ABSTRACT

Title of Thesis: AN INVESTIGATION OF CHILD AND ADOLESCENT DENTAL SEALANT PREDICTORS, NHANES 2011-2012

Agnieszka Anna Roman, Master of Public Health, 2016

Thesis directed by: Professor Dushanka Kleinman, D.D.S, M.Sc.D. Department of Epidemiology and Biostatistics

Objective: To examine sociodemographic and dental factors for associations with dental sealant placement in children and adolescents aged 6-18 years old.

Methods: Secondary data analysis of 2011-2012 NHANES data was conducted. Multiple logistic regression models were used to assess relationships between predictor variables and sealant presence.

Results: More than a third (37.1%) of children and adolescents have at least one sealant present; 67.9% of children compared with 40.4% of adolescents. Racial/ethnic differences exist, with Non-Hispanic black youth having the lowest odds of having sealants. Sealant placement odds vary by presence of dental home; the magnitude of the odds varies by age group. Those with untreated decay have lower odds of having sealants than those who do not have untreated decay (child OR: 2.6, 95% CI: 1.83-3.72; adolescent OR: 3.9, 95% CI: 2.59-6.07).

Conclusion: Disparities exist in odds of sealant prevalence across racial/ethnic groups, income levels, and dental disease and visit characteristics. Further research is necessary to understand the reasons for these differences and to inform future interventions.

AN INVESTIGATION OF CHILD AND ADOLESCENT DENTAL SEALANT PREDICTORS, NHANES 2011-2012

by

Agnieszka Anna Roman

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Public Health
2016

Advisory Committee:
Professor Dushanka Kleinman, Chair
Professor Xin He
Dr. Bruce Dye
Professor Alice Horowitz
Professor Hongjie Liu

Acknowledgements

A special thank you to my thesis committee members, Dr. Dushanka Kleinman, Dr. Bruce Dye, Dr. Xin He, Dr. Hongjie Liu, and Dr. Alice Horowitz who have graciously provided feedback and guidance throughout the research process. Additional thanks to Dr. William Maas, who contributed his expertise and input to the project. Thank you to the SPH Collaboratorium staff for being available to answer questions about SAS coding during the data analysis phase.

This research was supported by the Leidos Corporation Research Fellowship Program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Leidos Corporation.

Table of Contents

List of Tables

Chapter 1: Introduction

I. Background

Dental caries, commonly known as tooth decay, is one of the most prevalent, yet preventable, chronic diseases in the United States and worldwide, and susceptibility to this disease remains a concern throughout the lifetime. It is the most common chronic disease of U.S. children, currently four times more common than asthma, and is more prevalent in low income, underserved populations (1). Data from the 1999-2004 National Health and Nutrition Examination Survey reveals that 21 percent of children ages 6 to 11 have or have had dental caries in their permanent (adult) teeth, which includes teeth that were restored as well as teeth where dental caries was not treated (2). For ages 12-19, this percentage is close to three-folds greater, 59 percent of adolescents have or have had dental caries in their permanent teeth (3).

Primary preventive measures exist and include appropriate exposure to fluoride and use of dental sealants. Dental caries is an infectious disease process initiated by the combination of acid-producing bacteria, available refined carbohydrates, and a susceptible tooth, and if not controlled, results in the destruction of tooth structure, loss of teeth, and spread of the resulting infection. Symptoms of untreated dental caries include loss of tooth structure, pain, further infection and abscesses, and related inability to address daily functions (eating, speaking, concentrating and/or sleeping). Thus, this disease also contributes to decreased quality of life and missed days of school or work due to symptoms or required treatment. In extreme cases, dental caries and related infections have led to premature

death, as in the case of Deamonte Driver, a 12 year old boy from Prince George's County, Maryland, who died after bacteria from an untreated dental abscess spread to his brain (4). As a result of this tragedy, the state of Maryland has increased its investment in maintaining community water fluoridation, extending professional fluoride treatments to at risk children, improving administration of Medicaid and increasing reimbursement rates, supporting school-based dental sealant programs, and launched oral health literacy campaigns, among other preventive regimens (5).

Evidence-based measures to prevent dental caries include community water fluoridation, other fluoride containing measures (dentifrice, rinses, professional applications) and dental sealants (6). Fluoride has long been a proven and effective measure in preventing caries, and contributes to the process of tooth enamel (outer surface of teeth) remineralization (6). The role and effectiveness of fluoride in preventing caries has been extensively documented in peer reviewed literature. A systematic review by the Community Preventive Services Task Force resulted in a strong recommendation of community water fluoridation and of school-based sealant delivery programs due to their high effectiveness in reducing caries across populations (7,8). The dental caries preventive action of fluoride and dental sealants complement one another, and with the application of sealants in a community with fluoridated water can increase caries protection by about 20 percent (9).

To aid in the prevention of dental caries, dental sealants were introduced in the 1960s for professional application. Dental sealants are thin, plastic resin material that is bonded to the occlusal (chewing) tooth surface in order to seal out caries-causing bacteria and refined carbohydrates from pits and fissures of the chewing

surfaces of posterior (back) teeth. The potential impact of placing a physical barrier on this surface is substantial since 90 percent of all caries occur on the occlusal surface of teeth in schoolchildren (1). It has been shown that sealants are nearly 100 percent effective in preventing the development of caries as long as they remain intact. Their efficacy, relatively low-cost, and the durability of the sealants, which have been shown to last over 20 years in many cases, make sealants an excellent complement to fluoride for caries prevention, especially for those who are at high risk for developing caries (10). Current recommended guidelines dictate that sealants should be placed in pits and fissures of teeth in children and adolescents who are at risk of developing caries (11). Children who are at higher risk for developing caries include those who have a family history of caries, those of low socioeconomic status, those who frequently eat sugary snacks, those without a dental home, and those with low salivary flow, as identified by the American Academy of Pediatric Dentistry (AAPD) within their Caries-Risk Assessment Tool (12). In addition to the aforementioned risks, lack of exposure to fluoride from sources such as fluoridated tap water or fluoridated toothpaste also contributes to caries development.

The inclusion of increasing the proportion of children and adolescents who receive sealants as a Healthy People 2010 & 2020 objective is a recognition of their importance as a prevention tool in decreasing the burden of dental caries.

