the lifespan. Recent trends in the United States towards cessation of community water fluoridation (CWF) may increase disparities in oral health. The purpose of this quantitative retrospective cohort study was to analyze Medicaid dental claims records for caries related procedures among 0 to18-year-old patients during an optimal CWF year 2003 (n = 854) and compare them to claims records from 2012 (n = 1,053), 5 years after CWF was ceased. The theoretical framework of this study was the diffusion of innovations theory. Statistically significant results included higher mean number of caries related procedures among 0 to18 year and < 7-year aged patients in the suboptimal CWF group (2.57 vs. 2.43, $p < 0.001$; 2.68 vs. 2.01, $p = 0.004$, respectively). Mean caries related treatment costs per patient was also higher in the 0 to18 year and < 7-year suboptimal CWF groups compared to the optimal CWF group (583.70 vs 344.34 $, $p < 0.0001$; 692.87 vs. 350.13 $, $p < 0.0001$, respectively). Binary logistic regression analysis results indicated a protective effect from optimal CWF for the 0 to18 and < 7 year age groups ([*OR*] 0.75, 95% CI [0.62, 0.90], $p = 0.002$); *OR* = 0.70, 95% CI [0.52, 0.95], $p = 0.02$, respectively). The results confirm optimal CWF exposure prevents dental decay, expand the evidence base of caries epidemiology under CWF cessation, and indicate patients without early childhood CWF exposure experience more dental caries procedures and treatment costs. These findings may create opportunities for social change by supplying evidence that can be used to improve equity oriented oral health public policies that protect population health.

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Dedication

This dissertation is dedicated to my parents. I am eternally grateful for the sacrifices they made for their children and for their continual support in all that I do.

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As my doctoral degree efforts finally come to an end, I must thank my family who have graciously accepted “mommy doing homework” over the last eight years so I could achieve this goal. I would also extend thanks to my parents who helped me finance the high cost of the dataset and for their consistent support.

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Chapter 1: Introduction to the Study

Introduction

While the oral health of most Americans has improved over the last century, it remains a significant unmet health care need for children and marginalized groups (National Children's Oral Health Foundation [NCOHF], 2015; U.S. Department of Health and Human Services [DHHS], 2015). Dental caries continue to be one of the most common chronic diseases of childhood (Centers for Disease Control and Prevention [CDC], 2015a; NCOHF, 2015; Newacheck, Hughes, Hung, Wong, & Stoddard, 2000). From the 1980s through the early part of the 21st century, the research community has dedicated energy producing comparison studies of fluoridated versus nonfluoridated communities. As a result, they have established a large body of work supporting both efficacy and safety standards for community water fluoridation (CWF) systems (CDC, 1999; Gillcrest, Brumley, & Blackford, 2001; Griffin, Gooch, Lockwood &, Tomar, 2001; Maupome, Clark, Levy, & Berkowitz, 2001). The recent trends towards CWF discontinuation from public water systems represents an opportunity to evaluate suboptimal CWF exposure in light of commonly available fluoride products and advanced fluoride technologies used in today's contemporary dental offices (Maupome et al., 2001).

The most current CWF cessation study in the United States was published 45 years ago (Lemke, Doherty, & Arra, 1970). Additionally, among the fluoride cessation studies from other countries, researchers have observed a mixed representation of results. These variations could secondary to differences in health care systems, availability of dental technologies, and socioeconomic factors (Cho, et al. 2014; Kunzel & Fischer, 2000; Maupome et al., 2001; Seppä, Kärkkäinen, & Hausen, 2000). Thus, a gap in the available research exists given the small number of CWF cessation studies both domestically and abroad. Lastly, because the epidemiological impact of CFW discontinuation has only been analyzed in a small number of studies, it has not been established if there are specific age groups or income levels that would be more at risk for caries attack following cessation (Atwood & Blinkhorn, 1991; Maupome et al., 2001, McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Wong, 2013).

In this chapter, I provide background and context for the study, including the problem statement, purpose, and the specific research questions with corresponding hypotheses.

Background

The CDC, along with large independent reviews, have repeatedly concluded that CWF is both a safe and cost-effective method for decreasing dental disease and caries among populations regardless of age or income (CDC, 2015a, 2015b; Griffin, Jones, & Tomar; 2001; Iheozor-Ejiofor et al., 2015; McDonagh et al., 2000). Recent social trends among communities in the United States towards the discontinuation of fluoride in community water systems may move more children into pain, suffering, and costly dental procedures for advanced decay (Atwood & Blinkhorn, 1991; Wong, 2013). Significantly, the burden of negative oral health outcomes is disproportionately borne by vulnerable groups, those least able to advocate for themselves–children from low income families (DHHS, 2000). However, observations and research analyses assessing caries epidemiology post CWF cessation is lacking. In this study, I intended to contribute to this gap in the research by assessing and quantifying oral health changes secondary to CWF discontinuation among Medicaid eligible children and adolescents in Juneau, Alaska. The Juneau City Council voted to cease fluoridation of the public water system in January of 2007. Included below is a brief discussion of CWF and main research concepts that are further described in Chapter 2.

Understanding Dental Disease

Dental care in the United States has been described as the most prevalent unmet health care need (Mattheus, 2010; Newacheck et al., 2000). The CDC (2015a; 2015b) has continued to find CWF at the optimal level of .7mg/L is the lowest effective supplement. Research among populations that are properly fluoridated have demonstrated a 20 to 40% reduction in dental decay even with the additional universal use of fluoride toothpaste, rinses, gels, and foams (American Dental Association [ADA], 2005; Iheozor-Ejiofor et al., 2015; McDonagh et al., 2000). Therefore, water fluoridation remains an important tool in the prevention of dental caries and advanced dental disease.

How Fluoride Works

The fluoridation of public water involves a process of adjusting the naturally occurring fluoride in the water to the lowest therapeutic level that reduces dental decay among the entire population (CDC, 2001; 2015b; Iheozor-Ejiofor et al., 2015; Murthy, 2015). Fluorine is an abundant mineral in the earth's crust and is found in a variety of forms (fluorspar, cryolite, and apatite). These minerals are sparingly soluble so they can be found commonly in water sources as fluoride ions at a range of levels (Freeze & Lehr, 2009). The fluoride ion is considered an important micronutrient for human health and works primarily topically (but also systemically) through frequent exposure of small amounts via beverages (CDC, 2011). This exposure allows tooth enamel to remineralize and become more resistant to demineralization by acids produced when chewing (CDC 2011; Whistler, 2012). In the United States, typically hexafluorosilicic acid and sodium hexafluorosilicate are commonly used for CWF (Freeze & Lehr, 2009).

Vulnerable Populations

According to the NCOHF (2015), approximately 20 million children in the United States lack dental insurance, and an estimated 17 million do without dental care. Researchers have indicated more than 51 million school hours and 164 million work hours are lost each year due to dental disease, leading to increased educational disparities and decreased productivity (NCOHF, 2015). In Alaska, only 45% of the population in 2011 was served with optimally fluoridated water (Whistler, 2012). The CDC's Arctic Investigations Research Group found that among children in nonfluoridated villages, they experienced 2.6 times the number of decayed teeth when compared to their counterparts in fluoridated communities (CDC, 2011).

Rationale for Research

According to several studies, CWF offers significant cost savings for communities both large and small (Campain et al., 2010; Griffin et al., 2001). Additionally, water fluoridation has been significantly related to children's experience with dental caries (CDC, 2014). Caries free children are also more likely to live in fluoridated communities (CDC, 2015b). For example, one study demonstrated a 21%

decrease of caries in primary teeth, and a 25% lower number of caries in permanent teeth for those living in fluoridated communities compared to those living in nonfluoridated communities (Gillcrest, Brumley, & Blackford, 2001). Cost saving estimates specify that for every $1 spent on oral health preventive measures such as CWF, taxpayers can save as much as $50 dollars in treatment costs for the low income citizen who relies on state support (CDC, 1999; 2001; 2015a). Associations among CWF, caries, and adult tooth loss are also significant for improving economic, racial, and ethnic disparities in oral health (Neidell, Herzog, & Glied, 2010). However, research on the cessation of CWF is lacking, and questions remain regarding the fiscal impacts on publicly funded insurance programs covering dental treatment costs and identification of any vulnerable groups disproportionately affected by CWF cessation (McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016).

Problem Statement

Dental caries continue to be one of the most common chronic diseases of childhood (CDC, 2015a; Newacheck et al., 2000; NCOHF, 2015). Impacts on population health after removing exposure to fluoride in public water systems remains understudied (CDC, 1999; Gillcrest et al., 2001; Griffin, Gooch, Lockwood &, Tomar, 2001; Maupome, Clark, Levy, & Berkowitz, 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016). The popular trend in some regions of the United States towards CWF discontinuation from public water systems represents an opportunity to evaluate oral health impacts in a natural setting under modern conditions (Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016).

The most recent community water fluoride cessation study in the United States was published 45 years ago (Lemke et al., 1970). Thus, a gap in the research exists given the few numbers of CWF cessation studies available. Additionally, among fluoride cessation studies from other counties, there has been a mixed representation of results, perhaps due to variations in health care systems, availability of dental technologies, and socioeconomic factors (Hyun-Jae et al., 2014; Kunzel & Fischer, 2000; Maupome et al., 2001; McLaren & Singhal, 2016; Seppä et al., 2000). Lastly, because the epidemiological impact of community water fluoridation discontinuation has only been analyzed in a small number of studies, it has not not established if there are specific age groups or income levels that would be more at risk for caries attack (Atwood & Blinkhorn, 1991; Iheozor-Ejiofor et al, 2015: Maupome, et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Wong, 2013).

The weight of the scientific evidence clearly demonstrates CWF is both a safe and cost effective method for decreasing dental disease and caries among populations, regardless of age or income (Griffin et al.; 2001; Iheozor-Ejiofor et al., 2015; McDonagh et al., 2000; Murthy, 2015). Discontinuation of fluoride from community water systems may move more children into pain, suffering, and costly dental procedures for advanced decay (Atwood & Blinkhorn, 1991; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Wong, 2013). Significantly, the burden of negative oral health outcomes is typically and disproportionately borne by vulnerable groups, those least able to advocate for themselves – children from low income families (DHHS, 2000).

Purpose of the Study

In this study, I used a retrospective cohort design to illuminate any oral health effects following CWF discontinuation. The purpose of the study was describe the effect of CWF discontinuation on the number of caries related procedures and the associated costs of caries treatment pre- and post-cessation as experienced per patient. The retrospective cohort research design provided a method for investigating the main effect of CWF removal from community water systems on pediatric and adolescent oral health as assessed by standard dental indices (ADA, 2015; World Health Organization [WHO], 1997). Medicaid dental claims records from 4 years prior to cessation and 5 years post cessation for Medicaid eligible children ages 0 and18 years were analyzed in order simultaneously assess caries related procedures rates and caries related treatment costs per child and costs associated with treatment (CDC, 1999; Kumar, Adekugbe & Melnik, 2010; Maupome et al., 2001).

The purpose of the retrospective cohort study was to reveal the potential impact of fluoride discontinuation on the oral health of Medicaid eligible children in a community whose local government discontinued fluoridation in the public water system. The results of this study add to the growing body of information available for improving conditions that contribute to poor oral health based on sound scientific evidence. The study goals and objectives included comparing the mean number of caries related procedures and treatment costs per client under pre and post CWF cessation conditions.

Research Questions and Hypotheses

Research Question (RQ)1: To what extent does CWF cessation impact the frequency of dental caries and caries related procedures among Medicaid eligible children and adolescents?

RQ2: To what extent does CWF cessation impact caries severity as measured by related treatment costs among Medicaid eligible children and adolescents?

RQ3: To what extent does CWF cessation impact caries attack rates for specific age cohorts among Medicaid eligible children and adolescents?

Hypotheses 1

RQ1H_0: Mean caries procedure rates for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different.

RQ1H_a: Mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions are higher than optimal CWF conditions.

Independent variables: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Mean number of caries related claims per child (continuous).

Mediating variables: Gender and race.

Hypothesis 2

RQ2H_0: Mean caries treatment costs for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF were not significantly different.

RQ2H_a: Mean caries treatment costs for Medicaid eligible children and adolescents increased under suboptimal CWF conditions compared to optimal CWF conditions.

Independent variable: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Caries related treatment costs (continuous).

Mediating variables: Gender and race.

Hypothesis 3

RQ3H_0: Mean caries experience (attack rates) for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different.

RQ3H_a: Age groups with the highest mean caries experience (attack rate) include younger children (< 7 years) with only suboptimal CWF exposure.

Independent variable: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Dental caries procedures (continuous).

Mediating variables: Gender and race.

Theoretical Framework

The theoretical framework that guided this study was the diffusion of innovations theory by Rogers (2003). It was originally created in 1962 as a way to explain how new innovations (behavior or product) are embraced by the society in stages identified by adopter categories (Rogers, 2003). The first group that typically accepts a new product or behavior is termed the innovators, followed by the early adopters, the early majority, the late majority, and lastly the laggards (Rogers, 2003). Understanding the factors that might influence the populations in these categories appears central to the innovation being successfully integrated into society. In the case of this study, health advocates, researchers, public health practitioners, and policy makers have the opportunity to reevaluate decisions regarding how they will digest and share the information in a way that supports the call for crafting new water fluoridation policy that reintroduces CWF. Further discussion of how the diffusion of innovations theory (Rogers, 2003) relates to this study is offered in Chapter 2.

Nature of the Study

The nature of this study was quantitative. I intended to carry out a retrospective cohort study in a natural setting in which CWF was discontinued. The aim of the study was to assess the impacts of CWF discontinuation on the oral health of Medicaid eligible children and adolescents. The major advantage of having both pre- and post-fluoride cessation data among the same population is the potential to assess the net difference in the intervention condition (suboptimal CWF) and the control condition (optimal CWF; Murray, 1998). In other words, the independent variable was CWF, and the dependent variable was dental caries. In the study, I assessed the frequency and cost differences of dental caries through Medicaid dental claims before and after CWF cessation. In this natural setting, I had the opportunity to observe what occurs in a population as a result of fluoride cessation. Results indicate a clear caries epidemiologic shift, while discerning the impact of dental technologies such as sealants needs further research (Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016).

Definitions

Children's Health Insurance Program (CHIP): The CHIP provides health insurance for children up to age 19 whose families make too much money to qualify for Medicaid (Centers for Medicare and Medicaid [CMS], n.d.). Among most states, including Alaska, CHIP benefits can be secured for children up to 200% the federal poverty level, which is about $44,000 annual income for a family of four (CMS, n.d.).

Dental Procedures and Nomenclature codes: These codes are used by medical billing and allow for uniformity, specificity, and efficiency for facilitating reimbursement for dental claims (ADA, 2016b). They are developed and maintained by the ADA. These codes accurately record and report dental treatment. The codes have a consistent format (Letter D followed by 4 numbers) and are at the appropriate level of specificity to adequately encompass commonly accepted dental procedures (ADA, 2016).

Community water fluoridation (CWF): CWF is the controlled addition of a fluoride compound to a public water system in order to achieve optimal fluoridation for oral health (DHHS, 2000).

Decayed, missing, or filled teeth (DMFT): Dental indices for adults (DMFT) and children (dmft) secured during typical dental exams (ADA, 2016b; WHO, 2013).

Dental caries: Considered both a chronic and infectious disease. Caused by the interaction of a susceptible tooth surface, bacteria from dental plaque, and byproducts secondary to the breakdown of carbohydrates in the mouth (ADA, 2016b).

Dental decay: A general term for carious lesions (cavities) in the structure of teeth. Without treatment, it will lead to pain, inflammation, infection, and tooth loss (ADA, 2016b).

Dental sealant: This is a plastic material applied by a dentist to posterior teeth on the occlusal surfaces forming a protective shield and in turn help prevent cavities (ADA, 2016b).

Fluoride: The element fluorine contains the fluoride ion (ADA, 2005). This fluoride ion is a naturally occurring mineral compound that strengthens tooth enamel while developing (preeruptively), bathes teeth when present in saliva after ingestion, and can be assimilated into dental plaque (ADA, 2005). All three benefits support the remineralization of the tooth surface and prevent decay (ADA, 2005). Thus, fluoride works best when the exposure is both systemic and topical (ADA, 2005, 2015). Fluoride helps teeth become more resistant to decay (systemic benefit) and remineralize early dental decay (topical benefit).

