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Periodontal treatment needs in a Medicaid expansion population

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PERIODONTAL TREATMENT NEEDS IN A MEDICAID EXPANSION POPULATION

by

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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To my husband, Alex Sukalski,
for your complete support.

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ABSTRACT

Objective: To investigate and determine periodontal treatment needs by the use of the Community Periodontal Index of Treatment Needs (CPITN) of a Medicaid expansion population in the state of Iowa (DWP) in comparison with patients insured by the traditional Medicaid State Plan, patients with private dental insurance, and self-pay patients, while evaluating for systemic health conditions and socio-behavioral factors.

Methods: A secondary data analysis of electronic health records (EHR) from the University of Iowa College of Dentistry was completed and analyzed. Univariate and bivariate analyses were conducted. Logistic regression models were used to analyze relationships between predictors and periodontal treatment need.

Results: Out of the study population, 54% were indicated for scaling and root planing (SRP). Predictors of indicating the need for SRP treatment were found to be: Age ($p<.0001$), gender ($p<.0001$), medical diagnosis of diabetes ($p=.031$), smoking status ($p<.0001$), and not receiving regular dental check-ups ($p<.0001$).

Discussion: Our findings are consistent with common periodontal disease predictors found in the literature. Interestingly, insurance status was not a significantly associated predictor of periodontal treatment needs. However, approximately 50% patients

with all insurance types were indicated for SRP.

Implications: DWP patients must earn benefits by maintaining dental appointments. This earned benefits approach delays periodontal treatment as patients must earn this procedure, potentially leading to deteriorating periodontal health. Further assessment of periodontal burden in the DWP population should be conducted and potential program structure evaluated.

PUBLIC ABSTRACT

Lack of routine dental care can lead to oral complications. Recent studies connected periodontal disease with other health concerns such as cardiovascular diseases and diabetes. With new evidence linking periodontal disease and serious health problems, it becomes concerning that approximately 50% of the U.S. population suffers from the disease.

The Dental Wellness Plan (DWP) is part of Iowa's Medicaid expansion program providing dental coverage to low-income adults not categorically eligible for Medicaid. DWP patients must "earn" benefits by maintaining dental appointments. This earned benefits approach delays periodontal treatment as patients must earn this procedure, potentially worsening disease.

This study was a secondary data analysis of electronic health records (EHR) at the University of Iowa College of Dentistry. It assessed periodontal treatment needs by determining whether an individual required periodontal disease treatment or routine dental cleaning. It also explored the relationships that exist between treatment need, systemic health conditions, and socio-behavioral factors among DWP in comparison with other insurance types.

It was found that 54% were indicated for periodontal treatment. Predictors of SRP need were found to be: Age ($p<.0001$), gender

(p<.0001), diagnosis of diabetes (p=.031), smoking status (p<.0001), and not receiving regular dental check-ups (p<.0001).

Interestingly, insurance status was not significantly associated with periodontal treatment needs. However, approximately 50% of patients with all insurance types were indicated for SRP. While a large portion of the study population were indicated for periodontal therapy, delaying of treatment in the DWP program could exasperate systemic health and worsen periodontal health of these individuals.

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LIST OF ABBREVIATIONS

DWP	Dental Wellness Plan
ACA	The Affordable Care Act
UI COD	The University of Iowa College of Dentistry
OD	Oral Diagnosis clinic
PD	Probing depth
BOP	Bleeding on probing
CAL	Clinical attachment loss
CEJ	Cementoenamel junction
Loc.	Localized
Gen.	Generalized
OHI	Oral hygiene instruction
Prophy	Prophylaxis
SRP	Scaling and root planing
PRN	When needed
CVD	Cardiovascular diseases
LBW	Low birth weight
NHANES	National Health and Nutrition Examination Survey
CPITN	Community Periodontal Index of Treatment Needs
PSR	Periodontal Screening and Recording
WHO	World Health Organization

SES	Socioeconomic status
FPL	Federal Poverty Level
IHAWP	Iowa Health and Wellness Plan

CHAPTER I

INTRODUCTION

In a report published in 2012 (Eke et al. 2012), it was estimated that nearly half of the adult population in the United States suffers from chronic periodontitis, also known as periodontal disease or simply, gum disease.