II. Research Question

Although previous research has been conducted to investigate factors that potentially determine sealant effectiveness and longevity, the question regarding the

full complement of factors associated with sealant placement had not yet been answered, especially among adolescents. The analyses in this study were designed to contribute to the body of knowledge about the factors associated with receipt of sealants in children ages 6-11, and add new knowledge about the prevalence of dental sealants in adolescents, ages 12-18. Factors under study include variables such as, family income, type of insurance, race/ethnicity, dental visit history, dental caries history, and variables related to caries risk assessment. With the knowledge gained from this study, and that of dental care utilization and services delivery, long term objectives include development of strategies to increase rates of sealant application among children and adolescents at risk for developing caries, in alignment with Healthy People 2020 objectives of "increasing the proportion of children and adolescents who have received dental sealants on their molars". Ideally, the goal is to inform future oral health policies and recommendations by increasing the understanding of factors related to receipt of sealants and identifying populations at risk.

In the past, the focus has been on younger children with primary emphasis on sealant application in children at the time of first molar eruption at about age 6 or 7, largely ignoring sealant placement in adolescents after the eruption of the second molar at about ages 11 to 13 (13). The investigation into factors associated with sealant placement in children and in adolescents provides data to inform current practice guidelines and recommendations. This study also evaluates whether sealant placement is present in high risk populations.

III. Specific Aims

To test the aims below, the 2011-2012 NHANES Demographic, Examination, and Questionnaire Data sets were used.

Specific Aim #1: Describe the characteristics (gender, family income, type of insurance, race/ethnicity, dental visit history, and dental caries history) of US children (ages 6-11) and adolescents (ages 12-18) with and without sealants on permanent teeth.

Specific Aim #2: Explore possible associations between the presence of sealants on permanent teeth and predictors (gender, family income, type of insurance, race/ethnicity, dental visit history, and dental caries history), and determine if these associations are moderated by age group (6-11 or 12-18 year olds).

Specific Aim #2 Hypothesis: Those with at least one sealed permanent tooth differ from those without any permanent teeth sealed by gender, family income, type of insurance, race/ethnicity, dental visit history, and dental caries history. These associations vary by age group (6-11 or 12-18 years old).

Specific Aim #3: Describe and contrast associations between variables placing youth at high risk for caries and sealant presence on permanent teeth in children (ages 6-11) and adolescents (ages 12-18). Variables defined as high risk for caries are aligned with the AAPD Caries-Risk Assessment Tool.

Specific Aim #3 Hypothesis: Those with at least one sealed permanent tooth differ from those without any permanent teeth sealed by family income, presence of untreated caries, and having a dental home.

Chapter 2: Literature Review

Oral health is a vital component of overall health and well-being, with the mouth reflecting general health or disease status (1). In developing children, the detrimental consequences of caries, especially untreated caries are significant. Those with severe caries report lower body weights, slower growth patterns, and decreased quality of life (14). To prevent the downstream effects of caries, it is important to target those at risk through preventive regimens to minimize later health consequences and restoration costs. This study expands on the body of knowledge about factors associated with sealant presence across children and adolescents. Additionally, the study examines whether those at highest risk of developing caries have sealants, in line with the current recommendations. This information provides guidance on whether further actions are needed in increasing the prevalence of sealants in those at high risk of developing caries.

Before investigating the associations between various population characteristics and sealant prevalence to try to inform new policies, the current body of knowledge on this topic must be explored. It is known that caries prevalence is not uniform across populations, rather disproportionately affects certain segments of the population, especially low income populations. Among all children and adolescents, those who live below the poverty level are at higher risk for developing dental caries. In addition, there are racial/ethnic differences. For example, in children ages 2-9, whether they are poor or non-poor, Mexican Americans are at highest risk for dental caries in primary teeth, followed by non-Hispanic blacks and non-Hispanic whites (1). In adolescents ages 12 to 17, the average number of permanent teeth with dental

caries is similar among Mexican Americans, non-Hispanic whites, and non-Hispanic blacks (1).

After an analysis of over 75 supporting academic articles, the American Academy of Pediatric Dentistry released a Caries-risk Assessment Tool which accounts for a variety of factors that put someone at risk for developing caries. Among children ages 6 and above, those who are of low socioeconomic status, those who have more than three sugary snacks or beverages between meals, those with one or more interproximal lesions, those with active white spot lesions or enamel defects, those without a dental home, and those with low salivary flow are considered at high risk for developing caries (12). This is largely consistent with previous findings across all age groups which show that risk factors for development of caries include variations in tooth enamel in terms of pits and fissures, high streptococci mutans count, previous caries experience, frequent snacking, poor oral hygiene, poverty, inadequate fluoride, and reduced saliva flow (6). Recommendations for care vary based on risk status, and therefore it is important to assess risk early in childhood to prevent the development of caries in the future. Careful risk assessment also guides treatment options for community-based programs, where prudent use of resources is critical. Dental sealant placement requires use of trained professionals and thus has higher related costs. Currently, sealants are under-utilized by private providers. School-based sealant programs have the potential to be more efficient, as they are usually targeted at those schools whose students are mostly low-income and eligible for free school lunches, with a cutoff at 185% of the federal poverty guideline, but

these programs are under-utilized as well, reaching less than 25% of high-need schools in most states (15,16).

While the dental caries infectious process could potentially affect all surfaces of the tooth structure, it is more likely to occur where the biofilm remains undisturbed, allowing acid-producing bacteria to thrive. Among these locations are the pits and fissures that occur on the occlusal (chewing surfaces) of the teeth. Dental sealants are specifically designed to protect the occlusal tooth surfaces. For these surfaces, sealants are very effective when applied correctly, having been proven to reduce caries by 80 percent in the two years after their placement (16). Dental sealants have also been shown to prevent the progression of early, noncavitated carious lesions (11). Due to the relatively low cost of placing a sealant, about one third of what a filling would cost, sealants have been touted as a cost-saving measure when applied according to current guidelines (16). This is evident when examining services provided to those enrolled in private dental insurance plans and Medicaid, as those who had sealants placed on permanent first and second molars were associated with reductions in provisions of restorative dental services (17,18). Sealant placement recommendations include those at high risk for development of caries, particularly those who have been affected by caries in the past and those who have medical conditions associated with higher rates of caries (1).

Overall, this research study addresses the shortcomings in sealant understanding in terms of what characteristics are associated with having sealants. Current literature to date details temporal outcomes in relation to the placement of sealants and their effectiveness using a randomized experimental or cohort design.

Previous studies investigate whether or not sealants are present as an exposure, but fail to account for who is actually receiving the sealants. A major innovation of this study is that sealant prevalence in children (ages 6-11) and adolescents (ages 12-18) is investigated. Adolescents are often overlooked in ongoing research, a gap which this study addresses. Variables which most accurately determine whether someone has sealants, and the variation by age group (6 to 11 year olds or 12 to 18 year olds) were examined. A gap in literature that this proposal addresses is its distinction of high risk variables for developing caries through the use of the AAPD's Caries-risk Assessment Tool, and their association with sealant prevalence.