Fluoride concentration: The amount of fluoride present in drinking water. Recommended fluoride concentration in community water systems is 0.7mg/L for prevention of cavities and minimal risk of fluorosis. This reflects a change from previous range recommendation of (0.7-1.2 mg/L; Murthy, 2015).

Fluorosis: Dental fluorosis, streaking or discoloration of tooth enamel, can occur during tooth development (0-5 years) if consumption of fluoride is above optimal limits (ADA, 2005). Classification can be ranked from very mild to severe (ADA, 2005).

Medicaid: Federal insurance program for low income individuals, families, pregnant women, children, and individuals with disabilities (CMS, n.d.). Medicaid programs are administered by states while funded from both federal and state tax revenues (CMS, n.d.).

Assumptions

There are several assumptions related to this study. First, I assumed providers who assess and treat Medicaid patients have not changed their billing habits over time and that Medicaid reimbursement policies have not changed dramatically over the study period. For example, concerns about providers over or under treating Medicaid patients would reflect a small minority, and these habits at the very least would remain constant, thus not altering the conclusions drawn from the analysis of claims records. Secondly, I assumed that any challenges related to home oral hygiene and diet habits for this population would remain the same under fluoridated and nonfluoridated conditions. Lastly, I assumed the number of patients who might delay or abstain from seeking dental care due to costs remained consistent over time.

Scope and Delimitations

In this study, I evaluated the relationship of two dependent variables, dental caries related procedures and dental caries related costs, with the independent variable of optimal CWF. Dental caries was measured by documented dental caries related procedures performed by a dentist, such as restorations and crowns. I analyzed changes in the numbers of dental caries procedures and the associated treatment costs under optimal CWF conditions and suboptimal CWF conditions (CDC, 2016). There are several other factors known to influence dental caries, such as home hygiene, economic status, access to dental care, diet, and nutritional factors, which could lead to confounding and impact the internal validity of the study (Dye, Arevalo & Vargas, 2010). CWF is one of many factors that can influence the rate and severity of dental caries (Iheozor-Ejiofor, et al., 2015). The study design supports control for these confounding factors by working with the Medicaid claims database only (Kumar et al., 2010). Families eligible for Medicaid live near or below the poverty level (CMS, n.d.). This group could be more vulnerable to the impact of CWF cessation and, therefore, the economic group most likely see changes in surface enamel first and thus more caries related procedures. Secondly, by working with only Medicaid claims data, it is possible to increase external validity of the results by limiting the influence of higher income groups (Kumar et al., 2010). Families with high incomes may have easier access to dental care and routine refill of supplemental fluoride tablets and could potentially dilute small changes in caries rates under both fluoridation and nonfluoridation conditions. Results could be generalizable to other Medicaid groups in communities considering cessation. Lastly, I analyzed pre- and post-cessation dental claims data from two comparison years unaffected by Medicaid expansion secondary to the Affordable Care Act. I also assumed economic conditions for families living in poverty, and thus were eligible for Medicaid, remained within normal limits.

Inclusion and Exclusion Criteria

Two of the three largest communities in Alaska have halted CWF of the public water systems. These include Juneau in January 2007 and Fairbanks in 2011 (Chomitz, 2011). Therefore, I proposed to secure the mean number of restorative procedures (caries related services) per client year along with the associated costs per client year (Kumar et al., 2010). I sought to include claims data from an optimally fluoridated year and a suboptimally fluoridated year approximately 5 years after cessation. Patients eligible for Medicaid under the age of 18 years and serviced by city water were included in the study. Those who resided outside city water service areas as indicated by zip code were excluded.

Limitations

In the study, I relied on the quality of data available from the Medicaid Claims database. Once extracted, the data were divided into age cohorts for analysis. All public schools in the study area were serviced by city water. Additionally, I did not follow the same client over time, and personal information was de-identified (other than birthdate). Therefore, it was unknown how long the client had lived in the region. Incoming new residents from fluoridated communities could impact the data; however, in and out migration was estimated to be small. Juneau can only be accessed by boat or plane. I also assumed new residents would be somewhat constant and represent a small number of individuals.

As with most research, this study had potential confounding factors that could impact the internal and external validity of the results. However, by focusing on this particular economic demographic, I limited the influence of these confounding factors on dental caries. The selection of appropriate statistical methods also helped address confounding factors, and more details on these methods are provided in Chapter 3.

Additionally, the study design allowed me to assess claims records during periods of adequate fluoridation exposure and under nonfluoridation conditions. Therefore, I made some generalizable statements, particularly for this age and economic group. The study provides much needed information for communities considering a nonfluoridation policy and the potential costs associated for state and federal funded dental programs (McLaren & Singhal, 2016; Murthy, 2015). Lastly, this study design presented a novel methodology for data analysis within a natural community context. Cessation of CWF from the public water system was the primary factor that changed, thus strengthening the internal validity of the study. Under these unique conditions it was possible to attribute the statistically significant increases in mean dental caries procedure rates and treatment costs to CWF cessation. The results yield new insights for dental health sciences and support the generation of innovative questions for future research.

Significance of the Study

The social change implications of this research were twofold. The first related to the process of informed public policy based on an scientific evidence from CWF cessation caries epidemiology. The second involved informed policy making based on cost analyses for publicly funded dental insurance programs (Medicaid).

First, public health is the science of population health and primary prevention. CWF is an excellent example of primary prevention in action. However, communities large and small are vulnerable to a growing culture of opposition to CWF (Freeze & Lehr, 2009). The aim of this study was to describe the impact of fluoride discontinuation from the public water system on the prevalence and incidence of dental caries by age group and the costs associated with treatment. Earlier fluoride research led me to expect changes in population dental health after CWF discontinuation; however, this assumption has not be adequately studied or evaluated. Of particular scientific interest is the opportunity to observe changes with the same sample population over an extended period of time (Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016). Therefore, the results may help narrow the research gap on CWF cessation by contributing valuable information not only to research community, but also to the ongoing community-based policy discussions related to CWF programs at local levels.

Second, dental disease and untreated dental caries can significantly impact young children not only in the expected form of pain and discomfort but also in association with reduced quality of life indicators such as lack of sleep, reduced growth, and increased absences from school (CDC, 2015; Low, Tan & Schwartz, 1999; Reisine, 1985). For school aged children, the complications of dental decay leads to lost school time (117,000 school hours lost per 100,000 children), increased costs for advanced procedures (surgery), and higher caries severity due to delays in seeking care (Gift, Reisine & Larach, 1992). In this study, I intended to assess the impacts of ending CWF programs on population dental health among early childhood, school age, and adolescent age groups as measured by rates of dental caries related procedures and the associated costs as documented in Medicaid Dental Claims. Results indicated statistically significant increases in mean caries related procedures and treatment costs post CWF cessation. Therefore, communities and policy makers now have the opportunity to ask themselves if they are comfortable with the cessation associated caries increase and additional tax payer burden or if they would like to reevaluate the local CWF policy.

Summary

The purpose of this retrospective cohort study was to reveal the impact of CWF discontinuation on the oral health of Medicaid eligible children and adolescents in a community whose city council voted to prohibit CWF. The results of this study add to the growing body of information available for improving those conditions that contribute to poor oral health based on sound scientific knowledge. The study goals and objectives included determining the change in mean dental caries procedures and the change in mean dental caries treatment costs per Medicaid eligible client before and after the discontinuation CWF. Further review of health disparities associated with oral health, fluoridation science, and discontinuation studies are provided in Chapter 2.

Chapter 2: Literature Review

Introduction

Americans have enjoyed significant improvements in oral health over the last century (Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Murthy, 2015). Since recommended by the Public Health Service in 1962, CWF has been an important population health intervention in the United States for improving rates of decay and reducing cares related treatment costs (Murthy, 2015). Researchers have indicated the reduction in tooth decay for children and adults that can be attributed to low level fluoride exposure delivered through community water fluoridation was 25% annually, and rates of return on CWF investment (cost savings) per person per year range from $28 to $67 (Griffin et al., 2001; Griffin et al., 2007). The Cochrane Review also reported from meta-analysis among studies that compared a fluoridated versus nonfluoridated control group a 35% reduction in caries for children (dfmt) and a 25% reduction in caries for adults (DMFT) among those with exposure to CWF (Iheozor-Ejiofor et al., 2015).

Even with these measurable oral health improvements, fiscal cost savings and endorsement of major institutions dedicated to the promotion and protection of population health the decision to fluoridate a water system lies with state and local governments (DHHS, 2015). As of 2014, the CDC estimated 74.7% of the U.S. population (286,756,186 persons) receive fluoridated water through a community water system (CDC, 2016). Alaska ranks 43rd out of 50 states in terms of percentage of population served by optimally fluoridated water, reaching only 339,415 persons or 49.5% of the population (CDC, 2016).

Although the United States is considered to be a highly fluoridated country, marked disparities in oral health are continually observed (Dye et al., 2010; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Wong, 2013). Given the persistence of oral health disparities, the Healthy People 2020 initiative has the goal of increasing the percent of the population receiving fluoridated water to 79.6%. According to findings from the National Health and Nutrition Examination Survey (NHANES), significant oral health disparities persist (as cited in Dye et al., 2010). For example, one in four low income children live with untreated tooth decay; dental sealants are more prevalent among non-Hispanic White adolescents (56%) compared to 32% for non-Hispanic Black adolescents, and while one third of low income adults aged 65 to 74 lost all their permanent teeth, this is experienced by only 13% of older adults with incomes above the poverty threshold (Dye et al., 2010). More deleterious was the recent phenomenon of discontinuing CWF, potentially moving more children, adolescents, and adults into pain and suffering secondary to dental decay (Dye et al., 2010). Therefore, it was timely that the purpose of this research was to assess the oral health impacts among low income children and adolescents before and after CWF cessation from the public water system.

The most recent CWF cessation studies that observed dental trends among the same population both before and after cessation in the United States were published over 45 years ago (Lemke et al., 1970, Way 1964). A single meta-analysis was recently published, and documents result from only 15 CWF cessation studies, with a variety of analytic approaches occurring in the last 30 years (McLaren & Singhal, 2016). Therefore, a gap in the research exists given the few number of fluoride cessation studies available. This gap in the research also places policy makers and community members at a disadvantage since there are few studies they can use to guide their decisions making processes regarding CWF cessation (McLaren & Singhal, 2016). Furthermore, among the handful of fluoride cessation studies from other countries, I observed a mixed representation of results, perhaps due to variations in health care systems, availability of dental technologies, and socioeconomic factors (Hyun-Jae et al., 2014; Kunzel & Fischer, 2000; Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Seppä et al., 2000). Lastly, because the epidemiological impact of CWF discontinuation has only been analyzed in a small number of studies, it has not been clearly established if there exist specific health equity impacts for defined age groups or income levels that would be more at risk for caries attack (Atwood & Blinkhorn, 1991; Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; Wong, 2013). The theoretical framework underlying this study was the diffusion of innovations theory (Rogers, 1995, 2013).

In the following chapter, I present a deeper discussion of the available literature on the diffusion of innovations theory along with analysis related to the safety, effectiveness, and cost savings associated with CWF. Additional discussion related to Medicaid claims data as an oral health indicator or metric and a detailed overview of the existing CWF discontinuation research available from the US and abroad are presented.

Literature Search Strategy

I conducted a search of the relevant literature using Academic Search Complete, MEDLINE, CINAHL, ProQuest Central, Sage Premier, Thoreau Multi Database Search, Science Direct, and Google Scholar search engines. The following key terms were used: *fluoride or fluoridation, community water fluoridation (CWF), CWF discontinuation or cessation, caries prevention, health equity, pediatric dental caries prevention, Medicaid dental claims, oral health, fluoride safety, fluoride effectiveness, CWF return on investment,* and *CWF cost effectiveness*. Limits were set for peer reviewed scientific journal articles from the last 15 years regarding dental caries and community water fluoridation. However, due to the small number of fluoride discontinuation studies available, I expanded the investigation to include historical literature from as far back as the 1960s to find domestic CWF cessation research. Internationally, two cessation studies in which the same area population was assessed over an extended time period have occurred in the last 5 years, one from Korea and another out of Canada. Further details on these studies are presented in this chapter.

Given the extensive amount of peer reviewed literature on CWF safety and effectiveness, specifically using comparisons of matched communities during same time period (one adequately fluoridated and the other nonfluoridated), I turned to reputable agencies and expert panels for conclusions and recommendations after reviews of research that met certain quality requirements. Along with the WHO, the CDC, the DHHS, and the ADA, I found the research reviews and conclusions from The Guide for Community Preventive Services, the Office of the Surgeon General, and Healthy People

2020 documentation from the Office of Disease Prevention and Health Promotion to be particularly useful for scientifically sound up-to-date data analysis, benchmarks, recommendations, and identification of any research gaps. I also reviewed the fundamental research on which their conclusions were based.

Additionally, the conclusions from the National Research Council's Board on Environmental Studies and Toxicology report on the concentrations of fluoride in drinking water were also reviewed. The National Research Council (2006) noted a strong alignment among the conclusions from multiple independent, expert panel and government agencies which leave little doubt regarding the safety and effectiveness of community water fluoridation as a standard public health intervention for the protection and promotion of population oral health. For historical purposes, McDonagh et al.'s (2000) landmark meta-analysis of public water fluoridation, also known as the York Review, was used as a benchmark for research conducted from 1966 to 1999 with a focus on caries prevention and safety. The Cochrane review on water fluoridation for the prevention of decay was the second largest meta-analysis CWF review and used research meeting specific criteria from 1945 to 2015 (Iheozor-Ejiofor et al, 2015). Its focus was to evaluate the effects of water fluoridation on caries and fluorosis.

The following sections related to key study variables from the literature include discussion on the prevalence of dental caries as a significant chronic health issue for children followed by a brief review of the history and research evidence regarding the effectiveness of fluoride. I also present evidence from the literature regarding community water fluoridation cost savings or return on investment for communities using

CWF and a brief review of CWF safety recommendations. Additional discussion of Diffusion of Innovation Theory (DIT) is also included along with justification for its application to community water fluoridation in the context of community health education and positive social change.

Theoretical Foundation

DIT is regarded as one of the oldest theories in social sciences and one of the most well studied (Rodgers, 2003, 2004). It was put forward in 1962 by Rogers and based on previous agriculture research by Ryan and Gross (1943). Numerous academic disciplines have used DIT to understand how ideas, practices, and processes are disseminated among a group, agency, organization, community, or population (Rodgers, 2003). Specialties ranging from marketing, education, social science, public health, public administration, communications, agriculture, organizational change, and health care have used DIT to explain how innovations spread through a group, how they are communicated, and what particular attributes might lead one group to adopt an innovation while another does not (Rodgers, 1995,2003, 2004).

In public health, DIT has been used to examine a wide variety of research questions, often specifically studying the success of a proposed health promotion or health education program or campaign. Topics range from subjects such as HIV/AIDS prevention programs, water sanitation programs, diabetes prevention, practitioner practices, patient education, and cancer screening (Rodgers, 2003, 2004). Certain variables at each stage of the innovation process support transferability along with defined categories or types of individuals that make up a group or community and also have attributes that influence how an innovation moves through a social system (Rodgers, 2004).

Basic Diffusion of Innovation Theory Constructs

DIT, as presented by Rodgers (1995, 2003), posits that in any population, there are factors that influence an individual's response to innovation, components related to the communication of the innovation, and additional issues that impact the spread or reach of an innovation through a group or community. Once a certain number or threshold of individuals, agencies, or groups adopt an innovation, it can become self-sustaining and a part of the social, political, and cultural structures (Rogers, 1995, 2003). DIT was originally designed to study how new products or ideas were spread or communicated among individuals (Rogers, 2004). However, over the years, DIT has been applied to social groups, agencies, and organizations (Rogers, 2003).

Adopter Categories

DIT describes the attributes of individuals within a population that can either move an innovation forward or resist (Rogers, 2003). There are five classic categories of adopters, and they represent a percentage of the total population (Rogers, 1995, 2003). These include (a) innovators (2.5%) -- individuals with a keen interest in trying new innovations and often little motivation is needed, (b) early adopters (13.5%) – often opinion leaders who enjoy leadership, most likely already aware of the innovation, and feel comfortable trying new things, (c) early majority (34%) – not necessarily leaders but likely to adopt a new innovation before the average person, (d) late majority (34%) – this group is unlikely to adopt an innovation unless convincing evidence of success could push this group of adopters to move forward on an innovation, (e) laggards (16%) – this group is highly skeptical of change and often need emotional appeals, fear, and evidence along with pressure from the rest of the population to go along with an innovation (Rogers, 1995, 2003).