Chronic periodontitis is an inflammatory condition that affects the periodontium, which encompasses the alveolar bone, the periodontal ligament, and the gingiva. If not effectively treated, chronic periodontitis is characterized by the progressive destruction of the attachment of the periodontal structures to the tooth cementum, which may lead to profound alterations of the function and esthetics of the natural dentition, including tooth loss.

The pathogenesis of chronic periodontitis responds to intricate interactions between periodontopathogenic bacteria (and their byproducts) and a susceptible host that precipitates an altered immune system response, which is ultimately responsible for the tissue destruction. Clinically, chronic periodontitis is preceded by gingivitis, which is a reversible condition that involves inflammation that is confined to the supracrestal tissue compartment, with no actual attachment loss.

However, not everybody that suffers from gingivitis develops chronic periodontitis. The timeline and severity of periodontal breakdown differs from site to site and from individual to individual, depending on local and systemic factors. These factors may vary at different stages in the lifetime of the host, making chronic periodontitis a very complex disease.

In fact, recent studies have associated chronic periodontitis with other health conditions such as heart disease, stroke, diabetes, and adverse pregnancy outcomes. The high prevalence of chronic periodontitis in the adult U.S. population (~50%), combined with these emerging links between periodontal disease and serious health problems, as well as the impact that untreated severe chronic periodontitis typically has on the quality of life of patients suffering from this condition; make it imperative to consider the effective diagnosis and treatment of chronic periodontitis a top priority in contemporary dental care plans.

Implication

Iowa's Dental Wellness Plan (DWP), a novel insurance plan for low-income individuals, was implemented on May 1, 2014 in Iowa as part of ACA-related Medicaid expansion. This new plan covers individuals who were not categorically eligible for Medicaid but were

still considered to be low-income with incomes up to 133% of the federal poverty level (FPL). With DWP, patients become eligible for additional benefits by maintaining routine dental appointments, as a strategy to encourage patient responsibility for their health and accountability in their treatment.

Due to the population's low-income status, many have not had prior dental coverage. According to a recent survey of DWP members administered by the University of Iowa Public Policy Center, 82% of respondents stated that they had not had dental insurance previously (Reynolds et al. 2015). Many DWP patients have waited years, even decades, to have received dental treatment. This lack of treatment has been demonstrated with many DWP patients presenting for initial dental evaluation with severe periodontal disease conditions.

Unfortunately, the new earned benefits approach with the Dental Wellness Plan does not cover scaling and root planing (SRP), usually the first line of non-surgical therapy for chronic periodontitis, until at least 6 to 12 months after the initial comprehensive exam, dependent on receiving regular check-ups at the prescribed intervals.

The aim of this study was to conduct a secondary chart review to investigate and determine periodontal treatment needs of this Medicaid expansion population based on clinical periodontal record data at the University of Iowa College of Dentistry (UI COD) from the

Oral Diagnosis (OD) clinic.

A secondary aim was to evaluate for associations between treatment needs and systemic health conditions and socio-behavioral factors. The study population includes DWP members during the first two years of program implementation (May 2014 through April 2016); comparison groups include UI COD patients insured by the traditional Iowa Medicaid, patients with private dental insurance, and self-paying patients. This analysis is expected to help to better understand this newly insured patient population, their periodontal treatment needs, and associated risk indicators.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter is a review of the literature pertaining to the etiology of periodontal disease, diagnosis and treatment of periodontal disease, epidemiological considerations for assessing periodontal disease prevalence, and implications for dental health policy. In the first part of the chapter, periodontal diseases are defined. Factors that affect periodontal disease severity and the impact of periodontal disease on overall systemic health are also reviewed. An examination of the prevalence of periodontal disease in the United States and methods of measuring disease will be discussed.

The term periodontal disease is the common term for chronic periodontitis. However, periodontal disease is a broader term that encompasses more conditions than just chronic periodontitis. For the purposes of this study the term periodontal disease will be utilized when referring to chronic periodontitis.