Chapter 3: Methods and Study Population

I. Study Design

This study is a secondary data analysis of a subsample of the 2011-2012 NHANES Demographic, Examination, and Questionnaire data sets, and employs a design-based analysis, as recommended by the National Center for Health Statistics. The statistical software SAS University Edition (SAS Institute, Cary, NC) was used to analyze the data and determine associations between the variables.

II. Data Source

The data source is the NHANES 2011-2012 Demographic, Examination, and Questionnaire data sets. NHANES is a nationally representative, complex, multistage probability design, cross sectional data set collected in two year cycles and consists of a small number of primary sampling units across the United States (19). To have a sample size which is sufficient enough to produce reliable estimates in data analysis, the NHANES data used for this study oversamples Non-Hispanic Asians, Hispanics, Non-Hispanic blacks, Non-Hispanic white and Other race people aged 80 years and older, and non-Hispanic white and Other people at or below 130 percent of the federal poverty line, and subsequently weights the values associated with each oversampled group. Those 16 years and older were interviewed directly, while those under 16 had a proxy provide information for them.

The NHANES data is divided up into 5 data sets (Demographics, Dietary, Examination, Laboratory, and Questionnaire data sets) according to the phase in which it was collected. In this study, select variables from the Demographics,

Examination, and Questionnaire data sets from NHANES 2011-2012 are used since this is the most recently released set which includes data from a full mouth examination. The dental components of interest within this NHANES include: dental sealant assessment, tooth count, coronal caries, recommendations for dental care, and dental visits. The dental examination is rigorously formulated to ensure high inter-rater reliability between dental examiners. Participants are examined by trained dentists, and values for variables from the examination data set are recorded in accordance with standardized protocols to ensure minimal measurement bias. To maintain accuracy, there is an intense training period for all dental staff prior to data collection, monitoring of dental examiners, and periodic retraining of teams (19).

III. Description of Participants and Criteria for Selection

The 2011-2012 NHANES screened sample consisted of 13,431 persons, both male and female, 9,338 of who completed the examination portion of the survey, amounting to a response rate of 69.5 percent. A nonresponse bias analysis revealed that after weighting adjustments, there were no large relative differences for the examined people (20). NHANES data represents the US civilian non-institutionalized population. Criteria for selection include children ages 6-18 who are not edentulous, and completion of the Examination, Demographic, and Questionnaire portions of the survey. After applying all selection criteria, the NHANES sample of eligible participants ages 6-18 was 2,251.

IV. Human Subjects

A waiver was obtained from the Institutional Review Board (IRB) to verify non-human subject research with publicly-available, de-identified data.

V. Independent and Dependent Variables

Independent variables

An array of variables from the data sets were examined and incorporated into the analysis phase of the study. Independent variables included gender, age, family income, type of health insurance, race/ethnicity, dental visit history, dental caries history, and untreated decay. An additional variable, dental home, was constructed from the dental visit history variable.

Gender

Gender was a dichotomous variable, and consisted of two values, male or female, consistent with NHANES 2011-2012 reporting of variables.

Age

Age was measured in years, and was recoded as dichotomous, taking on the values of “child” or “adolescent”. Those coded as children were between the ages of 6 and 11, while those coded as adolescents were between the ages of 12 and 18.

Family income

Family income was measured as income to poverty ratio, consistent with federal poverty guidelines. Family income was recoded into a categorical variable for the purposes of the research aims, with the values of 0, 1, 2, 3. A value of 0 denotes a family income of below the federal poverty line, a value of 1 denotes a family income

of 1 to 2 times the federal poverty line, a value of 2 denotes a family income of 2 to 3 times the federal poverty line, and a value of 3, which denotes a family income of 3 or more times the federal poverty line.

Health Insurance

Type of health insurance was a categorical variable measured as having no health insurance, having private health insurance, or having public health insurance available through various federal and state programs. According to the U.S. Census Bureau's Current Population Survey Health Insurance definitions, those with health insurance provided by Medicare, Medicaid, SCHIP, military health care, Indian Health Service, state-sponsored plans, government insurances, or single-service plans were categorized as having public health insurance (21).

Race/ethnicity

Race/ethnicity was a categorical variable with the values of Mexican American, Other Hispanic, Non-Hispanic white, Non-Hispanic black, Non-Hispanic Asian, and Other race. The Other race category includes those children and adolescents who are multi-racial.

Dental visit history

Dental visit history was captured as a categorical variable, with values consisting of having seen a dentist within 6 months or less, 6-12 months ago, 1-2 years ago, 2 or more years ago, and never having visited a dentist.

Dental caries history

The variable assessing dental caries history was measured through the creation of a DMFT (decayed, missing, filled teeth) index of all those who currently have or have ever had dental restorations or were missing teeth due to dental disease (22). This allowed for the accurate measure of all those who had a history of caries before, and had at least one carious lesion in the past. This was a dichotomous variable and was measured as having had caries before or not having had caries before.

Untreated decay

The variable of untreated decay was dichotomous and measured whether any decay was present in any teeth during the time of the dental examination. This variable was created from the OHAROCDT variable in the NHANES data set, which only had data for all those who had present decay. The missing values were assumed to not have present decay through mutual exclusivity and coded as such.

Dental home

The AAPD defines a dental home as an ongoing relationship between a dentist and the patient which includes all aspects of oral health care (23). For the purposes of this study, presence of a dental home was defined by the surrogate measure of having been to a dentist within the past 2 years, while absence of a dental home was defined as not having been to the dentist within the past 2 years. This approach to a dental home measure was coded as a dichotomous variable, as the presence or absence of a dental home/visit in the last 2 years. Unfortunately, this variable definition is not truly a dental home as envisioned by term and policy, but is best measure available due to limitations of NHANES data (23).

Dependent variable

For both testable aims 2 and 3 and as the overall outcome of this study, the dependent variable was the presence or absence of dental sealants. This was a dichotomous variable and was measured as having no sealants on any permanent teeth, or having at least one sealant on a permanent tooth.

Chapter 4: Data Analysis

Necessary variables from the 3 different dataset components, Demographic, Examination, and Questionnaire, were merged together. This was done by first sorting by the unique identifier for each participant, the SEQN number. Once cleaning of data and definition of variables was complete, data analysis ensued. Descriptive statistics were used to assess the frequency distribution of each variable of interest before doing more in depth statistical analysis.

I. Aim 1

To address the aims, the presence of sealants was assessed on a dichotomous scale of 0 and 1, where 0 represents no sealants on any teeth, and 1 represents 1 or more sealants. For Aim 1, descriptive statistics consisting of frequency distribution and percent were conducted for each of the variables of interest, stratifying by age group (6-11 and 12-18). Binary analysis were performed via chi-squared tests to assess the crude associations between having sealants and the variables. Variables of interest include gender, family income, type of health insurance, race/ethnicity, dental visit history, dental caries history, dental home, and untreated decay.