Historical DIT in CWF Studies

For direct evidence of DIT used to study the dissemination of community water fluoridation, I secured an article by Crain (1966), who studied the diffusion of city water fluoridation among different regions in the United States. Crain noted that 34 states adopted the CWF innovation between 1947 and 1951 and that the diffusion of this innovation went through four stages: an early adopter (experimental) stage in 1951, a fashionable state in 1952, steady spread between 1953 and 1954, followed lastly by decline after 1955 with the antifluoridation movement. Crain speculated that the quality of media messaging and informal peer-to-peer conversations probably had a significant influence on adoption in large cities. Additionally, had the innovation not become so controversial, it likely would have faded as a conversation topic among the popular culture and simply become common practice (Crain, 1966).

Diffusion of Innovation Theory in Modern Public Health Dentistry

Evidence of direct reference to DIT in more modern dental research can also be found in studies using DIT to assess the uptake and practice of certain dental interventions by practitioners (Haugejorden, 1988; Parashos & Messer, 2006). Additionally, DIT has been used for framing a discussion of a particular success or failure of a dental health promotion campaigns, such as school based fluoride rinse programs (Scheirer, 1990).

DIT Application to Research

DIT was selected as the theoretical foundation for this research study in an effort to gauge where decision makers fall in terms of DIT adopter categories. Decision makers of interest include the community task force commissioned to author reports regarding CWF and local state governments, city councils, and/or general citizen groups that might fit into the diffusion of innovation process. DIT also offered helpful conceptual models for the dissemination of results communication strategy. The adopter categorization assisted in framing the current research problem and the potential for social change among all key actors, from parents and dental professionals to policy makers.

In studying a community that was once adequately fluoridated and now is not, the results could assist future public health workers who hope to promote oral health among vulnerable populations. The results could supplement additional information that could support reinforcing earlier policy approaches or present an opportunity for the re-invention of the original innovation (Rogers, 1995, 2003). For example, in Juneau I might consider DIT adoptor category definitions in an attempt to gauge where the City Council's Fluoride Task Force Committee might currently fit into the diffusion of innovation model. Then I could more appropriately apply strategies or leverage methods for moving the group to the next stage in the innovation process. For example, according to the adopter categories, I might assume the city council is made up of early, late majority, and laggard adopter categories -- given the vote to remove CWF in 2007.

Therefore, meeting the data gaps identified in the fluoride task force report with up-to-date local data on the impacts of CWF cessation may motivate council members to reconsider current CWF policy, or at the least plan for increased funding needs for the Medicaid program to treat increased dental caries among the service population.

Key Research Variables

Dental Caries Prevalence in the United States

From 2011-2012, it was estimated that 36.7% of children aged 2 to 8 years in the United States experienced dental caries in primary teeth (Dye et al., 2015). Twenty three percent of U.S. children aged 2 to 5 years and 55.7% of children aged 6 to 8 years experienced dental caries in primary teeth (Dye et al., 2015). The prevalence of dental caries in permanent teeth for children aged 6 to 11 years in the United States from 2011-2012 was 21.3%. Among 6 to 8-year-old children, 13.8% had dental caries in permanent teeth, and for the 9 to 11 year age group, 28.8% experienced dental caries in permanent teeth (Dye et al., 2015). For adolescents, the prevalence of dental caries experience in permanent teeth for those aged 12 to 19 years was 58.2% (Dye et al., 2015). With over half of all children and adolescents in the United States experiencing dental caries, it is clear why prevention has become a hallmark for improving oral health (DHHS, 2000). Individual, family, and community factors such as diet, professional dental care, twice daily brushing, CWF, and avoiding tobacco and alcohol have been linked to oral health (Guide to Community Preventive Services: 2017; DHHS, 2000; Murthy, 2015).

Although tooth decay is largely preventable, it remains a chronic disease for U.S. children and disparities persist, particularly for young children (Dye et al., 2010). For example, from 2011 to 2012, the prevalence of untreated decay in primary teeth for children between the ages of 2 and 8 years was twice as high for Hispanic (19.4%) and non-Hispanic Black (20.5%) children than for non-Hispanic White children (10.1%; Dye et al., 2015). Caries in young children concerns health professionals as it remains an accurate predictor of future tooth decay (Dye et al., 2010).

Race Associated Caries Prevalence Trends

Combined general statistics from the 2011-2012 National Health and Nutrition Examination Survey (NHANES) survey noted 23% of U.S. children between the ages of 2-5 years had caries in primary teeth, while 55.7% experienced caries between the ages of 6-8 years. Descriptive statistics for dental caries experience for children aged 2-8 years was 30.5% among non-Hispanic white, 43.6% among non-Hispanic black, 45% among Hispanic and 35.9% among non-Hispanic Asian (Dye et al., 2015). For untreated dental caries among the 2-5 year old population 10% had untreated caries and for the 6-8 years population 20% (Dye et al., 2015). For ages 2-8 years 10.0% of non-Hispanic whites, 20.5 % of non-Hispanic black, 19.4% of Hispanic and 15.6% for non-Hispanic Asian children had untreated dental caries (Dye et al., 2015). For the adolescent group aged 12-19 approximately 3 out of 5 had dental caries and 15% had untreated decay (Dye et al., 2015). Dental sealants were common among non-Hispanic white children at 44%, while among non-Hispanic Black and Asian children only 31% had sealants (Dye et al., 2015). Sealants are a thin plastic coating applied by a dental professional to prevent future decay and can be highly effective (ADA, 2016b).

Increases Noted in Prevalence Trends Associated With Income

While disparities based on income and race may unfortunately be well established an analysis by Dye, Arevalo &Vargas (2010) utilizing NHANES (2012) data for the age group 2-8 years between 1988-1994 and 1999-2004 noted an increase in caries was observed among primary teeth for poor (45-53%) and non-poor boys (23-31%). Among non-poor boys aged 2-5 years an increase was observed in caries experience from 13-21%. During this same time period for older age groups we observe no change or a decline in caries for some, yet ever increasing caries experience for ethnic minorities and low income groups. For example, among poor non-Hispanic whites aged 6-8 years caries prevalence in permanent dentition increased from 8-22%. Researchers conclude that disparities in dental caries remain while prevalence rates also appear to be increasing among previously low risk groups (Dye, Arevalo &Vargas, 2010).

Untreated Dental Caries

Untreated dental caries can affect body weight and growth of young children (Mattheus, 2010; Sheiham, 2006). Research indicates young children with untreated dental caries experience pain secondary to chronic inflammation and abscesses which can suppress the metabolic pathway and lower hemoglobin (Sheiham, 2006). Mattheus (2010) developed a concept map of early childhood oral health using the Social Ecological Model, based on earlier social ecology research (Stokols, 2000). Here we observe various risk factors at the community, family and child levels which placed children at risk of caries and poor oral health outcomes. At the community level these risk factors included poverty, non-fluoridated water, lack of dental and health care services, and cultural diversity. At the family level poor parental health, limited social support and low socio economic status. At the child or individual level reduced salivary flow, low birth weight and poor nutrition were also risk factors. Although the burden of untreated caries has declined in the last forty years, current estimates are that 19% of U.S. children ages 2-19 years have untreated caries with minority ethnicity and poverty as significant risk factors (CDC, 2014).

U.S. and Global Burden of Dental Caries

Dental decay represents an overwhelming public health problem globally, with enormous economic costs in terms of treatment and lost hours to work and school (Peterson et al. 2005). As with many public health issues, developing countries suffer the greatest proportion of dental caries, while the impact among industrialized countries is still significant (Peterson et al. 2005). According to the World Health Organization (WHO), poor oral health and dental caries represent a significant global oral health burden affecting 60-90% of school aged and adults living in high income countries (Peterson et al. 2005). In 2004, the WHO created an updated data set of the distribution of dental caries worldwide as measured DMFT index for 12 year olds. One a scale of: very low (less than 1.2 DMFT), low (1.2-2.6 DMFT), moderate (2.7-4.4 DMFT) and high (4.5 DMFT and above) the U.S is ranked as low, along with Canada, Mexico and most of South Asia and Africa. Very low DMFT ranking countries included Australia, South Africa, China, Greenland and France, among others. Moderate countries include Russia and most of South America. For adults in the U.S. aged 35-44 DMFT scores ranked in the moderate range (9-13.9 DMFT) on a four point scale.

Community Water Fluoridation

Many public health scientists conclude that fluoride in community drinking water was a major factor responsible for the decline in dental caries observed in the U.S. during the second half of the twentieth century (CDC, 1999). CWF remains unique among public health interventions as one of the most equitable - meaning it is available to the entire population, and cost effective - meaning the cost of delivering the service are smaller than the costs associated with not delivering the service, even with commercially available fluorides in toothpastes, gels, and rinses (Griffin, Jones & Tomar, 2001). Additionally, CWF has recently been studied in terms of cost effectiveness as measured in terms of the CWF systems capitol and maintenance as a cost per person compared to other methods of community based caries prevention (Griffin et al., 2001). CWF remains the cheapest community based form of prevention in terms of costs per tooth saved (Burt, 1989; Griffin et al., 2001). Cost savings can be calculated in term of restorative costs averted secondary to CWF (Griffin et al 2001). It should be noted cost savings depends largely on the size of the community however, with rising costs for restorative dental procedures, CWF remains continues to demonstrate financial savings for families and communities (Brunson et al., 2005; Griffin et al., 2001; McDonagh, 2000).

Brief History of Fluoride (1900-1960)

In 1901 Dr. Fredrick McKay documented an unusual ‘brown stain’ on the teeth of his patients in Colorado Springs, Colorado (McKay & Black, 1916; Freeze & Lehr, 2009). McKay and Black (1928) observed that teeth with ‘brown stain’ or mottled enamel were unusually less affected by dental caries. This led to the hypothesis that something in the water the patients consumed led to the brown stain. Decades later a chemist identified the ion element of fluorine (Fluoride) was present in the water and soils where populations experienced 'mottled enamel' and in the 1930's a multi city prevalence study was conducted comparing fluoride level in the piped water and DMFT assessments in children (Dean, 1945; Freeze & Lehr, 2009). At this point, researchers observed for the first time a strong relationships between fluoride level in public water, decreased dental caries and increased risk for enamel fluorosis (Dean, 1945; Dean, Arnold & Elove, 1942; Dean et al., 1950). As the decades passed more and more research was done assessing fluorosis risk and caries prevention with the focus on finding the lowest therapeutic dose with fewest adverse effects. It is important to remember that at very high levels fluoride can cause teeth and bones to be brittle leading to skeletal fluorosis. Areas of the world with high endemic fluoride in the ground water, (up to 18mg/L) such as India and Pakistan experience the negative effects of this naturally occurring mineral and seek de-fluoridation interventions for public water systems (The British Fluoridation Society, 2004; Freeze & Lehr, 2009).

Modern Times (1961-2016)

The U.S. Public Health Service Federal Panel on Community Water Fluoridation has and continues to recommend community water fluoridation as a safe and effective method for reducing dental caries across all age groups and income levels (U.S.DHSS, 2015). This public health strategy has been in place since 1945 and as of 2014 74.7% (214,213,860 people) had access to fluoridated water (CDC, 2016). Reviews of scientific information by multiple expert panels repeatedly concluded community water fluoridation was a safe and effective intervention for reducing caries (CDC, 2016; U.S. DHHS 2014; Murthy, 2015). Current recommendations are for the fluoride concentrations of community water systems at 0.7milligrams/liter (mg/L) (CDC, 2016; Murthy, 2015). The primary reason for the new recommendation from a range 0.7-1.2mg/l is concern regarding mild dental fluorosis and variations in water consumption (U.S.DHHS, 2015). While dental fluorosis is a primarily cosmetic concern resulting in white streaks or mottled enamel, the Public Health Service re-evaluated data on fluorosis and concluded 0.7mg/l to be the lowest effective concentration with near zero risk of fluorosis while still preventing dental caries (DHHS, 2015). In a landmark meta-analysis McDonagh and colleagues (et al. 2000) concluded community water fluoridation was associated with an increase in the number of children who were caries free (range of means: -5% to 64%, median 14.6%) and a reduction in DMFT scores (range of means: 0.5 to 4.4, median 2.25 teeth). In other words, on average children living in optimally fluoridated communities experienced an average of 2.25 fewer decayed teeth than children living in non-fluoridated communities (McDonagh, et al., 2000).

A recent study from Australia compared caries prevalence among 128,990 children ages 5-15 years who were screened by the Dental Service in 2002. They documented socioeconomic status, residence remoteness and fluoridation access (Armfield, 2010). This was a national study community based study, making it unique in the country (Armfield, 2010). Results support continued CWF and demonstrated children living in suboptimal fluoridated areas had 28.7% more caries in deciduous teeth, and 31.6% more caries in permanent teeth (Armfield, 2010).

Antifluoridation Propaganda

Since the 1950s, CWF has come under attack by small groups of individuals who employ tactics designed to encourage distrust towards scientists and governments who promote CWF for improving oral health (Freeze & Lehr, 2009). In 2011, an expert federal panel with the U.S. Public Health Service engaged a public comment period and received 19,300 responses were received of which 96% were nearly identical to a letter drafted by an organization opposing fluoridation (DHHS, 2015). Each complaint was investigated and included allegations ranging from CWF causing endocrine disruption, skeletal fluorosis, cancer, and lower IQ (DHHS, 2015). None of the complaint investigations resulted in any sound scientific peer reviewed literature supporting or confirming a link. In fact, expert groups from the American Dental Association, CDC and U.S Public Health Service all concluded after reviews of research that fluoridation of community water systems can reduce tooth decay in children and adults by an average of 25% (DHHS, 2015). In other words, a child or an adult living in a fluoridated community will on average have 25% less DMFT than their counterpart in a non-fluoridated community.

Cost Savings Associated With Community Water Fluoridation

Cost savings associated with community water fluoridation has been studied two major scientific publications (Griffin, Jones, Tomar, 2001; Griffin, Gooch, Lockwood & Tomar, 2001). Griffin, Jones and Tomar (2001) found cost savings depend on the size of the local population. For large populations more than 20,000 cost savings per person was .50 cents while for communities less than 5000 the savings was closer to $3.70. Given current price indices this range would be closer to (28.70-35.90) under 2010 economic conditions which is about ¼ of the average dental filling cost (US DHHS, 2015). Griffin, Gooch Lockwood & Tomars' (2001) meta-analysis also found when they compared fluoridated versus non fluoridated communities there existed a diffused benefit to children residing near a fluoridated community, termed a 'halo' effect – resulting in one less cavity per year. Both studies provide evidence indicating support a societal as well as cost effective benefit with CWF.

More recently Brunson, O'Connell, Anselmo, & Sullivan, (2005) studied 172 community water systems operating in Colorado and learned that the annual state wide cost savings associated with CWF was on average 148.9 million dollars, or a return on investment of $60.78 per person (Brunson et al., 2005). They concluded that if the remaining 52 non fluoridated systems became fluoridated they would save an additional 46.6 million dollars (Brunson et al., 2005).

Medicaid Claims as a Population Health Metric

Several comparison studies in the U.S. stand out for utilizing Medicaid claims for dental procedures as a metric for understanding the effectiveness and costs associated with fluoridation. An early study from Louisiana in 1995-1996 evaluated caries frequency and severity among Medicaid eligible children in both fluoridated and non-fluoridated parishes (neighborhoods). The results demonstrated the mean difference in treatment costs for pre-school children in non-fluoridated parishes to be $36.28 higher per child than the costs for children in fluoridated parishes. A second study from the Texas legislature drafted a report in May of 2000 in which they noted $19 dollars per child increase in dental care for Medicaid Eligible children residing in non-fluoridated communities. This money could be recovered if those communities fluoridated at an optimal level. More recently, Kumar, Adekugbe & Melnik (2010) found the mean number of caries related procedures for Medicaid eligible children was 33.4% higher in non-fluoridated communities when compared to fluoridated counterparts in New York. The researchers remark these types of studies demonstrate continued cost savings associated with community water fluoridation (even with multiple over the counter and professionally applied fluoride products widely available) and could offset concerns city councils might have regarding the costs of continued CWF operations, and provide a direct policy link to the benefits of continued CWF (Kumar, Adekugbe, Melnik, 2010). Kumar, Adekugbe & Melnik (2010) also note fluoridation correlated with lower restorative costs per child and when extrapolated over several decades' yields substantial financial savings for the larger society – particularly for publically funded dental insurance programs (i.e. Medicaid) paid for by citizens in the form of tax dollars.