Periodontal Disease

Chronic periodontitis (periodontal disease) is a condition that is characterized by the destruction of the attachment apparatus of

natural teeth. This surrounding structure is known as the periodontium and includes the gingiva, alveolar bone, and the periodontal ligament. The gingiva, commonly referred to as the gums, is a specialized masticatory mucosa that surrounds the teeth at the cervical level. The gingiva meets the lining alveolar mucosa at the mucogingival junction (Weinberg and Eskow 2003, Dentino et al. 2013, Newman et al. 2015).

The alveolar bone forms the tooth sockets that provides support to the teeth. The periodontal ligament is a specialized type of connective tissue, mainly composed of a complex matrix of collagen fibers that attach the tooth cementum to the alveolar bone. Cementum is a calcified matter that covers the root surface of a tooth and connects the teeth to the alveolar bone by securing the periodontal ligament (Perry and Beemsterboer 2007, Newman et al. 2015).

Periodontal disease is produced by a series of events that occur in the periodontium. This process is characterized by a process of dysbiosis in which the absence of adequate measures of oral hygiene propitiates the colonization and perpetuation of periodontopathogenic bacteria, typically gram negative anaerobes that replace gram positive species. This leads to an exacerbated response of the host's immune system (Albandar 2002, Perry and Beemsterboer 2007, Dentino et al. 2013).

As a result, the gingiva becomes initially red in appearance, inflamed with enlarged or bulbous tissues, and bleeds upon examination with a probe. This is compatible with a clinical diagnosis of gingivitis. As the lesion progresses and the severity of the disease increases in a susceptible host, the gingiva separates from the teeth and early bone loss occurs, creating periodontal pockets (Albandar 2002, Perry and Beemsterboer 2007, Dentino et al. 2013).

As the disease progresses, these pockets tend to become deeper. If no form of intervention is implemented to arrest the progression of disease, continuous bone loss can lead to serious esthetic and functional problems, ultimately resulting in tooth loss (Reddy et al. 2000, Albandar 2002, Perry and Beemsterboer 2007, Dentino et al. 2013, Newman et al. 2015).

Appropriate diagnosis is critical to treating disease. It is important to determine whether the disease is in an active state, the type of disease, extent, distribution, and severity. Diagnosis is determined after the analysis of the patient health history and the evaluation of the clinical signs and symptoms, as well as evaluation of complementary diagnostic aids, such as radiographs or specific lab tests. Important periodontal clinical parameters include periodontal pocket depth (PD), recession, calculation of clinical attachment loss (CAL), bleeding upon probing (BOP), amount of keratinized tissue,

furcation involvement, assessment of mobility and presence and distribution of calculus (Reddy et al. 2000, Perry and Beemsterboer 2007, AAP 2011, Sweeting et al. 2008).

Periodontal pocket depth is measured by probing using a periodontal probe, which measures the distance from the gingival margin to the base of the junctional epithelium (in conditions of health) or the base of the pocket (in conditions of disease). Recession is the distance from a reproducible landmark, typically the cementoenamel junction (CEJ), to the gingival margin. The CEJ is a slightly detectable border on a tooth. It is the location where the enamel (hard, white covering of the tooth surface) and the cementum (the covering of the root of a tooth) join together (Newman et al. 2015, Weinberg and Eskow 2003, Perry and Beemsterboer 2007). Recession can be a positive or a negative value. Clinical attachment loss (CAL) is calculated by the sum of pocket depth and recession.

Classification systems are essential in providing an outline in which to study the disease, the development and progression of disease, and treatment of disease. Guidelines have been created to help clinicians better diagnose periodontal disease severity. A common clinical criteria guideline for clinicians to use when determining periodontal health status is presented in Table 1 at the end of the chapter (Sweeting et al. 2008).