II. Aim 2

To complete Aim 2, a multiple logistic regression model was used, examining the independent associations between the presence of sealants on permanent teeth and gender, family income, type of health insurance, race/ethnicity, dental visit history, and dental caries history. The effect of age group was tested as a moderator. For the variable of gender, males were assigned as the reference group. To allow for a more

thorough examination of those living near or below the poverty line according to federal guidelines and the association different levels of this variable may have with sealant presence, family income was categorized into 4 distinct categories: those living below the poverty level (<1), those living at one to two times the poverty level (1-2), those living at two to three times the poverty level (2-3), and those living at three or more times the poverty level (>3). Those living below the poverty level served as the reference group for this variable. Having no health insurance was assigned as a reference group for the health insurance variable, to examine the impact public and private insurance has upon association with sealant presence. Public insurance was defined as Medicare, Medicaid, SCHIP, military health care, Indian Health Service, state-sponsored plans, government insurances, or single-service plans. In order to allow for comparisons to all races, Non-Hispanic white served as the reference category for the variable of race/ethnicity, consistent with previous literature on the topic. Having a history of caries was considered the reference group for dental caries history. When looking at dental visit history, the category "more than 2 years ago" served as the reference group to allow for a more precise comparison between those who never visit the dentist, those who rarely visit a dentist, and those who have recently and may more regularly visit the dentist.

III. Aim 3

To address Aim 3, the variables defined as high risk for caries referenced by the AAPD's Caries-Risk Assessment Tool were used, and consisted of family income, dental home, and untreated caries. For the purposes of this analysis, not having a dental home was defined as not having a dental visit within the past 2 years. Sealant

presence was a dichotomous variable which was defined as having sealants or not having sealants. A logistic regression was used to test associations between high risk variables and sealant presence. Presence of untreated decay served as the reference group for the variable measuring untreated decay, and absence of a dental home served as the reference for the dental home variable.

Initially, this study aimed to compare those who were at high risk for dental caries, classified as those meeting all three of the aforementioned AAPD criteria for being at high risk for caries, to those who were classified as low risk for developing caries, however, due to an extremely limited resulting sample size following variable classifications, this approach was modified to reflect the methodology explained above due to the issue of insufficient statistical power.

Chapter 5: Results

I. Aim 1

After applying all inclusion and exclusion criteria, the final study sample consisted of 2251 youth, with 1229 (54.6%) children and 1022 (45.4%) adolescents. The distribution of males and females was evenly balanced, with 1152 (51.2%) males and 1099 (48.8%) females. Of all children and adolescents, 835 (37.1%) had at least one sealant present during the Examination portion of the 2011-2012 NHANES data collection, while 1416 (62.9%) did not have any sealants present. When examining sealant presence by age group, 422 (34.3%) children had sealants, while 413 (40.4%) adolescents had sealants. Descriptive statistics for the sample as a whole, and by age group, pertaining to demographic characteristics and variables investigated are presented in Table 1 in further detail. The table provides descriptive statistics and crude associations with sealant presence for the same variables stratified by age group, for children (ages 6-11) and adolescents (ages 12-18).

II. Aim 2

Age was tested as a modifier in Aim 2, proving the interaction term to be significant ($p<0.01$), providing enough evidence to stratify the results by age and calculate odds ratios separately in children and adolescents.

In children, as seen in Table 2, those with a family income to poverty ratio of 1-2 and 2-3 times the poverty level had statistically significantly higher odds of having at least one sealant, compared with those who were living below the poverty level ($p=0.04$, 95% CI: 1.01-1.98 and $p=0.03$, 95% CI: 1.05-2.61, respectively). Non-

Hispanic black and Non-Hispanic Asian children had lower odds than Non-Hispanic white children of having at least one sealant ($p=0.01$, 95% CI: 0.40-0.82 and $p<0.05$, 95% CI: 0.38-0.98, respectively). Non-Hispanic black children had 0.56 times the odds of having sealants and Non-Hispanic Asian children had 0.61 times the odds of having sealants as compared with Non-Hispanic white children. Children who had visited a dentist within the past 6 months and those who had visited a dentist within the past 6 to 12 months also had increased odds for having at least one tooth sealed compared with those who had been to the dentist more than two years ago ($p<0.01$, 95% CI: 3.61-25.31 and $p=0.01$, 95% CI: 2.09-15.46, respectively). Compared with those who had been to the dentist more than two years ago, children who had been to the dentist within 6 months had 8.56 times the odds of having at least one sealant and those who had been to the dentist between 6 to 12 months ago had 5.13 times the odds of having at least one sealant. Gender, health insurance, and dental caries history were not statistically significant in association with sealant presence or absence in children.

Adolescents with a family income to poverty ratio of 3 or more times the poverty level had lower odds of having at least one sealant compared with those adolescents living below the poverty level ($p<0.05$, 95% CI: 0.41-0.99). Non-Hispanic black adolescents ($p=0.01$, 95% CI: 0.41-0.88) had lower odds of having sealants placed than did Non-Hispanic white adolescents. More specifically, Non-Hispanic black adolescents had 0.60 times the odds of having sealants than Non-Hispanic white adolescents. Those adolescents who never had any dental caries had 2.23 times the odds of having at least one sealant placed in comparison to those who

had a history of dental caries (p<0.01, 95% CI: 1.72-3.03). Adolescents who had visited the dentist within 6 months or within 6 to 12 months had higher odds of having sealants than did those adolescents who had been to a dentist more than two years ago (p<0.01, 95% CI: 2.63-9.28, p<0.01, 95% CI: 2.16-8.22). Those who had been within 6 months had 4.78 times the odds of having sealants as compared to those who had been to a dentist more than two years ago. Health insurance type and gender were not found to be statistically significant in association with sealant presence in adolescents as seen in Table 2.

III. Aim 3

After testing the associations of AAPD variables designated as placing youth at high risk for caries as detailed in Aim 3, untreated decay and dental home variables were found to be statistically significant in both children and adolescents (Table 3). In children, those without untreated decay had 2.59 times the odds of having sealants and those with a dental home had 6.40 times the odds for having sealants placed as compared to children with untreated decay and without a dental home (p<0.01, 95% CI: 1.83-3.72 and p<0.01, 95% CI: 2.98-16.71, respectively). Adolescents who did not have untreated decay had 3.91 times the odds of having sealants and those who did have a dental home had 2.94 times the odds of having sealants placed than those with untreated decay and without a dental home (p<0.01, 95% CI: 2.59-6.07 and p=0.01, 95% CI: 1.72-5.27, respectively). When looking at those without untreated decay in comparison to those with untreated decay, the odds ratio for adolescents is 1.51 times that of the odds ratio for having sealants in children. The opposite was true

when looking at those with a dental home in comparison to those without a dental home, where the odds ratio for children having sealants was 2.18 times the odds ratio of adolescents having sealants.