CWF Discontinuation or Cessation Studies

CWF cessation studies are fewer in number, particularly in the U.S. The most recent domestic study that assessed a population before and after CWF cessation include a study whose sample population was Galesburg, Illinois and published in 1962 by Dr. Robert Way. A 1970 study by Lemke, Doherty and Arra observed the effects of discontinuation in Antigo, Wisconsin. Both studies noted significant caries increases during non-fluoridation years and concluded continuous fluoridation as an important method to control caries (Way, 1962; Lemke, Doherty & Arra, 1970). The current movement in the 21st century by some communities to halt CWF represents an opportunity for researchers to fill this gap in the U.S. based literature.

Recent peer reviewed literature out of Korea and Canada have analyzed the impact of CWF cessation. Huan-Jae et al. (2014) studied dental caries prevalence after seven years of fluoride cessation and compared the fluoride-ceased group to a group that had never-been fluoridated. Children in three age groups were examined from ceased and non-fluoridated schools age 6 (n = 505), age 8 (n = 513) and age 11 (n = 467) and DMFT ratios calculated using regression statistics. The children that had never been exposed to fluoride had higher DMFT scores, which means more dental decay, than children in the fluoride ceased group who had some exposure as young children, thus demonstrating the importance of early exposure to fluoride and potential lasting benefit (Huan-Jae et al., 2014). Therefore, in other cessation studies we might expect to see the largest effect among age groups without any early life exposure to CWF.

A recently published Canadian study attempted to examine associations between dental caries measures and socio-economic indicators, among a population of second graders in 2009/10 pre-CWF cessation and 2013/14 post CWF cessation (McLaren, McNeil, et al., 2016). Cessation occurred in 2011 and the data points were gathered by dental exam only after a short period of two to three years (McLaren, McNeil, et al. 2016). Given the data from Korea, the children were exposed in early life to CWF might retain a protective effect from exposure with only two years after cessation that another dental assessment made. Alternatively, the results indicated there was in increase in dental caries among primary teeth following cessation, and more students had untreated decay (in both primary and permanent teeth), along with evidence indicating increasing inequities, even in the short time period (McLaren, McNeil, et al., 2016). Multiple explanations were explored by the research group regarding these results and the methodological challenges for how the dental insurance variable was measured and the material deprivation measures calculated (McLaren, McNeil, et al., 2016). Dental sealants and fluoride varnish programs were also in place, but perhaps not as widely available or effective as they once thought for the CWF ceased group (McLaren, McNeil et al., 2016). The research group also pointed out a comparison population in which cessation did not occur would be a useful control group for inclusion in future studies (McLaren, McNeil et al., 2016).

Although published in 2001, a study from British Columbia Canada presented intricate results and additional questions to consider regarding the impact of affluent family income, and thus perhaps better diet and regular access to preventative dental procedures, on caries among children in areas where CWF ceased (Maupome et al., 2001). Comparisons of caries prevalence and incidence where made between continuously fluoridated and fluoridation ended communities in British Columbia. Overall, the prevalence of caries decreased in fluoride ended decreased, while remaining the same in fluoridated communities (Maupome et al. 2001). Researchers explained these unexpected results by noting the number of filled surfaces had not changed while the number of sealed surfaces (sealants) increased in both groups – thus demonstrating the impact of new dental technologies on caries epidemiology among those with fiscal resources and easy access to high quality dental care (Maupome et al. 2001).

Additionally, both communities in the study were considered economically comparable with med-high income, accessible dental services and an overall low caries experience at baseline (Maupome et al. 2001). It should also be noted that the comparison groups included students from second and third grades along with eight and ninth grades (Maupome et al. 2001). Thus, the fluoride ended groups had the potential benefit of early exposure to fluoride, which may have provided a protective effect, and might explain the continued decrease in caries even after CWF discontinuation (Maupome et al., 2001).

Methodological Critique and Review

As indicated earlier, the research available regarding CWF cessation was limited primarily due to the small number of studies. Methodological factors include the value of utilizing a comparison group in which CWF did not cease, versus a time series study focused on assessing changes in one CWF ceased population. Additional methodological factors include finding ways to control for confounders, using dental exams versus claims data and the issue of short term versus long term changes. Based on CWF cessation research from Vancouver, it appeared higher income and easy access to dental services might be a confounding factor or a possible covariate for changes in CWF exposure (Maupome et al., 2001). Exactly, how that might be the case is unknown. Perhaps those with higher incomes have the luxury of time away from work to attend dental appointments, experience higher sealant use by providers, or can purchase additional fluoride supplementation.

Rugg-Gunn & Loc (2012) remark that among studies published in the last twenty five years exploring CWF using cross sectional comparison methodology, the multivariate statistical analysis adjusting for confounders yielded minimal change on the net effect of caries reduction with CWF. Typical covariates for dental caries, and dozens of other negative health outcomes, include diet, parental education and parental income (Rugg-Gunn &Loc, 2012). Among probable confounders it also appears even with widely available fluoride toothpaste, moderate access to school based fluoride varnish programs and in office fluoride applications, CWF still makes an improvement in oral health for children via caries reduction (McClaren & McNeil, et al., 2016; Murthy, 2015). It is worth remembering CWF is a unique population health intervention requiring no behavior change for individuals or additional work among health professionals in order for the entire population to receive a benefit. Most CWF studies since 1990 have used a concurrent comparison cross sectional approach while this proposed study aims to use a retrospective cohort design, with the possibility of a time series approach (Rugg-Gunn & Loc, 2012).

To review, with this study it is proposed three unique elements. One, to utilize claims data as a strong population health metric. Second, the consideration of time as an important factor for observing oral health changes after CWF cessation. Therefore, we plan to secure annual claims data for a CWF optimal year and a CWF suboptimal year approximately five years apart. Should database purchase price not be cost prohibitive we can request more annual data sets, ideally over a ten year time frame, in order to establish a stronger time series analysis in which future projections about average caries attack per child and average treatment costs. Lastly, we plan to focus on a particular risk group, vulnerable children and adolescents whose family incomes qualify them for state subsidized health and dental care, which we believe would be the group most likely to be experience effects the earliest post CWF cessation (McClaren & McNeil, et al., 2016; Murthy, 2015).

Summary

A review of the literature demonstrates a complicated picture among the few number of studies evaluating the influence of CWF cessation on caries experience in the U.S. and its potential impacts on publicly funded dental insurance programs. More research is needed to fill this gaps and add to the ever growing volume of evidence related to CWF. The multifactorial influence of individual hygiene, family income, community water fluoridation, access to high quality dental care, and nutritious foods all play a role in the prevention and control of dental caries.

Among seminal reviews of the available science conducted by the Cochrane Oral Health Group from the UK (Iheozor-Ejiofor et al. 2015) and the National Research Council (NRC) Committee on Fluoride in Drinking Water U.S. (2006) we can discern examples of the subtle yet conflicting conclusions from expert research bodies – which aggressive anti-fluoridation groups take advantage of in an effort to cause fear and confusion among the public. For example, according to the Cochrane Review there was a lack of ‘contemporary quality evidence that met the inclusion criteria for the panel’s assessment’ for effectiveness of CWF, as well as limited documentation of the effects post CWF cessation (Iheozor-Ejiofor et al. 2015). While the NRC summary analysis, whose focus was on safety and effectiveness, concluded that based on the available science CWF is an effective public health prevention strategy even with the wide use of fluoride in other products (i.e. toothpaste, mouthwash, professional application), and the only evidence of an adverse dental effect was cosmetic fluorosis (NRC, 2006). Health scientists realize most inclusion criteria and all scientific processes often call for additional research while the general public, with low science literacy, would perceive that statement as a 'risk to self.' Meanwhile, both the Cochrane Review and the York Review meta-analyses have demonstrated an average of a 25% reduction in caries with CWF, along with many other cross comparison studies of fluoridated and non-fluoridated communities (Griffin et al. 2007; Iheozor-Ejiofor et al. 2015; McDonagh et al, 2000; Kumar, Obubunmi & Melnik, 2010). With this study, I intended to make a contribution to the oral health evidence base while also filling the gap among CWF discontinuation studies that investigate the post cessation impacts on caries epidemiology. Lastly, this study also aimed to contribute to the small but growing public health literature in the U.S. utilizing Medicaid claims records as a data source for investigations of morbidity and cost trends over time.

Chapter 3 provides a detailed description of the research methodology design and rational, the process of selecting the study sample, the data collection and analysis procedures, as well as a thoughtful discussion of threats to validity and any ethical concerns.

Chapter 3: Research Method

Quality oral health remains a pressing unmet need for children worldwide and in the United States. The aim of this study was to analyze the potential oral health impacts of fluoride discontinuation from community water systems. Although the efficacy, equity, and cost effectiveness of CWF for caries prevention has been well established in cross sectional studies, it has not been adequately assessed in the community based context of CWF cessation (Atwood & Blinkhorn, 1991; Iheozor-Ejiofor et al., 2015; Maupome et al., 2001; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016; McLaren & Singhal, 2016). The following sections provide a detailed account of the research design, methodology, data collection, instrumentation, and analysis plan.

Research Design and Rationale

This research involved evaluating the impact of CWF cessation on oral health -- specifically dental caries among Medicaid eligible children and adolescents. I followed a retrospective cohort design methodology for investigating the main effect of fluoride removal from community water systems on pediatric and adolescent oral health (see Creswell, 2009; Murray, 1998). Medicaid dental claims records from Medicaid eligible children aged 0 to 18 years were analyzed in order to illuminate possible effects secondary to CWF cessation. Measurements for mean dental caries procedures and mean caries related treatment costs before and after cessation were determined. Database cost was a concern; therefore, I secured 1 year of claims during an optimal year and one during a suboptimal year (5 years postcessation).

The retrospective cohort research design provides a method for investigating the main effect of fluoride cessation/discontinuation (independent variable) from the community water systems on pediatric and adolescent oral health as assessed by standard Medicaid dental claims records. Claims records provided documentation of all dental services for Medicaid eligible patients during for that year. Caries related services and corresponding costs (dependent variables) were analyzed from 2003 and 2012 and provided suitable documentation to establish caries related services per client and costs associated with caries related treatment (CDC, 1999; Kumar et al., 2010; Maupome et al., 2001).

Few researchers have analyzed the treatment costs in the context of fluoride cessation, and it remains to be established if there are specific age groups or cohorts who are at greater risk (Adekugbe & Melnik, 2010; Maupome et al., 2001; McLaren et al., 2016). For example, I expected to observe the younger children with no CWF exposure in early life to experience more severe decay, while adolescents may have some protection from early childhood exposure to CWF and the strengthening of enamel among permanent teeth. The results add to the growing body of information available for improving those conditions that contribute to poor oral health based on sound scientific knowledge. The design choice allowed for analytic comparisons between exposed and nonexposed groups and documented statistically significant changes among all age group post cessation. The study goals and objectives were to determine the mean number of dental caries related procedures per client and the mean associated therapeutic costs before and after the discontinuation of CWF per Medicaid eligible client. In Chapter 3, I provide a detailed discussion of the study methodology, sampling procedures, data analysis and management procedures, human subjects concerns, and threats to validity.

Methodology

The research methodology followed a typical retrospective pre- and post-intervention research design. However, in this case, the intervention was removing exposure to CWF. I planned to collect data from Medicaid claims forms filed for residents serviced by the community water system for several years prior to discontinuation and for several years afterwards in order to assess any affect. The focus of the analysis was on measuring annual mean dental caries procedures (per age groups and per individual), and the annual mean associated restorative treatment costs. In this study, the independent variable was CWF, and the dependent variables was caries related procedures and associated treatment costs. To examine the research questions, I requested all 2003 and 2012 Medicaid dental claims for the 0 to18 years age group who resided in the Juneau zip code 99801. In order for a dental claim to be generated, a client had to first be evaluated by a dentist.

Population and Study Sample

The Juneau City Council decided to end CWF in 2007, and it is worth noting the Fairbanks City Council voted to cease CWF in June of 2011 (Chomitz, 2011). The availability of claims database information was continually updated, and at present includes services through year 2012. Therefore, given this short period of time since Fairbanks' cessation in 2011, I was forced to consider only Juneau (population 33,000) whose city council ceased CWF in 2007. In order to maximize sample size, I sought to secure all dental claims data from CMS for 2003 (optimal CWF) and 2012 (suboptimal CWF).

Target and Sample Size Estimates

The target population for this study was children and adolescents who live at or below the poverty line and in a community without optimal community water fluoridation. Current eligibility requirements for Alaskans seeking Medicaid include children up to age 18 years if the family income does not exceed 203% of the Federal Poverty Level. Family income limits vary depending on the size of the family. The rationale for this focus was to asses a group with a similar ages and economic status over time. Families living in poverty also represent the most vulnerable group likely to be affected by CWF cessation policy decisions and are those least able to participate in the health policy decision making processes (ADA, 2016).

Sampling and Sample Size

The Medicaid claims database yielded an adequate number of client records, a combined 1907 total patients. In and out migration from the region was assumed to have a limited impact given Juneau if off the road system and individuals under 18 may be less likely to change residency frequently.

Sample Size Calculations

Alaska has a small population compared to most cities in the United States. Therefore, I proposed to secure all Medical claims filed during an optimal CWF year and a suboptimal CWF year approximately 5 years after cessation. The costs of the data set were prohibitive, so I only secured 2 years. There were approximately 32,000 residing in Juneau, Alaska (U.S. Census, 2015). I estimated the 0 to18-year-old population at 25%, and those living in poverty at 10%, so 800 individuals who met the study criteria could have visited the dentist in 1 year. Using a standard sample size calculator with a 95% confidence interval, 5% margin of error, and a 50% response rate, I needed 260 claims per year to assess the research questions. These conditions were exceeded with 854 patients in 2003 and 1,053 patients in 2012.

I organized the data into specific age cohorts for comparison. These were ages 0 to 6.99, 7 to 12.99, and 13 to 18 years, recalling that early childhood caries are the most concerning (Mattheus, 2010; Sheiham, 2006). Each age cohort served as a stratified random sample (Trochim, 2008).

Research Questions

RQ1. To what extent does CWF cessation impact the frequency of dental caries as measured by caries related procedures among Medicaid eligible children and adolescents?

RQ2. To what extent does CWF cessation impact caries severity as measured by caries related treatment costs among Medicaid eligible children and adolescents?

RQ3. To what extent does CWF cessation impact caries attack rates for specific age cohorts among Medicaid eligible children and adolescents?

Case Selection Process

1. Cases were selected by obtaining all the claims filed for dental care for the 2 years in the study frame.

2. Claims associated with residence zip codes not serviced by city water were excluded from the study.
3. I aggregated and recoded claims groups into caries procedures/treatment claims and noncaries related claims.
4. Data were managed to assure unduplicated claims. This informed the study *N*, or denominator, for each year.

Allocation of Treatment Arms

The intervention in this study was the estimated impact of CWF cessation on the study population. Cessation has occurred in two communities of Alaska (Fairbanks in 2011 and Juneau in 2007). Anchorage remains fluoridated and will be used as a control group for future studies.

Study Variables/Measures

All dental claims from Medicaid eligible children and adolescents between the ages of 0 to18 years during the study period who received a dental assessment and billing claim were included in the study. These claims included services for numerous types of visits such as assessments and preventative care (fluoride varnish, x rays, cleanings, caries-related services, and outpatient surgeries).

N = The number of unduplicated client records

n = The number of patients in a particular age group

IV = Optimal or suboptimal CWF

DV = Mean dental caries procedure claims per child/adolescent

DV = Mean caries treatment costs per child/adolescent

Mediating variables: Gender and race

Sampling Strategy

In order to analyze the data in a manageable way, I stratified the subpopulation of 0 to 18-year-olds into age cohorts. Namely ages 0 to 6.99, 7 to 12.99, and 13 to 18 associated treatment costs for caries related services were tabulated and recorded accordingly. It was possible the introduction of dental sealants and fluoride varnishes could have a confounding effect, so these preventative services were aggregated and set aside from the main database.