Chapter 6: Discussion

I. Overall Findings

This study was designed to examine associations between demographic, socioeconomic, and descriptive variables and sealant presence in children and adolescents to contribute to the understanding of sealant prevalence across various populations. As expected, disparities in sealant presence exist between those of different racial/ethnic groups, family income levels, and dental histories and care-seeking behaviors. The odds of children from families living below the poverty line having at least 1 sealant were significantly lower than those children living above the poverty line. In adolescents, unlike in children, there was no difference in sealant presence between those living below and above the poverty line, with the exception of those who were of highest income. The association between family income and sealant presence provided evidence that those adolescents living at the highest family income levels were at lower odds for having sealants than the adolescents from the poorest families. This finding indicates that current targeted sealant placement and education programs, such as those implemented through schools with a majority of low income students, may be successfully reducing the risk of caries through sealant placement in low income adolescents. Previous studies seem to support the feasibility of this observation, with the conclusion that school-based sealant programs targeting low income schools are effective in reaching students who are at high risk for caries based on income level (24). Since the first set of molars, which are highly susceptible to decay, erupt at about the age of 6 or 7, initiating sealant placement immediately after eruption of those teeth would allow for a protective barrier preventing decay

before it begins and causes loss of tooth structure (25). According to the AAPD, adolescents from families with the lowest incomes are at highest risk for developing caries, indicating that they should be the ones who have the highest rates of dental sealant placement, making this study's findings appear promising for the field of dental caries prevention.

When looking at racial/ethnic differences, Non-Hispanic black children and adolescents had lower odds of having at least one sealant than did Non-Hispanic Asian (children only) and Non-Hispanic white children and adolescents. This is supported by the actual prevalence rates of sealants in these populations, where Non-Hispanic black children and adolescents have the lowest prevalence for having sealants compared with all other races/ethnicities (26). Especially unsettling is that Non-Hispanic black populations have one of the highest odds of having poor oral health and experiencing delayed care and unmet needs of all racial/ethnic groups (27). This need, combined with the disparity in sealant prevalence, pushes Non-Hispanic black children and adolescents towards the forefront of those requiring preventive measures in dental health.

Adolescents who had a history of dental caries had lower odds of having sealants than those who had never had caries before, which exposes a missed opportunity for education of patients while they are being treated for previous carious lesions. Since those who have had dental caries before are at a higher risk of future caries, these patients would benefit most from having sealants placed, making them excellent candidates for sealant placement (28). Given the wide underutilization of sealants, dental appointments at the time of tooth restoration could serve as a strategic

time during which future sealant placement could be addressed with a parent or caregiver of a patient.

Youth (6-18 year olds) with less frequent or non-existent dental visits, untreated decay, and without a dental home had much lower odds of having dental sealants than their counterparts. This is not unexpected since placement of dental sealants requires a dental professional, with encounter either through community programs (school-based) or through traditional dental visits, which rely almost entirely on the caregiver's initiative to take the child to a dentist for care.

This study provides evidence for further research into the use and application of dental sealants for high risk adolescents. In turn, these additional investigations may inform more targeted programs and recommendations for high risk youth who may be currently overlooked. Since the placement of sealants is effective even if not placed immediately after eruption, if those who fall through the cracks as young children are included in sealant application programs later on in adolescence, there is potential to decrease rates of caries initiation and progression (11). Evidence supporting the implementation of sealants later in childhood and into adolescence after second molars erupt could lead to expansion of current school-based sealant programs to encompass high schools, which could have a large public health impact in decreasing the rates of caries in high-risk, low-income school-aged children and adolescents (29).

II. Study Strengths and Limitations

Strengths:

This is the first study which examines the association between high risk variables for caries based on the AAPD Caries-Risk Assessment Tool and sealant prevalence using the NHANES 2011-2012 data for children and for adolescents. A major strength of this research is that it is based upon a large, diverse nationally representative sample, from which conclusions can be drawn about trends and health status nationwide. In addition, due to the high standards of accuracy and consistency within the NHANES data collection, the measurements taken are standardized according to strict protocols to minimize bias in recording of data.

Limitations:

Due to this study being a secondary analysis of a pre-existing dataset, the analysis was limited to the variables included in the NHANES data collection. Because of this, data could only be analyzed from a two-year sampling frame, 2011-2012, since this is the most recent data set which has tooth-by-tooth information on caries and sealant prevalence. The cross-sectional design and lack of data from previous years, does not allow for investigation of trends in sealant prevalence over time, but only for measurements which were taken at one point in time. Use of the proxy, time since last dental visit, is very limited in accurately determining whether someone has a dental home, since this value does not provide detailed information on the patient-provider relationship, continuity of care, and whether the dental visits were completed by a regular primary care dentist. Additionally, having a dental home and visiting a dentist regularly does not guarantee sealant placement will occur,

further devaluing dental home as a measure which may predict dental sealant placement.

As there is no data on whether sealants were placed through a community or school-based sealant program, there is no way to evaluate the effectiveness or reach of these programs to determine what proportion of sealants placed nationwide are through private practices or targeted sealant programs. Furthermore, the 2011-2012 NHANES did not collect data on household water fluoride levels, or other indicators of fluoride exposure, an important aspect of caries risk assessment. Ideally, the inclusion of this information as another potential high risk variable (if there is a lack of, or limited exposure to fluoride) would allow for a more informed estimation for identifying those at high risk for caries. However, the analytic plan and methodology detailed in this study allows for the inclusion of this variable when it becomes available for analysis with the release of the next wave of NHANES data in the spring of 2016.

III. Public Health Significance

This study evaluates associations between socioeconomic, demographic and high risk for caries variables and the presence of dental sealants. Findings indicate that dental visit behavior, dental caries history, and race/ethnicity are associated with disparities in sealant prevalence for children and for adolescents. These associations need to be further addressed, and have policy and recommendation implications in the effort to reduce the prevalence of caries. In accordance with the Healthy People 2020 OH-12 objective of increasing the proportion of children and adolescents who have

received dental sealants on their molar teeth (30), this study informs which populations are in highest need of a targeted intervention for increasing sealant placement in terms of cost-benefit. Naturally, those who have the most to gain from sealants should be the focus of interventions aimed at increasing sealant placement.

IV. Future Studies

The existence and value of dental sealants as a preventive measure against caries is unrecognized among many patients, and needs to be brought to the forefront through patient and provider education. To aid in this, patient attitudes towards sealants need to be examined across various populations and educational backgrounds nationwide. Barriers and facilitators to parents having sealants placed on their children's teeth also need to be investigated to synthesize the most effective interventions aimed at increasing sealant prevalence rates. Successful implementation of more widespread sealant application to those who need it requires the participation of providers, highlighting an area of research that remains to be explored. The examination of differential sealant placement patterns between providers could provide valuable information about which providers are hesitant in recommending sealants, and which patient characteristics serve as the impetus for such recommendations.

A better understanding of the design and structure of sealant outreach programs including venues such as school-based sealant programs would provide further insight into the factors reflecting differences in sealant placement. Issues with sealant placement protocol, availability of resources, and patient acceptance of

sealants should be explored to understand and ultimately increase the reach of these programs.

Additionally, more comprehensive information is necessary on sealant placement trends among adolescents, especially those pertaining to second molars. Future studies could focus on prevalence of sealants on second molars to see if the same patterns observed in this study hold true. This study provides an effective framework for further investigation of these associations within future waves of NHANES data sets after their release, in which fluoride exposure is captured in conjunction with sealant presence. The availability of information on fluoride is essential in the development of a comprehensive caries risk profile, and will allow for a more accurate description of what populations are at elevated risk for caries.

V. Conclusions

Disparities exist in sealant prevalence across racial/ethnic groups, and dental disease and visit characteristics.

Racial disparities in who receives sealants are highlighted throughout this study, as Non-Hispanic blacks have statistically significant lower odds of having sealants than Non-Hispanic whites, and Non-Hispanic Asians (in children). As expected for individuals in both of these age groups, not having untreated decay was associated with having at least one dental sealant. Given the need for professional placement of sealants, this study affirms the association of having dental sealants for both children ages 6-11 and adolescents ages 12-18 with having a dental visit in the past two years. However, the odds of adolescents who have had a dental visit in the

past two years having a dental sealant is half that of a child age 6-11. Further research is needed to understand the reasons for these differences and their etiologies.

Table 1. Sociodemographic and Dental Characteristics for All Individuals (ages 6-18) and Those with ≥1 Dental Sealants, by All Individuals, Children (ages 6-11), and Adolescents (ages 12-18)

				≥1 Sealant[₩]					
		Children (ages 6-11)	Adolescents (12-18)	Children and Adolescents		Children (ages 6-11)		Adolescents (ages 12-18)	
Variable	N(%)	N(%)	N(%)	N(%)	p-value[ω]	N(%)	p-value[ω]	N(%)	p-value[ω]
All participants	2251 (100)	1229 (54.6)	1022 (45.50)	835 (37.09)	-	422 (18.75)	-	413 (18.35)	-
Gender					0.953		0.8726		0.945
Male	1152 (51.18)	631 (51.34)	521 (50.98)	428 (19.01)		218 (17.74)		210 (20.55)	
Female	1099 (48.82)	598 (48.66)	501 (49.02)	407 (18.08)		204 (16.60)		203 (19.86)	
Age					0.003		-		
Children (ages 6-11)	1229 (54.60)	-	-	422 (18.75)		422 (18.75)		-	-
Adolescents (ages 12-18)	1022 (45.40)	-	-	413 (18.35)		-		413 (18.35)	-
Family Income*					0.238		0.1691		0.4655
<1	714 (31.72)	429 (34.91)	285 (27.89)	248 (11.02)		134 (10.90)		114 (11.15)	
1-2	552 (24.52)	299 (24.33)	253 (24.76)	210 (9.33)		114 (9.28)		96 (9.39)	
2-3	276 (12.26)	147 (11.96)	129 (12.62)	111 (4.93)		58 (4.72)		53 (5.19)	
>3	537 (23.86)	275 (22.38)	262 (25.64)	210 (9.33)		93 (7.57)		117 (11.45)	
Type of Health Insurance					0.2531		0.6644		0.1098
None	253 (11.32)	124 (10.11)	129 (12.80)	89 (3.98)		38 (3.10)		51 (5.06)	
Private	854 (38.21)	437 (35.62)	417 (41.37)	335 (14.99)		150 (12.22)		185 (18.35)	
Public	1128 (50.47)	666 (54.28)	462 (45.83)	405 (18.12)		232 (18.91)		173 (17.16)	
Race/Ethnicity					<0.0001		0.0059		0.0042
Mexican American	428 (19.01)	252 (20.5)	176 (17.22)	181 (8.04)		99 (8.06)		82 (8.02)	
Other Hispanic	258 (11.46)	142 (11.55)	116 (11.35)	90 (4.00)		46 (3.74)		44 (4.31)	
Non-Hispanic White	523 (23.23)	293 (23.84)	230 (22.50)	221 (9.82)		119 (9.68)		102 (9.98)	
Non-Hispanic Black	645 (28.65)	345 (28.07)	300 (29.35)	191 (8.49)		97 (7.89)		94 (9.20)	
Non-Hispanic Asian	277 (12.31)	125 (10.17)	152 (14.87)	103 (4.58)		35 (2.85)		68 (6.65)	
Other Race (incl. multiracial)	120 (5.33)	72 (5.86)	48 (4.70)	49 (2.18)		26 (2.12)		23 (2.25)	
Dental visit history[ǂ]					<0.0001		<0.0001		<0.0001
6 months or less ago	1385 (61.75)	774 (63.18)	611 (60.02)	601 (26.79)		318 (25.96)		285 (27.80)	
6 - 12 months ago	456 (20.33)	256 (20.90)	200 (19.65)	159 (7.09)		75 (6.12)		84 (8.25)	
1-2 years ago	216 (9.63)	110 (8.98)	106 (10.41)	52 (2.32)		23 (1.88)		29 (2.85)	
2 or more years ago	138 (6.15)	52 (4.24)	86 (8.45)	19 (0.85)		5 (0.41)		14 (1.38)	
Never have been	48 (2.14)	33 (2.69)	15 (1.47)	4 (0.18)		1 (0.08)		3 (0.29)	
Dental caries history[§]					0.0089		0.3445		<0.0001
History of caries	1341 (59.57)	723 (58.83)	618 (60.47)	468 (20.79)		256 (20.83)		212 (20.74)	
No history of caries	910 (40.43)	506 (41.17)	404 (39.53)	367 (16.30)		166 (13.51)		201 (19.67)	
Presence of untreated decay					<0.0001		<0.0001		<0.0001
Yes	439 (19.5)	253 (20.59)	186 (18.20)	76 (3.38)		46 (3.74)		30 (2.94)	
No	1812 (80.5)	976 (79.41)	836 (81.80)	759 (33.72)		376 (30.59)		383 (37.48)	
Dental home					<0.0001		<0.0001		<0.0001
Yes	2057 (91.71)	1140 (93.06)	917 (90.08)	812 (36.20)		416 (33.96)		396 (38.90)	
No	186 (8.29)	85 (6.94)	101 (9.92)	23 (1.03)		6 (0.49)		17 (1.67)	
Presence of sealants[β]					-		-		-
Yes	835 (37.09)	422 (34.34)	413 (40.41)	422 (34.34)		-		413 (40.41)	
No	1416 (62.91)	807 (65.66)	609 (59.59)	-		-		-	

ω p-values of crude associations with sealant presence generated by Chi-Square tests for statistical significance.