Data Collection

The database was secured from the Centers for Medicare and Medicaid Claims Database Research Unit for the selected study years. This application process was coordinated by myself with ResDAC technical support professionals. The CMS Research Assistance Center estimated the fee required based on the size and number of years requested for the database, $10,500 (CMS, 2013; ResDAC, 2016). The annual claims data groups were recoded in order to analyze the number of caries procedures and costs over time using SPSS. Electronic databases were located in a secure location and only myself and dissertation chair had access.

Data Collection Instruments

Processed Medicaid claims data were available from the Centers for Medicare and Medicaid Research Unit who process the ADA issued claims forms from providers for reimbursement (ResDAC, 2016). Please see Appendix A for an example of the Medicaid Dental Claims form and the corresponding data fields (ADA, 2012).

Data Analysis

The purpose of the research was to observe and assess any changes in population oral health disease using Medicaid claims financial records for caries related procedures and costs as a proxy metric for the oral status of children and adolescents before and after CWF cessation (Kumar et al., 2010). Previous research comparing fluoridated and nonfluoridated communities observed children were three times more likely to receive a dental treatment in the operating room, and the costs per child increased more than twice those of children in the comparison fluoridated communities (CDC, 2001, 2011; Wong, 2013). The aim of this study was to assess the impact of fluoride discontinuation in Juneau, Alaska using the comparison of an optimal CWF year (0.7-1.2mg/L) and a suboptimal CWF year (< 0.7mg/L).

Statistical Package for Social Sciences (SPSS) software was to import the claims data from the aggregated samples. Descriptive statistics were generated for study samples during optimal and suboptimal CWF years. Analysis also included the mean number of claims per child, procedure codes, and treatment cost estimates of procedures completed.

The Dental Claims data fields (see Appendix A) from which the data were extracted reflect any dental services received and could also be considered a limitation. For example, the billing claims form does not include the patient's complete dental record therefore for outpatient procedures such as extractions or outpatient full mouth reconstruction, which were quite likely caries related, had to be set aside from the primary data analysis because I had no mechanism of confirming these were caries related procedures. In contract, a restorative procedure is decay related. This coding scheme also assumes that within 1 year, the dental professional was treating all points of decay for each individual.

In order to achieve a variable that reflected the number of dental caries related claims an individual client received, the number of caries claims was summed for each client. For example, a claim for single surface restoration counted as one. Similarly, a claim for a three surface restoration or crown would each have been counted as one claim even though they reflect a more advanced procedure indicating more significant decay. The second research question intended to capture changes in caries severity by analyzing caries related treatment costs. For example, multiple surface restorations and crowns are more expensive and reflect a provider's advanced skills and time treating more advanced decay conditions.

Research Questions and Hypotheses

RQ1: To what extent does CWF cessation impact the frequency of dental caries and caries related procedures among Medicaid eligible children and adolescents?

RQ2: To what extent does CWF cessation impact caries severity as measured by related treatment costs among Medicaid eligible children and adolescents?

RQ3: To what extent does CWF cessation impact caries attack rates for specific age cohorts among Medicaid eligible children and adolescents?

Hypotheses 1

RQ1H_0: Mean caries procedure rates for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different.

RQ1H_a: Mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions are higher than optimal CWF conditions.

Independent variables: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Mean number of caries related claims per child (continuous).

Mediating variables: Gender and race.

Analysis plan (Table 1). I calculated a *t* test of the dependent variable using the Mann-Whitney U test secondary to nonnormal distribution. Multiple linear regression was used to analyze how strongly CWF status related to the mean number of claims for caries related procedures per child and was adjusted for the mediating variables above. If the assumptions of linear regression were not met, such as linearity and homoscedasticity, binary logistic regression was used (Statistics Solutions, 2013). The intent of this analysis was to assess any changes in the frequency of dental caries experienced per child per year secondary to optimal or suboptimal CWF exposure.

Hypotheses 2

RQ2H_0: Mean caries treatment costs for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF were not significantly different.

RQ2H_a: Mean caries treatment costs for Medicaid eligible children and adolescents increased under suboptimal CWF conditions compared to optimal CWF conditions.

Independent variable: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Caries related treatment costs (continuous).

Mediating variables: Gender and race.

Analysis plan (Table 1). Calculated a *t* test of the dependent variable using Mann-Whitney U test secondary to non-normal distribution. Multiple linear regression was used to analyze how strongly CWF status relates to caries related treatment costs per child and adjusted for the mediating variables. If the assumptions of linear regression were not met, binary logistic regression was used. Adjustments were made to factor in inflation. The intent of the second research question was to observe differences in caries related treatment costs experienced by patients under suboptimal and optimal CWF conditions.

Hypothesis 3

RQ3H_0: Mean caries experience (attack rates) for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different.

RQ3H_a: Age groups with the highest mean caries experience (attack rate) include younger children (< 7 years) with only suboptimal CWF exposure.

Independent variable: CWF optimal or suboptimal (nominal, two levels).

Dependent variables: Dental caries procedures (continuous).

Mediating variables: Gender and race.

Analysis plan (Table 1). Calculated a *t* test using the Mann-Whitney U test since the data was not normally distributed. Multiple linear regression was used to analyze how strongly CWF status among cohort age groups influences caries attack rates. If the assumptions of linear regression were not met, such as linearity and homoscedasticity, binary logistic regression was used (Statistics Solutions, 2013).

A primary advantage of having both pre and post CWF cessation data was the ability to assess the 'net difference' in the intervention condition (non-fluoridation) and the control condition (fluoridation) (Murray, 1998). Again, since dataset cost was a barrier I was only able to secure two comparison years and unable to perform a time series analysis.

Data Management Plan

The database arrived on an encrypted CD with instructions for decryption. Data dictionaries were also included on the CD. Data was decrypted and secured on a password protected laptop dedicated to the research project. Database management and organization was conducted by myself using Access, Excel and SPSS. Descriptive and regression statistical analysis was conducted to analyze the relationship of caries related procedures, costs and associations with the fluoridation condition.

The mean number of claims for each eligible child for caries related services was calculated using a statistical package (SPSS) (Kumar, Adekubbe, & Melnik, 2010). The total costs for caries related services was also calculated both pre and post discontinuation to observe any cost benefit relationships. Database aggregation, filtering, quality control and quality assurance of the data was managed by myself, the principle investigator. Table 1 summarizes the research questions, variables and statistical tests.

Table 1

Research Questions, Hypotheses, and Statistical Tests

Research question	Hypothesis (Ha)	Variables	Statistical test
RQ1.To what extent does CWF cessation impact the frequency of dental caries related procedures among Medicaid eligible children and adolescents?	RQ1Ha. Mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions are higher than optimal CWF conditions.	IV: CWF (nominal, two levels) DV: number of caries related procedures per child (continuous) MV: Race, Gender	Bivariate between IV and DV: *t* test if DV normally distributed, and Mann-Whitney U test, if not normally distributed. Multivariate: between DV and IV and MVs as predictors; Multiple linear regression if assumptions met, otherwise binary logistic regression
RQ2. To what extent does CWF cessation impact caries severity as measured by caries related treatment costs among Medicaid eligible children and adolescents?	RQ2Ha. Mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions are higher than optimal CWF conditions.	IV: CWF (nominal, two levels) DV: caries related procedure costs per child, (continuous) MV: Race, Gender	Bivariate between IV and DV: *t* test if DV normally distributed, and Mann-Whitney U test, if not normally distributed. Multivariate: between DV and IV and MVs as predictors; Multiple linear regression if assumptions met, otherwise binary logistic regression
RQ3. To what extent does CWF cessation impact caries experience (attack rate) for specific age cohorts among Medicaid eligible children and adolescents?	RQ3Ha. Age groups with the highest mean caries experience (attack rate) include younger children (6.99 yrs and below) with only suboptimal CWF exposure.	IV: CWF (nominal, two levels) DV: number of caries procedures per child, (continuous) MV: Race, Gender	Bivariate between IV and DV: *t* test if DV normally distributed, and Mann-Whitney U test, if not normally distributed. Multivariate: between DV and IV and MVs as predictors; Multiple linear regression if assumptions met, otherwise binary logistic regression

Threats to Validity

The goal of this analysis was to carry out a retrospective cohort study in a natural real world setting. In this case, I compared the oral health of children and adolescents eligible for Medicaid before and after fluoride discontinuation. The focus of the analysis used Medicaid dental claims data as an indices for measuring fluctuations in mean caries related procedures and mean caries treatment costs annually per client.

According to Frankfort-Nachmias and Machmias (2008) there were both advantages and disadvantages of a retrospective cohort design. First, this study did not assign individuals to control and treatment groups limiting ethical concerns, but this could have also limited internal validity. In contrast, the analysis examined a population in their natural environment which might increase the external validity of the study. Unlike an experiment, I could not manipulate the independent variable (CWF) in the direction of causation and therefore it was 'logically' inferred by either the presence of optimal CWF levels or suboptimal levels (Frankfort-Nachmias and Nachmias, 2008). Annual trend data could help mitigate this threat, along with regression analysis and adequate sample sizes. Generalization of conclusions to other Medicaid populations in Alaska whose communities have ceased CWF could be particularly useful for budget and service planning.

Securing an appropriate sample size was important especially when making annual comparisons or seeking to establish trends. An inadequate sample size could lead to Type 1 error = not identifying an effect when there is one, or a Type 2 error = incorrectly identifying an effect when there isn't one (Murray, 1998). Internally, multivariate analysis helped to mitigate the multifactorial influences on the development of caries such as home oral care, socioeconomic status, regular access to quality dental care and financial concerns that lead to postponing treatment (Low, Tan & Schwartz, 1999). However, the weight of those additional risk factors as possible covariates has not demonstrated a significant effect the net impact of CWF across previous studies (Rugg-Gunn & Loc, 2012). Secondly, there could have been some influence of variation among provider's therapeutic approach as well as billing practices. However, I did not observe anything unusual in the datable that would indicate dramatic changes in these practices during optimal or suboptimal CWF periods. Although minimal, there was always a risk that some providers might over or under treat individuals on Medicaid for several reasons, however I stress again this would not be different in the pre or post CWF cessation conditions. Third, there could be coding errors or human errors in the database however, these were estimated to be small. Regarding external validity, one could argue the Medicaid population does not does not have the same set of risk factors as higher income groups and therefore this would limit the generalizability of conclusions to the overall population. Parent education level not a part of the claims database and therefore could not be used as a possible mediating variable to limit poverty bias. Again, the adequate sample size certainly makes the statistically significant conclusions generalizable to other Medicaid 0-18 age groups in which CWF has discontinued or is currently being considered for cessation by local policy makers. Replication of the study among higher income groups and those with private insurance would clarify these conclusions.

Numerous community partnerships could have been generated during this study which would certainly be a strength for the analysis as well as for creating appropriate ways to disseminate results. Although I did not intend to formally use the methodology of community based participatory research (CBPR), I borrowed elements in the form of partnership development and an equity orientation in the dissemination of the results (Israel, Schulz, Parker, & Becker, 1998).

Ethical Procedures in Human Subjects Research

Walden's Institutional Review Board approved this study and granted permission to carry out this research upon receiving notification of the release of data from the Centers for Medicare and Medicaid. The Walden IRB approval number for this study was 10-31-16-0075333. The intent of the proposed research project was to determine the average carried related procedural rates and costs for Medicaid eligible children prior to the discontinuation of fluoride in the community water system and afterwards. Although the gold standard for dental surveillance might be dental screening by a trained providers the labor costs associated with that type of process make it prohibitive. Previous comparison studies among once fluoridated and never fluoridated communities have repeatedly demonstrated the never fluoridated groups experience more dental decay requiring treatment and thus increasing costs compared to fluoridated communities (Griffin, Jones & Tomar, 2001; Iheozor-Ejiofor et al., 2015; McDonagh et al., 2000; McLaren, McNeil et al., 2016; McLaren, Patterson et al., 2016). Studies assessing fluoridated and fluoride ended communities have yielded more complex results supporting the multifactorial influences on dental decay (McLaren & Singhal, 2016).

This study assessed the impact of fluoride discontinuation in Juneau, Alaska and utilized data routinely collected and maintained in the CMS Claims Database.

The Institutional Review Board (IRB) was most concerned with the three basic elements of the Belmont Report (2009) and how they related to this particular study. These include ‘respect for persons’ which means individuals in the study have their human rights protected in that they can voluntarily chose to participate. Those who can’t voluntarily choose or have diminished capacity such as children, elderly and the disabled must also be protected. The second element of ‘do no harm’, means no harm will come to the participants and the benefits outweigh the costs of participation. Lastly the third element is ‘justice.’ For example, I assured the participants records in the study were selected in a fair way and not in order to exploit a vulnerable group. The database included HIPAA protected health information however, beneficiary ID’s were changed to a research identifiable format prior to shipping.

Regarding this study the IRB was concerned with the health protected data required from children and adolescents who were low income, representing a vulnerable group. However, it was precisely because they were a vulnerable group that the merit of the study outweighed this concern. Therefore, I was be prepared to explain how it was necessary to review the routine data found in dental claims of Medicaid eligible children in order to learn if CWF cessation policy had moved Medicaid eligible children and adolescents into pain, suffering and costly caries related treatment. As Hutton (2001) explains, the use of cluster randomized trials in health care and health science research has raised new issues regarding the ethics of research in this particular arena. Although this proposed study was both retrospective and observational in nature, as an ethical public health practitioner I thoughtfully considered any potential risks for the study population.

All communications and day to day operations were coordinated by the principle investigator. The University of Alaska IRB committee was also made aware of the research project, Walden's IRB approval, and database security practices were reviewed with the University of Alaska Office of information Technology and approved by CMS . Questions related to oral health specifics, Juneau fluoridation history and local community practices regarding CWF were directed to the State of Alaska Chief Dental Officer and pediatric dentist at the Southeast Alaska Regional Health Consortium (SEARHC), whose unit serves primarily Denali Kid Care (Medicaid) patients. In the event of unforeseen issues I planned to communicate in writing with my committee chair and the State Dental Officer regarding any concerns.

Summary

A detailed discussion of the research design, rationale, variables, analysis plan and threats to validity were presented. The Medicaid Dental Claims database needed was requested December 2, 2016. After a lengthy applications process CMS approved the release of data on February 2 2017. The administrative fee of $10,500 was paid February 28, 2017. The database finally arrived March 30, 2017. In Chapter 4, I present the data analysis and provide a detailed description of the results.

Chapter 4: Results

Introduction

The purpose of this retrospective cohort study was to examine caries related oral health impacts secondary to CWF discontinuation among Medicaid eligible children and adolescents. To analyze this general question, I used various statistical tests, including regression, to compare mean caries procedure rates and mean caries procedure costs among children between the ages of 0 and 18 years under optimal CWF conditions (0.7-1.2 mg/L or ppm) compared to those exposed to suboptimal CWF conditions (<0.7mg/L). Local water quality reports document natural suboptimum fluoride levels in Juneau water 0.1mg/L annually. In this chapter, I present a summary of the research results; I begin with a review of the research questions and a description of the study sample.

Research Questions 1 through 3 were both descriptive and inferential in nature and were as follows.

RQ1: To what extent does CWF cessation impact the frequency of dental caries related procedures among Medicaid eligible children and adolescents?

RQ1H_0*:* Mean caries procedure rates for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different.

RQ1H_a*:* Mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions are higher than optimal CWF conditions.

RQ2: To what extent does CWF cessation impact caries severity as measured by caries related treatment costs among Medicaid eligible children and adolescents?

RQ2H_0:. Mean caries treatment costs for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF were not significantly different.

RQ2H_a*:* Mean caries treatment costs for Medicaid eligible children and adolescents increased under suboptimal CWF conditions compared to optimal CWF conditions.

RQ3: To what extent does CWF cessation impact caries attack rates for specific age cohorts among Medicaid eligible children and adolescents?

RQ3H_0*:* Mean caries experience (attack rates) for Medicaid eligible children and adolescents under optimal CWF and suboptimal CWF conditions are not significantly different between age group cohorts.

RQ3H_a*:* Age groups with the highest mean caries experience (attack rate) include younger children (< 7yrs) who experienced primarily suboptimal CWF exposure.