* Expressed as income to poverty ratio, where family income is expressed as a ratio to the federal poverty line.

ǂ Dental visit history refers to the last time participant visited a dentist.

§ Whether participant has ever had dental caries.

β Whether participant has one or more dental sealants.

₩ Percentages expressed as a proportion of participants with at least one sealant.

Table 2. Sociodemographic and Dental Characteristics of Children and Adolescents with ≥1 Dental Sealants

	Children (ages 6-11)		Adolescents (ages 12-18)	
Variable	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Gender				
Male	1	-	1	-
Female	0.954 (0.745-1.221)	0.708	0.907 (0.694-1.185)	0.4742
Family Income[₱]				
<1	1	-	1	-
1-2	1.413 (1.009-1.978)	0.0440**	0.711 (0.485-1.039)	0.0786
2-3	1.662 (1.057-2.609)	0.0272**	0.763 (0.470-1.234)	0.2723
>3	1.062 (0.688-1.638)	0.7856	0.639 (0.409-0.995)	0.0482**
Health Insurance				
None	1	-		-
Private insurance	0.890 (0.540-1.476)	0.6473	0.995 (0.615-1.613)	0.9833
Public insurance	1.044 (0.662-1.664)	0.8533	0.819 (0.521-1.290)	0.3871
Race/Ethnicity				
Mexican American	1.170 (0.799-1.714)	0.419	1.413 (0.910-2.198)	0.1244
Other Hispanic	0.820 (0.525-1.272)	0.3787	0.675 (0.412-1.098)	0.1156
Non-Hispanic White	1	-	1	-
Non-Hispanic Black	0.575 (0.403-0.817)	0.0021**	0.603 (0.412-0.881)	0.0090**
Non-Hispanic Asian	0.614 (0.378-0.984)	0.0450**	1.005 (0.647-1.560)	0.9816
Other Race (incl. multiracial)	0.950 (0.540-1.648)	0.8563	1.208 (0.629-2.314)	0.5689
Dental caries history[§]				
History of caries	1	-	1	-
No history of caries	0.922 (0.711-1.194)	0.5387	2.275 (1.716-3.027)	<.0001**
Dental visit history[ǂ]				
6 months or less ago	8.561 (3.608-25.308)	<.0001**	4.780 (2.626-9.284)	<.0001**
6 - 12 months ago	5.126 (2.094-15.455)	0.0011**	4.096 (2.161-8.221)	<.0001**
1-2 years ago	2.577 (0.964-8.191)	0.0772	1.746 (0.846-3.734)	0.1388
More than 2 years ago	-	-	-	-
Never have been	0.330 (0.017-2.193)	0.3234	0.746 (0.151-2.839)	0.687

[₱]Expressed as income to poverty ratio

[ǂ] Dental visit history refers to the last time participant visited a dentist.

[§] Whether participant has ever had dental caries.

Table 3. Association of Select Caries Risk Variables and Presence of ≥1 Dental Sealants in Children and Adolescents

	Children (ages 6-11)		Adolescents (ages 12-18)	
Variable	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Family Income[Ꝑ]				
<1	1	-	1	-
1-2	1.350 (0.980-1.859)	0.0662	0.858 (0.595-1.234)	0.4096
2-3	1.356 (0.906-2.023)	0.1364	0.881 (0.566-1.367)	0.5742
>3	0.916 (0.657-1.274)	0.6026	0.890 (0.623-1.270)	0.52
Untreated decay				
Yes	1	-	1	-
No	2.590 (1.832-3.724)	<.0001**	3.909 (2.592-6.070)	<.0001**
Dental home				
Yes	6.404 (2.975-16.707)	<.0001**	2.937 (1.724-5.274)	0.0001**
No	1	-	1	-

[Ꝑ]Expressed as income to poverty ratio

Appendices

1. MPH in Epidemiology Competencies
2. IRB Approval Form

MPH in Epidemiology Competencies Addressed

Competency	How it was addressed
1. Identify vital statistics and other key sources of data for epidemiological purposes	This was achieved through the planning of the thesis and searching for appropriate sources of data. The final determination was to work with the cross-sectional NHANES data set for the epidemiological purpose of conducting a secondary data analysis.
2. Describe a public health problem in terms of magnitude, person, time and place.	In the decision to address dental caries as a public health problem, I identified the magnitude, persons affected, time, and place in the background/literature review section of the thesis.
4. Comprehend basic ethical and legal principles pertaining to the collection, maintenance, use and dissemination of epidemiologic data.	This is addressed in the background investigation into using the NHANES data set, as all legal and ethical principles pertaining to the collection, maintenance, use and dissemination of the data from the sets was addressed in their IRB approval, as well as throughout the tutorial about the data set.
5. Explain the importance of epidemiology for informing scientific, ethical, economic and political discussion of health issues.	The importance of the epidemiological data analysis results are detailed in the discussion and conclusion section of the thesis, in relation to further scientific studies needing to be done on sealant use, related ethical concerns, economic implications, and political influences such as policy changes.
6. Apply the basic terminology and definitions of epidemiology.	The writing and completion of the thesis allowed me to apply basic epidemiological terminology and definitions when describing the incidence, prevalence, and distribution of dental caries and associated sealants.
7. Calculate basic epidemiology measures.	The completion of the descriptive statistics portion of my analysis included the calculation of basic epidemiology measures.
8. Communicate epidemiologic information to lay and professional audiences.	In detailing my results, I communicated my findings in terms of epidemiologic information to both lay and professional audiences.
10. Draw appropriate inferences from epidemiologic data.	The interpretation of my statistical analysis allowed me to draw inferences from the data and make conclusions based on my findings.
13. Calculate advanced epidemiology measures.	The statistical analysis portion of my thesis completed using SAS allowed me to calculate advanced epidemiology measures based on the 2011-2012 NHANES data available.

IRB Approval Form

UNIVERSITY OF MARYLAND
INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	December 11, 2015
TO:	Agnieszka Roman, BS, BS
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[844573-1] An Investigation of Child and Adolescent Dental Sealant Predictors, NHANES 2011-2012
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF NOT HUMAN RESEARCH
DECISION DATE:	December 11, 2015

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has determined this project does not meet the definition of human subject research under the purview of the IRB according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Maryland College Park (UMCP) IRB's records.

Bibliography

1. U.S. Department of Health and Human Services, National Institute of Dental and Craniofacial, Research, National Institutes of Health. Oral Health in America: A Report of the Surgeon General. 2000.

2. Dental Caries (Tooth Decay) in Children (Age 2 to 11) [Internet]. [cited 2015 Oct 17]. Available from: http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/DentalCaries/DentalCariesChildren2to11.htm

3. Dental Caries (Tooth Decay) in Adolescents (Age 12 to 19) [Internet]. [cited 2015 Oct 17]. Available from: http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/DentalCaries/DentalCariesAdolescents12to19.htm

4. Casamassimo PS, Thikkurissy S, Edelstein BL, Maiorini E. Beyond the dmft: The Human and Economic Cost of Early Childhood Caries. J Am Dent Assoc. 2009 Jun;140(6):650–7.

5. Thuku NM, Carulli K, Costello S, Goodman HS. Breaking the cycle in Maryland: oral health policy change in the face of tragedy. J Public Health Dent. 2012 Jan 1;72:S7–13.

6. Selwitz RH, Ismail AI, Pitts NB. Dental caries. The Lancet. 2007 Jan 12;369(9555):51–9.

7. Community Preventive Services Task Force. Oral Health, Dental Caries: Community Water Fluoridation [Internet]. 2013 [cited 2015 Nov 4]. Available from: http://www.thecommunityguide.org/oral/fluoridation.html

8. Ahovuo-Saloranta A, Forss H, Walsh T, Hiiri A, Nordblad A, Mäkelä M, et al. Sealants for preventing dental decay in the permanent teeth. In: The Cochrane Collaboration, editor. Cochrane Database of Systematic Reviews [Internet]. Chichester, UK: John Wiley & Sons, Ltd; 2013 [cited 2015 Nov 4]. Available from: http://doi.wiley.com/10.1002/14651858.CD001830.pub4

9. Horowitz HS. The potential of fluorides and sealants to deal with problems of dental decay. Pediatric Dent. 1982;4(4):286–95.

10. Wendt L-K, Koch G, Birkhed D. On the retention and effectiveness of fissure sealant in permanent molars after 15–20 years: a cohort study. Community Dent Oral Epidemiol. 2001 Aug 1;29(4):302–7.

11. Beauchamp J, Caufield P, Crall J, Donly K, Feigal R, Gooch BF, et al. Evidence-based clinical recommendations for the use of pit-and-fissure sealants. J Am Dent Assoc. 2008 Mar;139(3):257–67.

12. American Academy of Pediatric Dentistry. Guideline on caries-risk assessment and management for infants, children, and adolescents. 2014.

13. ADA Division of Communications. Tooth Eruption: The permanent teeth. J Am Dent Assoc [Internet]. 2006 Jan [cited 2016 Apr 20];137. Available from: http://www.ada.org/~/media/ADA/Publications/Files/patient_58.ashx

14. Sheiham A. Dental caries affects body weight, growth and quality of life in pre-school children. Br Dent J. 2006 Nov 25;201(10):625–6.

15. Scherrer CR, Griffin PM, Swann JL. Public Health Sealant Delivery Programs: Optimal Delivery and the Cost of Practice Acts. Med Decis Making. 2007 Nov 1;27(6):762–71.

16. Pew Charitable Trusts. States Stalled on Dental Sealant Programs [Internet]. 2015. Available from: http://www.pewtrusts.org/~/media/assets/2015/04/dental_sealantreport_final.pdf

17. Weintraub JA, Stearns SC, Rozier RG, Huang CC. Treatment outcomes and costs of dental sealants among children enrolled in Medicaid. Am J Public Health. 2001 Nov;91(11):1877–81.

18. Dennison JB, Straffon LH, Smith RC. Effectiveness of sealant treatment over five years in an insured population. J Am Dent Assoc 1939. 2000 May;131(5):597–605.

19. NHANES 2001 - 2002: Oral Health Data Documentation, Codebook, and Frequencies [Internet]. [cited 2015 Nov 5]. Available from: http://wwwn.cdc.gov/nchs/nhanes/2001-2002/OHQ_B.htm

20. CDC. National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2012. 2013.

21. Staff DI. US Census Bureau Health Insurance main page [Internet]. [cited 2016 Apr 6]. Available from: https://www.census.gov/hhes/www/hlthins/methodology/definitions/cps.html

22. Beltrán-Aguilar ED, Barker LK, Canto MT, Dye BA, Gooch BF, Griffin SO, et al. Surveillance for Dental Caries, Dental Sealants, Tooth Retention, Edentulism, and Enamel Fluorosis — United States, 1988-1994 and 1999-2002. Morb Mortal Wkly Rep Surveill Summ. 2005 Aug 26;54(SS-3):1–43.

23. American Academy of Pediatric Dentistry. Definition of a Dental Home [Internet]. 2015 [cited 2016 Apr 12]. Available from: http://www.aapd.org/media/policies_guidelines/d_dentalhome.pdf

24. Siegal MD, Detty AMR. Do school-based dental sealant programs reach higher risk children? J Public Health Dent. 2010 Jun 1;70(3):181–7.

25. Macek MD, Beltran-Aguilar ED, Lockwood SA, Malvitz DM. Updated Comparison of the Caries Susceptibility of Various Morphological Types of Permanent Teeth. J Public Health Dent. 2003 Sep 1;63(3):174–82.

26. Dye BA, Thornton-Evans G, Li X, Iafolla T. Dental caries and sealant prevalence in children and adolescents in the United States, 2011–2012. [Internet]. NCHS; 2015. Available from: http://www.cdc.gov/nchs/data/databriefs/db191.pdf

27. Fisher-Owens SA, Isong IA, Soobader M-J, Gansky SA, Weintraub JA, Platt LJ, et al. An examination of racial/ethnic disparities in children's oral health in the United States. J Public Health Dent. 2013 Mar 1;73(2):166–74.

28. Ritter AV. Sealants. J Esthet Restor Dent. 2002 May 1;14(3):192–192.

29. Gooch BF, Griffin SO, Gray SK, Kohn WG, Rozier RG, Siegal M, et al. Preventing dental caries through school-based sealant programs: updated recommendations and reviews of evidence. J Am Dent Assoc 1939. 2009 Nov;140(11):1356–65.

30. Oral Health | Healthy People 2020 [Internet]. [cited 2015 Oct 17]. Available from: https://www.healthypeople.gov/2020/topics-objectives/topic/oral-health/objectives