Data Collection

The dental claims database required for this study was released after a lengthy application process and arrived encrypted on a password protected CD. Secondary to high database costs and study time constraints, only dental claims records for years 2003 and 2012 were purchased. 2003 served as the baseline for optimal CWF conditions while 2012 served as the comparison (suboptimal) year noting CWF cessation occurred January of 2007. The protected health information included in the dental claims database remained in research identifiable format through the analysis and was securely stored. The necessary age groups were filtered and organized using Excel and later imported into

SPSS 21 for analysis. Dental code reference material, specifically CDT codes, are publicly available for referencing procedure type and cost under study years.

In order to accurately measure the research questions, additional variables were developed and created using SPSS. Along with sorting data into age group cohorts, a variable reflecting number of caries related procedures and total costs for caries related procedures were used. More specifically, all dental procedures codes were organized into four levels. Level 1 represented the type of oral exam (e.g., partial, comprehensive), Level 2 represented preventative care (e.g., x rays, sealants, fluoride varnish), Level 3 represented caries related services (e.g., restoration by amalgam, resin, crown, sedative filling, endodontic/root canal treatments), and Level 4 represented all other services, such as extractions and surgeries. The focus of the study required analysis of the Level 3 category of procedure claims service. I hand tabulated the number of caries related claims (Level 3 claims) and the total dollar amount the provider charged for these restorative treatments and entered the sums into SPSS for analysis.

Descriptive and Demographic Statistics

Descriptive statistics were calculated in SPSS for the independent variable of CWF and dependent variable of dental caries procedures and mediating variables of gender and race. The database involved Medicaid dental claims only; therefore, the participants involved qualified for the program based on low income status. Parent education was not a variable in the database. Qualification for Medicaid was and is based on income level and varies by family size, disability status, and other metrics. For example, in 2003, the poverty level for a family of three in Alaska was defined as an annual income of $15,140, and in 2012 it was $23, 870 (DHHS, 2003, 2012). Proximity to a dental provider in the small community of Juneau, which has about 30 miles of road, remained unchanged. Race, gender, and ethnicity codes were available with the claims database and included in the analysis.

Sample Demographics

The entire sample including both 2003 and 2012 yielded 1,907 patients. All dental claims submitted to CMS during the study year were reviewed and coded according to study parameters (i.e., Level 1-4). In 2003, under optimal CWF conditions, the sample size for the age group 0 to18 years was 854, and in 2012, under suboptimal CWF conditions, the sample included claims from 1,053 patients. Roughly one-half of the participants were male, 51.2%. Slightly more than one half of the participants were American Indian or Alaska Native, 53.9%, and 30.9% were white/Caucasian. Tables 2-5 summarize the full descriptive statistics of the complete study sample for the 0 to 18 year age group that was used for the analysis required to answer RQ1 and RQ2. Descriptive statistics, bivariate and regression analysis were completed in SPSS.

Table 2

CWF Status of Juneau Study Sample (N = 1,907)

	Frequency	Percent
Suboptimal	1053	55.2
Optimal	854	44.8
Total	1907	100.0

Table 3

Gender Juneau 0-18 Year Age Group Study Sample (N = 1,907)

Sex	Frequency	Percent
Female	931	48.8
Male	976	51.2
Total	1907	100.0

Table 4

Race and Ethnicity Juneau 0-18 Year Age Group Study Sample (N = 1,907)

Race/Ethnicity	Frequency	Percent
White/Caucasian	589	30.9
Black	38	2.0
American Indian or Alaskan Native	1028	53.9
Asian or Pacific Islander	60	3.1
Hispanic	70	3.7
Native Hawaiian or Other Pacific	73	3.8
Unknown	49	2.6
Total	1907	100.0

Table 5

Age Group Cohort Sample Sizes (N = 1,907)

Age/Years	Frequency	Percent
0<7	763	40.0
7<13	754	39.5
13-18	390	20.5
Total	1907	100.0

Research Question 1 Results

RQ1: To what extent does CWF cessation impact the frequency of dental caries as measured by caries related procedures among Medicaid eligible children and adolescents? The null hypothesis was that there is no difference in between the two groups for mean caries related procedures. The alternative hypothesis stated that mean caries related procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions would be higher than for those under optimal CWF conditions. To test this hypothesis, I conducted a bivariate analysis of mean caries procedures for the study groups under both conditions. According to the results of Shapiro-Wilk test ($p < 0.0001$), the data were not normally distributed. Thus, a Mann-Whitney U test was used to evaluate the hypothesis that there is a difference in the mean dental caries related procedures per child between the two independent CWF groups (Table 6). The results below demonstrate the mean of caries related procedures is significantly higher in the suboptimal group (2.57 vs. 2.43, $p < 0.001$).

Furthermore, since the data were not normally distributed, binary logistic regression was used instead of linear regression. This was in accordance with the data analysis plan as presented in Chapter 3. In order to conduct logistic regression, the dependent variable (number of caries related procedures) was converted to a binary variable (high and low) based on the median score and then adjusted for CWF level, gender, and race. According to the Hosmer and Lemeshow test, there was no evidence the model was not a good fit to the data (Table 7). The binary logistic regression results indicated the odds for patients ages of 0 to 18 years under optimal CWF conditions to receive dental caries procedures was .748 times (or 25.2%) less when compared to those in the suboptimal group (Table 8). According to these results, I can reject the null hypothesis and accept the alternative hypothesis that under suboptimal CWF conditions, the mean caries related procedures experienced per child increased.

Table 6

Bivariate Analysis of Mean Caries Related Procedures per Client Under Two CWF Conditions

CWF	Mean	*N*	Std. Deviation
Suboptimal	2.57	1053	8.91
Optimal	2.43	854	13.82
Total	2.51	1907	11.37
Mann-Whitney U: 412232, *p*<0.001			

Table 7

Research Question 1 Logistic Regression Analysis and Classification Table

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2625.713	.009	.012

Hosmer and Lemeshow Test

Step	Chi-square	df	p
1	1.965	6	.923

	Observed		Predicted Regression Number Caries Procedures .00	Predicted Regression Number Caries Procedures 1.00	Percentage Correct
Step 1	Regression Number Caries Procedures	.00	499	456	52.3
		1.00	424	528	55.5
	Overall Percentage				53.9

Table 8

Research Question 1: 1Binary Logistic Regression Analysis

	B	*S.E.*	*Wald*	*df*	*p*	*OR*	95% CI	
							LL	*UL*
CWF Level (optimal)	-.290	.094	9.503	1	.002	.748	.622	.900
Female	.067	.092	.527	1	.468	1.069	.892	1.281
Race (Ref: White)			6.158	6	.406			
Black	-.353	.343	1.057	1	.304	.703	.359	1.377
American Indian Or Alaskan Native	.125	.104	1.438	1	.230	1.133	.924	1.391
Asian Or Pacific Islander	.039	.272	.021	1	.886	1.040	.610	1.773
Hispanic	-.165	.256	.418	1	.518	.848	.513	1.399
Native Hawaiian Or Other Pacific	.312	.253	1.529	1	.216	1.367	.833	2.243
Unknown	-.237	.303	.613	1	.434	.789	.435	1.429
Constant	.031	.107	.082	1	.775	1.031		

Note: B = B coefficients; *S.E.* = standard error; *Wald* = Wald test, *df* = degrees of freedom, *p* = probability value, *OR* = odds ratio, CI = confidence interval for odds ratio, *LL* = lower level, *UL* = upper level

Research Question 2 Results

RQ2: To what extent does CWF cessation impact caries severity as measured by caries related treatment costs among Medicaid eligible children and adolescents? The null hypothesis was there is no significant difference in caries related procedure costs under the two CWF conditions (beyond what could be explained by inflation). The alternative hypothesis was that caries related treatment costs for this group increased under suboptimal conditions (beyond what could be explained by inflation). To test this hypothesis, I conducted a bivariate analysis of mean caries related treatment costs per client under both conditions. According to the results of Shapiro-Wilk test ($p < 0.0001$), the data were not normally distributed, so a Mann-Whitney U test was used to evaluate the hypotheses that there was a difference in the mean dental caries treatment costs per client under the two independent CWF conditions (Table 9). The results demonstrate the mean for caries related treatment costs was significantly higher in the suboptimal CWF group ($593.70 vs. $344.34, $p < 0.0001$), without adjusting for inflation (between 2003 and 2012, the inflation rate increased an estimated 24.75% according to the U.S. Department of Labor, 2017).

In order to conduct logistic regression the dependent variable (cost of caries related procedures) was converted to a binary variable (high and low) based on the median score and adjusted for CWF group, gender, and race. According to the Hosmer and Lemeshow test, there was no evidence the model was not a good fit to the data (Table 10). The results of the binary logistic regression analysis were also significant According to the analysis the odds, a patient aged 0 to18 years under optimally fluoridated conditions would be billed for dental caries treatment was 0.749, or 25.1% less than the same aged patient living in suboptimal CWF conditions group (Table 11). According to these results, I can reject the null hypothesis and accept the alternative hypothesis that under suboptimal CWF conditions the mean caries related treatments costs per client increased.

Table 9

Bivariate Analysis of Mean Caries Related Treatment Cost per Client

CWF	Mean (US$)	*N*	Std. Deviation (US$)
Suboptimal	593.70	1053	1169.56
Optimal	344.34	854	713.97
Total	482.03	1907	999.25
Mann-Whitney U: 395338.5 , p<0.0001			

Table 10

Research Question 2 Regression Analysis and Classification Table

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	2625.310	.010	.013

Hosmer and Lemeshow Test

Step	Chi-square	df	p.
1	1.627	6	.951

			Predicted		
			Regression cost related caries		Percentage Correct
	Observed CWF		.00	1.00	
Step 1	Regression cost related caries	.00	499	456	52.3
		1.00	424	528	55.5
	Overall Percentage				53.9

Table 11

Binary Logistic Regression Analysis for Caries Treatment Costs

	B	*S.E.*	*Wald*	*df*	*p*	*OR*	95% CI	
							LL	*UL*
CWF level (optimal)	-.289	.094	9.450	1	.002	.749	.623	.901
Female	.075	.092	.669	1	.413	1.078	.900	1.292
Race (Ref: White)			6.421	6	.378			
Black	-.346	.343	1.019	1	.313	.707	.361	1.386
American Indian Or Alaskan Native	.136	.104	1.698	1	.193	1.146	.934	1.406
Asian or Pacific Islander	.045	.272	.027	1	.868	1.046	.613	1.784
Hispanic	-.158	.256	.384	1	.535	.853	.517	1.409
Native Hawaiian Or Other Pacific	.320	.253	1.601	1	.206	1.377	.839	2.259
Unknown	-.230	.303	.575	1	.448	.795	.439	1.440
Constant	.019	.107	.032	1	.859	1.019		

Note: B = B coefficients; *S.E.* = standard error; *Wald* = Wald test, *df* = degrees of freedom, *p* = probability value, *OR* = odds ratio, CI = confidence interval for odds ratio, *LL* = lower level, *UL* = upper level

Research Question 3 Results

Recall the purpose of question Research Question 3 was to observe if a particular age group within the study cohort was at higher risk for caries related procedures and associated treatment costs. To what extent does CWF cessation impact caries experience (attack rate) for specific age cohorts among Medicaid eligible children and adolescents? The null hypothesis was there is no significant difference in mean caries related procedures compared across age group cohorts under the two study conditions. The alternative hypothesis was dental caries related procedures occurred more frequently under suboptimal conditions, particularly for the youngest age group who had the least exposure to optimal CWF. To test this hypothesis I conducted a bivariate analysis of mean caries related procedures across three age group cohorts. A Mann-Whitney U test was used (because again the data was not normally distributed) to evaluate the hypotheses that there was a difference in the mean dental caries procedures per age group cohort under the two independent CWF conditions (Table 12). The results below demonstrate the caries related procedures was significantly higher in only the youngest age group (0 < 7 years). It was notable, the mean caries procedures for age group cohorts 7 -12.99 years and 13-18 years showed no significant difference under the two conditions, therefore no further regression analysis was conducted for the older groups. For the youngest age group cohort (0 < 7 yrs), 50.6% was female, the two largest racial groups represented were AI/AN (55.6%) and White (26.6%), followed by Hispanic (4.5%), Asian (4.3%) and Native Hawaiian (3.9%). The analysis showed the mean caries related procedures per patient to be significantly higher in the suboptimal CWF group compared to the optimal group (2.68 vs. 2.01, $p<0.004$) (Table 12) The results for binary logistic regression were also significant ($OR = 0.70$, 95% CI [0.52, 0.95], $p < 0.02$) and indicate a protective effect of CWF exposure, particularly for the younger age group. In other words, the odds of a child experiencing dental caries procedures while living in optimal CWF conditions was 0.70 times (or 30.1%) less than the odds of caries experience by children living in suboptimal CWF conditions (Table 14). Based on the results of the analysis for the null hypothesis that was no significant difference in mean caries procedures for children living under the two study CWF conditions was rejected in favor of the alternative. The alternative hypothesis stated that younger children, with the least number of years exposure to optimal CWF, experienced a higher number of caries procedures under suboptimal CWF conditions.

Table 12

Age Group Cohort Results for Bivariate Analysis of Mean Caries Procedures per Client in 0-6.99 Yr Age Group.

CWF	Mean	*N*	Std. Deviation
Suboptimal	2.68	461	4.57
Optimal	2.01	303	4.22
Total	2.4136	764	4.44
Mann-Whitney U: 62018, p<0.004			

Table 13

Research Question 3 Regression Analysis and Classification Table

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1036.961	.018	.024

Hosmer and Lemeshow Test

Step	Chi-square	df	p.
1	4.532	6	.605

			Predicted		
			Regression Number Caries Procedures		Percentage Correct
	Observed CWF		.00	1.00	
Step 1	Regression Number Caries Procedures	.00	382	40	90.5
		1.00	288	54	15.8
	Overall Percentage				57.1

Table 14

Binary Logistic Regression Analysis Summary for Age Group 0-6.99yrs

	B	*S.E.*	*Wald*	*df*	*p*	*OR*	95% CI *LL*	95% CI *UL*
CWF Level (Optimal)	-.358	.154	5.399	1	.020	.699	.517	.945
Female	.113	.147	.587	1	.444	1.119	.839	1.493
Race (Ref: White)			5.275	6	.509			
Black	-1.310	.654	4.019	1	.045	.270	.075	.971
American Indian or Alaska Native	-.094	.173	.294	1	.588	.910	.648	1.278
Asian Or Pacific Islander	.061	.377	.026	1	.871	1.063	.508	2.227
Hispanic	-.006	.373	.000	1	.987	.994	.478	2.066
Native Hawaiian Or Other Pacific	.039	.395	.010	1	.922	1.040	.479	2.256
Unknown	-.523	.482	1.181	1	.277	.592	.230	1.523
Constant	-.039	.173	.052	1	.820	.961		

Note: B = B coefficients; *S.E.* = standard error; *Wald* = Wald test, *df* = degrees of freedom, *p* = probability value, *OR* = odds ratio, CI = confidence interval for odds ratio, *LL* = lower level, *UL* = upper level

Summary

The statistical analysis of the study supported the alternative hypotheses for research questions one through three. The mean caries procedure rates for Medicaid eligible children and adolescents under suboptimal CWF conditions were significantly higher compared to optimal CWF conditions. Mean caries treatment costs for Medicaid eligible children and adolescents also increased significantly under suboptimal CWF conditions compared to optimal CWF conditions. Lastly, the age group with a statistically significant increase in mean caries experience (attack rate) included only the younger children (< 7years) who experienced the least number of years under optimal CWF conditions.

Chapter 5 includes a summary of the study results, a detailed discussion of the studies limitations and conclusions from this research. Additional analysis will be offered regarding the social change implications of the study and recommendations for both future research and practice.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The overarching question this research aimed to address was whether the cessation of CWF in Juneau, Alaska led to an increase in dental decay among Medicaid eligible children and adolescents. This study was designed to measure changes in average annual dental caries procedures experienced per child and associated treatment costs from Medicaid dental claims documentation among children and living in a community during an optimally fluoridated year (pre cessation) compared to a suboptimally fluoridated year (post cessation). Specifically, I focused on the children and adolescents residing in Juneau during 2003 after several decades of standard CWF concentration (ranging within recommended levels of 0.7 mg/L-1.2mg/L) to those living in the same community during 2012, approximately 6 years after CWF was discontinued. Since discontinuation, annual city water reports indicate the fluoride concentration remained a stable at 0.1mg/L.

Key findings from the bivariate analysis include a statistically significant increase in mean dental caries procedures experienced per client and the mean associated dental caries treatment costs for both the 0 to 18 year (2.58 vs. 2.43, $p < 0.001$; $593.70 vs. $344.34, $p < 0.0001$) and 0 to 6.99 year age groups (2.68 vs. 2.01, $p < 0.004$; (692.87vs. 350.13 $, $p<0.0001$), living in suboptimal CWF conditions. Similarly, the results of binary logistic regression were also significant for the 0 to 18 year and 0 to 6.99 year age groups, thus confirming what is known about the protective effect of fluoridation. Specifically, the odds of a 0 to 18-year-old patient under optimal CWF conditions experiencing dental caries procedures was .748 times, or 25.2%, less than their peers in the suboptimal CWF group. Similarly, the odds of a 0 < 7 year old Medicaid eligible patient, and/or family, to be billed for dental caries treatment was 0.699 times, or 30.1%, less than a child in the suboptimal CWF comparison group.

In this chapter, I elaborate further on these results and offer a detailed discussion of how conclusions both confirm understanding of CWF's protective benefits and extend the evidence based CWF cessation research. I also review the limitations of the study and offer recommendations for future research and for community/public health practitioners. Based on these results, it is my hope that this study and others with similar modeling can provide communities considering CWF cessation with evidence for what might occur with such a change in policy. For example, State and Federal Medicaid program planners could also use this type of forecasting to prepare for CWF cessation driven increases in caries treatment costs for their patient groups. Dental providers serving children and adolescents could plan for staffing increases to meet the greater needs of patients. Lastly, city and state governments could use these results along with others as an opportunity to reconsider their cessation decision and develop efforts to track the increased financial burden on for tax payers funded programs.

Interpretations of Findings

Individually, and as a whole, the results of this study confirm what is known about the benefits of community water fluoridation and adds to knowledge about what oral health impacts can occur when fluoridation is ceased. Published research over several decades along with two major meta analyses and multiple major health institutional reviews have documented the benefits of the fluoride compound to drinking water by preventing tooth decay among children, adolescents, and adults (CDC 2015a, 2015b; Iheozor-Ejiofor et al., 2015; McDonagh et al., 2000). In contrast, CWF cessation epidemiology is less well explored in the literature. For example, the first known meta-analysis of CWF cessation studies noted only 15 instances of CWF cessation investigations published over several decades (McLaren & Singhal, 2016). Each varied in study methodology, economic contexts, and research modalities. The most common modality of study was a concurrent cross section analysis using DMFT screening from a community that had ceased CWF at some point in the past compared to a community that continued CWF (McLaren & Singhal, 2016). Therefore, this research offered an alternative modality for studying cessation using Medicaid Claims Data from the same community before and after cessation.

Dental Caries Related Procedures

The results of Research Question 1 demonstrate a statistically significant increase in the number of dental caries procedures and associated treatment costs for the general cohort, aged 0 to 18 (2.58 vs. 2.43, $p < 0.001$). This supports what might be expected to happen when CWF is ceased based on the chemistry and biology of how fluoride works. Without exposure, teeth form with weaker enamel preeruptively, become more vulnerable to decay, and lack the ability to remineralize tooth enamel through the presence of fluoride in the mouth and saliva through drinking water (ADA, 2015a, 2015b; Murthy, 2015).

Because fluoride is a mineral that works both topically and systemically, I expected to observe a general increase in dental caries related procedures and treatment costs across age groups (ADA, 2015a, 2015b). Additionally, I expected to observe a more significant impact in the number of caries related procedures and treatments among those with the least amount of exposure to CWF. Youth without the benefit of fluoridated drinking water, particularly in early development, miss the strengthening of enamel preeruptively, cavity prevention, and remineralization of early decay (ADA, 2016a, 2016b, 2017; CDC 2015a, 2015b). Cho et al. (2014) noted that children who experienced CWF during their first 4 years of life had lower DMFT (decayed, missing, filled, teeth) scores at age 8 than those of similar age with no CWF exposure. Permanent teeth typically erupt about age 6 or 7, so the results support the current evidence base that there is a systemic preeruptive benefit of stronger more resilient permanent teeth by ingesting fluoridated water (ADA, 2016a, 2016b; CDC 2015a, 2015b; McLaren, 2016).

Research Question 3 analyzed the impact of CWF cessation among young children. I observed the following results. Mean caries procedures for the 0 to 6.99 year age group was significantly higher in the suboptimal CWF group compared to the optimal CWF group (2.68 vs. 2.01, $p < 0.004$). The 7 to 12.99 and 13 to 18 year age groups did not show statistically significant differences in the means for number of caries procedures (1.63 vs. 2.60 $p < 0.052$; 4.27 vs, 2.75 $p < 0.191$) respectively. Although these results were not statistically significant, it is notable that the middle age group was the only one that favored a lower mean among the suboptimal group than the optimal group. I might surmise that the older preteen groups and adolescents still reaped the enamel strengthening benefit of CWF before cessation. Lastly, by looking at aggregate data for specific procedures codes, I noted a large increase in the number of dental sealants placed in the year 2012 vs 2003. Given the birth years of the middle age group (2005 and 2000), they may have benefited from early CWF exposure and sealants since cessation occurred just about the time many of them had permanent teeth. Perhaps dentists were more attuned to the lack of fluoridation after January 2007 and were more alert to the importance of sealant placements for this age group.

During early childhood, fluoride supports the development of tooth enamel preeruptively that is more resistant to acids produced when eating (ADA, 2016; Institute of Medicine, 1997). Therefore, these statistically significant results from the 0 to 6.99 year age group confirms what would be expected regarding dental caries procedures and treatment costs since both increased for this group with the least early life exposure to CWF. This issue of early life CWF exposure including the preeruptive benefit is important (ADA, 2016). Several studies have indicated a protective effect from exposure to CWF in early life. Although the weight of the preliminary research in this area is growing, it indicates a systemic benefit preeruptively towards more resilient tooth enamel (ADA, 2016; Cho et al., 2014). Based on the results of this study, it there is already a change in the rate of dental caries procedure needs, particularly for the younger age group. This may be an early indication that tooth enamel in the population may be weaker overall, and over time as the children reach adulthood could experience more negative dental outcomes including the associated higher dental care bills (ADA, 2016).

Dental Caries Related Treatment Costs

A small number of published studies have addressed the variable of caries treatment costs as a function of CWF cessation. For example, the Texas Department of Health and Human Services (TX DHHS,2000) compared fluoridated and nonfluoridated communities and assessed dental treatment costs versus the costs of fluoridating the water. The results showed that for every unit increase in CWF (0.0-0.1ppm fluoride), mean cost for dental care per child decreased by $24 (optimal level CWF yields $168 decrease per person). To install CWF systems in counties that lacked them the Texas DHHS (2000) estimated $0.71-$1.90 per resident to install CWF systems and $0.35 per person for system maintenance. Kumar et al. (2010) compared Medicaid claims for caries related procedures among fluoridated, partially fluoridated, and nonfluoridated counties. The results indicated the mean number of restorative, endodontic and extraction procedures per recipient was 33.4% higher in less fluoridated counties (Kumar et al., 2010).

The results of this study are consistent with previous research and provide evidence that dental caries treatment costs are significantly higher under suboptimal or nonfluoridated conditions. The comparison of mean treatment costs and binary regression analysis were statistically significant overall and for each age group cohort. It could be that mean caries procedures were not significant for the older age groups, but mean costs were significant because they required more expensive caries treatments (proxy for caries severity). However, this would require deeper analysis of dental codes than I set out to study. Below is a summary of the caries related treatment cost differences adjusted for inflation based on U.S. Department of Labor Consumer Price index inflation calculator (US DOL, 2017), which estimated $100 dollars in 2003 was worth $124.75 in 2012. Caries treatment costs were calculated using the provider service charge, which was more likely to be influenced by consumer inflation. Typically, Medicaid only reimburses 50 to 70% of these charges and are subject to partisan debates. Provider billing charges reflect staff, supplies, office operations, and overhead, and are more susceptible to inflation and market changes. It is likely 25% is a generous inflation adjustment and the increased costs for age groups under suboptimal conditions is listed in Table 15. Also worth noting is these data were from pre Medicaid Expansion in Alaska, which occurred in 2015.

Table 15

Mean Caries Related Procedure Costs by Age and Adjusted for Inflation

Age Group	Sub-Optimal Mean ($)	Optimal Mean	*p*	Cost Inc/ %Inc	Adjusted -25%inf	Increase attributed to Sub CWF ($)
0-18	593.70	344.34	0.0001	249.36 / 72%	47%	117.20
0-6.99	692.87	350.13	0.0001	342.74 / 98%	73%	250.20
7-12.99	382.44	241.52	0.001	140.92 / 58%	33%	79.70
13-18	795.68	519.07	0.035	276.61/ 53%	28%	77.45

The results presented in Table 15 indicate the higher burden of costs was suffered by the younger age groups. Recall the older patients in this study were exposed to several years of CWF since it was ceased in 2007. For example, those in the 7 to 12.99

year age group had birthdays between 2000 and 2005 and thus benefited from the early life/childhood CWF exposure. Still, the costs of caries treatment services increased for each age group cohort even after adjusting for inflation and was markedly higher under suboptimal conditions. These results support the current evidence that even under modern conditions with widely available fluoride toothpaste, rinses, and professionally applied prophylaxis such as fluoride varnish and sealants, there appears to be both cost effectiveness and a caries prevention benefits associated with CWF for population health.

Limitations

In this section, I explore the study limitations, beginning with a discussion of the study sample and generalizability of the results. Then, I review validity and reliability issues and close with comments on the transferability of the analysis. First, the inquiry focused on the available Medicaid claims database, which only had processed claims through 2012; later years were not available. Second, due to time and cost constraints, I did not include a control group, which would add more scientific rigor to the analysis. Additionally, I only analyzed 2 years of claims when multiple years might lend more support through larger sample sizes, trend analysis, projections, and forecasting. Furthermore, the Medicaid Dental Claims form completed for reimbursement of services documents demographic data along with completed procedures and costs. It does not document the patient's DMFT score or include any medical history. Without the medical record or history claims that could have been caries related such as extractions and outpatient surgery, they had to be excluded from the analysis. It is possible the exclusion of these procedures may have underrepresented the number of caries procedures per client and therefore the studies construct validity. However, the results were statistically significant, so it was concluded this effect would likely be modest. For example, by comparing the rate of extraction between 2003 and 2012 for the (0-6.99) age group, it was 29% and 30% respectively. Therefore, if there was an effect, it was likely equally distributed for both comparison years. Lastly, regarding the sample, Medicaid eligible patients who did not visit a dentist during the study years were not included in the results. Although all health care professionals are trained to be concerned about access to services, which while important, the influence of access to care as an issue in this study was limited since I was only concerned with those who were evaluated by a dentist.

The primary concern with validity is how strongly the results are accurately measuring the study question. The focus of the analysis uses Medicaid dental claims data as indices measuring caries related treatments, procedures, and costs associated. According to Frankfort-Nachmias and Machmias (2008), there are advantages and disadvantages of a retrospective cohort design. First, because I was not assigning individuals to control and treatment groups, I had less ethical concerns, but this might limit internal validity. In contrast, studying the group in a natural environment might increase external validity and generalizability to other groups. Internally, multivariate analysis can help mitigate the multifactorial influences on the development of caries such as home oral care, socioeconomic status, regular access to quality dental care, and financial concerns that could lead postponing treatment. Additionally, analysis indicates the weight of those additional risk factors as possible covariates has not demonstrated a significant effect the net impact of CWF in previous studies (Rugg-Gunn & Loc, 2012).

Other covariates that could have influenced the results would have been prescriptive fluoride supplementation, school fluoride rinse programs, and dental sealants. There was evidence in the database of higher sealant use postcessation. For example, rates of sealant placement among the youngest age group increased seven fold between 2003 and 2012. However, this group still experienced a significant increase caries related procedures. There were no school-based oral health or school rinse programs in Juneau, and prescriptive supplementation was very limited (personal communications with Dr. Whistler and Dr. Hort, January 2017).

Socioeconomic status and poverty place individuals at high risk for many negative health outcomes. As with most negative health outcomes, income plays a strong role in role in determining an individual's oral health, often driving diet and stress levels. By focusing the entire study sample from a population who lives under poverty conditions, I was able to measure the influence of the independent variable CWF on the dependent variable dental caries procedures and treatment costs both before and after cessation. In some ways, because of the income criteria for Medicaid eligibility, one could argue this population is more homogenous, and therefore the results are more valid than if drawn from the general population (Kumar et al., 2010). In regards to reliability, there could be some influence of variation among a provider's therapeutic approach, as well as billing practices, although I would anticipate this to be similar in both study years. In terms of how the data were managed and recoded, this was done by only two individuals, and errors are estimated to be minimal. In summary, the strong internal and external qualities of this study support generalizability to other 0 to 18-year-old Medicaid populations in Alaska who have already or are considering CWF cessation. The methodology and analysis process are certainly transferrable to other regions and are important tools for future research.

Recommendations for Further Research

Most dental caries studies use a traditional DMFT score which requires an open mouth exam from similarly trained personal during a particular point in time, or drawn from medical records (Kumar, Adekugbe, Melnik, 2010; McLaren, 2016). However, based on the results of this study Medicaid claims databases may also serve researchers well particularly with longitudinal pre and post cessation study designs. Analysis over multiple years pre and post CWF cessation in order to analyze for normal variability and trends can only be established with metrics available over many years. Individuals without exposure to CWF as children may be more vulnerable while those who experiences an abrupt cessation may take years for the effects to be observed and treated. Medicaid data may be one of the more simpler avenues given the databases already exist and DMFT comparison baselines may not be available. Database costs could be a barrier to conducting these studies, particularly for smaller communities and city governments.

Expanding the study to include other income groups would be a logical next step and reveal if increases in dental caries is distributed across economic groups. This would involve private practices and client consents for use of the medical records databases. Conditions could certainly be created to protect health information, however it would be an investment of time and money for the private provider. The addition of a control group from a continuously fluoridated community could add more scientific rigor to the conclusions of this analysis.

Lastly, CWF cessation may have limited studies available for communities to utilize as evidence and support in making CWF decisions (McLaren & Singhal, 2016). Yet, even less is known about how communities make policy decisions for implementing or ceasing CWF (McLaren & Singhal, 2016). McLaren and Singals' (2016) recent meta-analysis noted CWF cessation studies are limited and vary greatly in methodology Little is known about the distribution of caries post cessation and if it disproportionately impacts certain group more than others. Or if a combination of interventions to CWF such as prescription fluoride supplementation or weekly rinse programs make any difference in caries epidemiology post cessation. At a fundamental level qualitative research on how communities engage in the appraisal of scientific research and what influences their decision making processes regarding CWF policies is needed (McLaren & Singhal, 2016). These are each critical priorities for future dental caries and CWF research.

Recommendations for Practice

The results of this study indicate several practice implications for public health practitioners, oral health providers, child health advocates, leaders and public policy makers. As mentioned earlier this research provides evidence for what occurs among the oral health of a vulnerable group post CWF cessation. The results can be used by policy makers to re-evaluate current cessation policies. State and Federal Medicaid program planners could use the study results for forecasting and preparation for CWF cessation driven increases in caries treatment costs for their patient groups. Dental providers serving children and adolescents could plan for staffing increases to meet the greater needs of patients. The conclusions also remind oral health providers to remain vigilant serving CWF cessation communities and utilize all the tools available for caries prevention such as fluoride supplements, school sealant programs, and fluoride rinse programs. Without such efforts disparities in caries experiences by marginalized groups will continue and likely increase.

It is also worthwhile for policy makers and oral health professionals to consider the anti-fluoridationists most science based argument against CWF, dental fluorosis (Freeze & Lehr, 2009). While not harmful to teeth or physical health it is a cosmetic concern (ADA, 2016). The CDC (2016) has recently changed the CWF recommendation to .7mg/L from .7mg/l-1.0mg/l in an effort to limit any potential risk of visible fluorosis (Murthy, 2015). Providers and advocates have a critical role to play in educating patients and families, most of whom have little background in advanced sciences and therefore can be vulnerable to propaganda. Should the community remain resistant to CWF advocates can shift the conversation to focus on what they might be willing to do to limit dental caries and furthering disparities in oral health among children and adolescents residing in their communities.

Social Change

The social change implications of this research were twofold. The first related to the process of informed public policy based on an evaluation of CWF discontinuation caries epidemiology. The second involved informed policy making based on cost analyses for publicly funded dental insurance programs such as Medicaid. The study results create an opportunity for policy makers to re-evaluate current CWF cessation policy and evaluate cost effectiveness and cost benefits of re-instituting CWF and/or other caries prevention interventions.

Diffusion of innovation theory provides a critical theoretical framework and dissemination strategy for bridging the gap between science and public policy (Rogers, 1995, 2013). DIT as presented by Rodgers (1995: 2003) posits that in any population there are factors that influence and individual's response to innovation, components related to the communication of the innovation and additional issues that impact the spread or reach of an innovation through a group or community. Once a certain number or threshold of individuals, agencies or groups adopt an innovation, it can become self-sustaining and a part of the social, political and cultural structures (Rogers, 1995: 2003). DIT was originally designed to study how new products or ideas were spread or communicated among individuals (Rogers, 2004). However, over the years, DIT has been applied to social groups, agencies and organizations (Rogers, 2003).

The results of this study indicate CWF cessation had a negative impact on oral health outcomes, as measured by frequency of dental caries procedures and costs, for 0-18 year old community members eligible for Medicaid. The results also contribute to the evidence base from which policy makers can turn to for guidance both now and in the future. There exists a popular trend towards CWF discontinuation from public water systems represents an opportunity to evaluate oral health impacts in a natural setting under modern conditions (Maupome et al., 2001; McLaren, McNeil et al., 2016;

McLaren, Patterson et al., 2016). As CWF cessation research grows it could be useful to use DIT as a construct from which to gauge social and community actions strategies for dissemination of results. For example, perhaps the Juneau city council fits the definition of early, late majority and laggard DIT adopter categories - given the vote to remove CWF. Therefore, meeting the data gaps identified by both Juneau and Fairbanks City Council Reports with up to date local data on the impacts of cessation might motivate council members to reconsider current CWF policy and, at the very least, plan for future increased revenue requirements for Medicaid programs to meet oral care needs should cessation continue.

Conclusion

This study analyzed oral health changes secondary to CWF discontinuation among Medicaid eligible children and adolescents in a community whose local government ceased fluoridation of the public water system Juneau, Alaska. Through rigorous statistical analysis of Medicaid dental claims records I examined the relationship between dental caries related procedures and costs under optimal CWF and suboptimal CWF conditions and determined the following conclusions. Based on the results, I can conclude with statistical certainty, CWF cessation supported the marked increase in the frequency of caries related procedures and treatment costs experienced by Medicaid eligible children and adolescents aged 0-18. Additionally, the results indicated those in the younger age groups appear to be experiencing more dental caries than older age group cohorts who benefitted from early childhood exposure to optimal CWF. These results add to the growing body of information available regarding CWF cessation epidemiology by both confirming the dental caries prevention benefit of CWF expanding the evidence base regarding CWF cessation under modern conditions.

The study outcomes supply information to better inform community leaders, decision makers, oral health providers and health care agencies regarding the impacts of CWF cessation policies on oral health. For example, the results can offer city and state governments considering CWF cessation assistance with budgets and forecast future costs. Practitioners can use the study results for service planning and local advocacy efforts. This type of research could be particularly useful for decision makers who may need to anticipate the increased needs of the Medicaid population under CWF cessation conditions. Statewide dental and public health leaders also now have more evidence to accurately inform those crafting future community water fluoridation plans, and support equity oriented population health policies.

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Appendix A: Add the Appendix Title Here

Medicaid Dental Claim Form
Claim Field Identification Number and Explanation Statement
Source:http://manuals.medicaidalaska.com/dem/claim_form_instructions/dental_form_instructions.htm

Claim Field Identification		Explanations and Instructions
HEADER INFORMATION		
1.	Type of Transaction □ Statement of Actual Services □ EPSDT/Title XIX □ Request for Predetermination	Optional. If used, check box.
2.	Predetermination/ Prior Authorization Code	Required, if applicable. If services have been prior Authorized, enter the Prior Authorization Number you received from the Affiliated Computer Services PA Unit (see Field 20 of the Prior Authorization Request and Invoice, shown in Section II).
INSURANCE COMPANY/DENTAL BENEFIT PLAN INFORMATION		
3.	Company Plan/Name, Address, City, State, ZIP Code	Required. Enter Affiliated Computer Services as primary payer here. If patient has other coverage, complete Items # 4-11. Affiliated Computer Services, Inc. P.O. Box 240769 Anchorage, AK 99524-0649
OTHER COVERAGE		
4.	Other Dental or Medical Coverage? □ No (Skip Items #5-11) □ Yes (Complete Items #5-11)	Required. A “No” or “Yes” response is required based on information available to the dentist.
5.	Name of Policyholder/Subscriber in Item #4 (Last, First,	Required, if applicable. If the patient has other coverage through a spouse, domestic partner or, if a child, through both parents, the name of the person who has the other coverage is reported here.

Claim Field Identification		Explanations and Instructions
	Middle Initial, Suffix)	
6.	Date of Birth MM/DD/CCYY	Required, if applicable. Enter the date of birth, in eight-digit format, of the person listed in Item #5.
7.	Gender ☐ Male ☐ Female	Required, if applicable. Mark the gender of the person who is listed in Item #5.
8.	Policyholder/Subscriber ID (SSN or ID#)	Required, if applicable. Enter the Social Security Number or the identifier number of the person who is listed in Item #5. The identifier number is a number assigned by the payer/insurance company to this individual.
9.	Plan/Group Number	Required, if applicable. Enter the group plan or policy number of the person identified in Item #5.
10.	Patient's Relationship to Person Named in Item #5 ☐ Self ☐ Spouse ☐ Dependent ☐ Other	Required, if applicable. Mark the patient's relationship to the other insured named in Item #5.
11.	Other Insurance Company/Dental Benefit Plan Name, Address, City, State, ZIP Code	Required, if applicable. Enter the complete information of the additional payer, benefit plan or entity for the insured named in Item #5.
POLICY HOLDER/SUBSCRIBER INFORMATION (For Insurance Company Named in #3)		
12.	Policyholder/Subscriber Name (Last, First, Middle Initial, Suffix), Address, City, State, ZIP Code	Required. Enter the recipient's name, address, and ZIP Code.
13.	Date of Birth (MM/DD/CCYY)	Optional. Enter date of birth in MM/DD/CCYY format.
14.	Gender ☐Male ☐ Female	Optional. Enter the patient's gender in appropriate box.

Claim Field Identification		Explanations and Instructions
15.	Policyholder/Subscriber ID	Required. Enter the recipient's Alaska Medical Assistance ID number.
16.	Plan/Group Number	Leave Blank.
17.	Employer Name	Optional. If applicable, enter the name of the recipient's employer.
		PATIENT INFORMATION
18.	Relationship to Policyholder/Subscriber ☐ Self ☐ Spouse ☐ Dependent ☐ Other	Optional. If used, mark the box titled "Self" and skip to Item #23.
19.	Student Status ☐ FTS ☐ PTS	Optional. Mark "FTS" if patient is a dependent and a part-time student. If neither applies, skip to Item #23.
20.	Name, Address, City, State, ZIP Code	Leave Blank.
21.	Date of Birth (MM/DD/YY)	Leave Blank.
22.	Gender ☐ Male ☐ Female	Leave Blank.
23.	Patient ID/Account # (Assigned By Dentist)	Optional. Enter the patient's medical record or account number. This field can accommodate up to 11 characters. Both alpha and numeric characters are acceptable. This information will print following the claim control number (CCN) on your Remittance Advice (RA).
RECORD OF SERVICES PROVIDED		
24.	Procedure Date (MM/DD/CCYY)	Required. Enter the date(s) that services were rendered, in MM/DD/CCYY format (e.g., 03/15/2007). Each service or procedure must be entered on a separate line with no more than 10 lines per claim form.
25.	Area of Oral Cavity	Optional. Always report the area of the oral cavity unless one of the following conditions in Item #29 (Procedure Code) exists:

Claim Field Identification	Explanations and Instructions

Code	Area	Code	Area
00	Entire Oral Cavity	20	Upper Left Quadrant
01	Maxillary Arch	30	Lower Left Quadrant
02	Mandibular Arch	40	Lower Right Quadrant
10	Upper Right Quadrant		

26.	Tooth System	Optional.
27.	Tooth Number(s) or Letter(s)	

Required, if applicable. Enter the appropriate tooth number or letter when the procedure directly involves a tooth or range of teeth, otherwise leave blank. If the same procedure is performed on more than a single tooth on the same date of service, report each procedure and tooth involved on separate lines on the claim form.

If applicable, use the following codes. When a procedure involves a range of teeth, the range is reported in this field with a hyphen to separate the first and last tooth in the range (e.g., 1-4, 7-10) or by the use of commas to separate individual tooth numbers or ranges (e.g., 1, 2, 4, 7-10).

Supernumerary teeth in the permanent dentition are identified by the numbers 51-82, beginning with the arch of the upper right third molar, and following around the upper arch to the area of the lower right third molar.

UPPER ARCH: Commencing in the upper right quadrant and rotating counterclockwise

Tooth #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
“Super” #	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66

LOWER ARCH:

Too	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17

Claim Field Identification		Explanations and Instructions

Tooth #																
"Super" #	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67

Supernumerary teeth in the primary dentition are identified by the placement of the letter "S" following the letter identifying the adjacent primary tooth (for example, supernumerary "AS" is adjacent to "A;" supernumerary "TS" is adjacent to "T").

UPPER ARCH: Commencing in the upper right quadrant and rotating counterclockwise

Tooth #	A	B	C	D	E	F	G	H	I	J
"Super" #	AS	BS	CS	DS	ES	FS	GS	HS	IS	JS

LOWER ARCH

Tooth #	T	S	R	Q	P	O	N	M	L	K
"Super" #	TS	SS	RS	QS	PS	OS	NS	MS	LS	KS

No.	Claim Field Identification	Explanations and Instructions
28.	Tooth Surface	Required, if applicable. When the procedure performed involves one or more tooth surfaces, use the following codes. Do not leave any spaces between surface designations in multiple surface restorations.

Code	Description	Code	Description
B	Buccal	L	Lingual
D	Distal	M	Mesial
F	Facial (or labial)	O	Occlusal
I	Incisal		

No.	Claim Field Identification	Explanations and Instructions
29.	Procedure Code	Required. Enter the dental procedure code that describes the service provided (refer to the table in your billing manual).
30.	Description of Service	Required. Enter a brief description of services provided. When billing for general anesthesia or any form of sedation, state justification for service in Item #35.

Claim Field Identification		Explanations and Instructions
31.	Fee	Required. Report the dentist's full fee for the procedure.
32.	Other Fee(s)	Optional.
33.	Total Fee	Required. Enter the total charge for all services and fees.
MISSING TEETH INFORMATION		
34.	Place an "X" On Each Missing Tooth	Required. Missing teeth should be reported when pertinent to Periodontal, Prosthodontic (fixed and removable), or Implant Services procedures on a particular claim.
35.	Remarks	Required, if applicable. Use this field to report Third Party Liability amounts, emergency services and medical justification. If more than one situation applies to a claim, first enter the TPL amount paid followed by two spaces ($###.##) and then any additional information. Use this field when services require justification of medical necessity or other unusual services, such as the name of the recipient's Primary Care Dentist when care is rendered by a dentist other than the Primary Care Dentist (refer to Appendix E for additional Care Management Program information), a procedure code that requires a report or multiple supernumerary teeth. The remarks must state the reasons for treatment, including the need for anesthesia. Additional documentation may be attached to the claim, if desired.
AUTHORIZATIONS		
36.	Patient/Guardian Consent Signature	Optional. Alaska Medical Assistance recipients do not need to sign.
37.	Insured's Signature	Optional. Alaska Medical Assistance recipients do not need to sign. Claims prepared by the dentist's Practice Management Software may insert "Signature on File."
ANCILLARY CLAIM/TREATMENT INFORMATION		
38.	Place of Treatment	Required. There are four possible choices to mark: provider or dentist office, a hospital, an extended care facility or other if none applies.

Claim Field Identification		Explanations and Instructions
39.	Number of Enclosures (Radiographs or Oral Images)	Required. This item is completed whether or not radiographs, oral images or study models are submitted with claim: No enclosures, enter “00,” or enter number of images in appropriate box using two digits. If less than 10, use “0” in the first position. Please do not submit radiographs with claim or prior authorization requests unless specifically requested to do so.
40.	Is Treatment for Orthodontics?	Required. If “No,” skip to Item #43. If “Yes,” complete Items #41 and 42.
41.	Date Appliance Placed (MM/DD/CCYY)	Required, if applicable. Indicate the date an orthodontic appliance was placed. This information should also be reported in this section for subsequent orthodontic visits.
42.	Months of Treatment Remaining	Required, if applicable. Enter the estimated number of months required to complete orthodontic treatment.
43.	Replacement or Prosthesis? ☐ No ☐ Yes (Complete Item #44)	Required, if applicable. This item applies to crowns and all fixed or removable prosthesis. Follow these criteria: a. If claim does not involve a prosthetic restoration, mark “No.” b. If the claim is for the initial placement of a crown, or a fixed or removable prosthesis, or the claim is to replace an existing crown, mark “No.” c. If the patient has previously had these teeth replaced by a crown, or a fixed or removable prosthesis, or the claim is replacement of a crown, mark “Yes.”
44.	Date of Prior Placement (MM/DD/CCYY)	Optional. Complete if answer to Item #43 was “Yes.”
45.	Treatment Resulting From: ☐ Occupational Injury ☐ Auto Accident ☐ Other Accident	Required. If the dental treatment listed on the claim was provided as a result of an accident or injury, mark the appropriate box.
46.	Date of Accident (MM/DD/CCYY)	Required, if applicable. Enter the date on which the accident noted in Item #45 occurred.
47.	Auto Accident State	Required, if applicable. Enter the state in which the auto accident noted in Item #45 occurred, otherwise leave blank.

Claim Field Identification		Explanations and Instructions
BILLING DENTIST OR DENTAL ENTITY		
48.	Dentist's Name, Address, City, State, ZIP Code	Required. Enter the dental professional's name (individual or group name). Enter your mailing address (street, city, state, and ZIP Code+4).
49.	Dentist's National Provider Identifier	Required. Enter the NPI number for the billing entity.
50.	Dentist's License Number	Optional. Note: If the billing dentist is an individual, enter the dentist's license number. This is not the dentist's Medicaid Contract ID. Leave blank if a billing entity (e.g. corporation).
51.	Dentist's Social Security Number or TIN (Federal Tax ID)	Optional. Enter the SSN or TIN of the biller/pay to provider.
52.	Dentist's Phone Number	Optional. Enter the telephone number of your office.
52a.	Additional Provider ID	Required. Enter the billing provider's Medicaid Contract ID.
TREATING DENTIST AND TREATMENT LOCATION INFORMATION		
53.	Dentist Signature	Required. The claim must be signed and dated by the dentist or authorized representative of the dentist. A facsimile signature is acceptable. Claim forms prepared by the dentist's Practice Management Software may insert the treating dentist's printed name in this Item #.
54.	Dentist's National Provider Identifier	Required. Enter the NPI for the rendering /servicing dental provider.
55.	Dentist's License Number	Required. Enter the license number of the Treating Dentist. This may vary from the Billing Dentist. Note: This is not the dentist's Medicaid Contract ID.
56.	Treating Dentist's Address, City, State, ZIP Code	Required. Enter the physical location where the treatment was rendered. Must be a street address, not a Post Office Box. Enter street, city, state, and ZIP Code+4.
56a.	Dentist's Provider Specialty Code	Required, if applicable. Enter the taxonomy code that indicates the type of dental professional who delivered the treatment. The provider specialty codes (also known as provider taxonomy codes) can be viewed at

Claim Field Identification	Explanations and Instructions
	www.wpc-edi.com/codes/codes.asp .
57. Dentist's Phone Number	Optional. If used, enter the telephone number of your office.
58. Additional Provider ID	Required. Enter the rendering provider's Medicaid Contract ID.

Note: This ADA claim form is a two-part form. Keep the yellow carbon copy and mail the white original to: Affiliated Computer Services, Inc., P.O. Box 240769, Anchorage, AK 99524-0769