The first classification is Case Type 0 indicating healthy tissues, where the gingiva appears normal with a knife edge appearance, stippling, pink in color, and with no bleeding on probing. Case Type I, gingivitis, has the presence of inflammation with bleeding on probing. There will also be a slight change in color of the gingiva to a darker pink or red color. Case Type II, slight chronic periodontitis, is characterized by gingival inflammation that encroaches into the alveolar bone that results in slight bone loss with loss of connective tissue attachment. Case Type III, moderate chronic periodontitis, presents with inflammation but also increased destruction of the connective tissues and alveolar bone, often with furcation involvement and possible mobility of the teeth (Sweeting et al. 2008).

A furcation defect occurs when there is bone loss between the roots of a multi-rooted tooth where two or more roots are united together. A furcation may be detected with radiographs or gently probing the area (Newman et al. 2015, Weinberg and Eskow 2003, Perry and Beemsterboer 2007).

Periodontal Disease Treatments

Periodontal disease can have a significant impact on an individuals' life and well-being, thus, it is important to treat the disease as early as possible with individualized comprehensive

periodontal therapy (AAP 2011). The comprehensive examination should begin with evaluation of individual's health status, history of diseases, and risk factors that could influence periodontal disease behavior and diagnosis (Newman et al. 2015, AAP 2011).

There are a wide variety of treatment options that can be considered when treating periodontal disease. Patient education regarding periodontal disease development and progression, oral hygiene instruction, and discussion about behavioral risk factors should always be completed during treatment (Dentino et al. 2013, AAP 2011). Typically, the treatment of periodontal disease commences with a non-surgical intervention, with or without chemotherapeutic agents (Newman et al. 2015, Perry and Beemsterboer 2007, AAP 2011). If disease progression has not been halted after this form of treatment or if the initial probing depths are too deep (Heitz-Mayfield and Lang 2013), surgical intervention may be required in order to gain access for thorough debridement and to attempt either pocket reduction surgery with osseous recontouring or, in some selected cases, periodontal regeneration.

Non-surgical Periodontal Treatment

Scaling and root planing (SRP) is a non-surgical treatment of teeth affected by periodontal disease through complete removal of

subgingival (apical to the gingival margin) plaque biofilm, calculus, diseased cementum, and granulomatous tissue in order to stop the disease from progressing by recreating a subgingival environment compatible with health in order to stop the disease from advancing (Newman et al. 2015, Perry and Beemsterboer 2007, Heitz-Mayfield and Lang 2013).

SRP may be accomplished by using hand instruments such as curettes, scalers, and ultrasonic powered instruments. A panel of experts brought together by the American Dental Association Council on Scientific Affairs developed a clinical guideline established based on a systematic review of 72 research articles that presented information regarding clinical attachment levels in studies of at least 6-month duration. The authors of this review were in agreement that SRP is the gold standard initial non-surgical treatment for chronic periodontal disease (Smiley et al. 2015).

Chemotherapeutic agents may also be used to reduce or eradicate bacterial pathogens by means of local or systemic delivery. It has been stated that the use of chemotherapeutics should be decided on an individual basis with emphasis still on sufficient elimination of calculus and bacteria, good individual oral hygiene, and regular maintenance care.

Surgical Periodontal Treatment

Surgical treatment of periodontal disease infected tissues can be performed to help control the progression of the disease, and is often used after non-surgical therapy has proven to be insufficient (AAP 2011). A major benefit of periodontal surgery is that is provides access to the deep root surfaces that are infected by the periodontal pathogens. These are often sites that are unreachable by SRP. By surgically retracting the gingiva, the clinician is able to access the deep pockets, furcations, and any osseous defects that may be present in order to attempt either regeneration or perform bone recontouring, depending on the anatomy of the defects (Newman et al. 2015, Heitz-Mayfield and Lang 2013).

Summary

Periodontal disease is a chronic inflammatory response to specific bacteria and their byproducts mediated by the host's immune system that can lead to the destruction of the periodontium. An individual is described as having gingivitis when the gingiva is red, swollen, and bleeds easily. Gingivitis is often caused by poor oral hygiene when bacterial plaque is allowed to accumulate and flourish on the tooth and gingival surfaces.

If left untreated, gingivitis can progress into periodontal disease (periodontitis). Undisturbed bacterial plaque has the ability to grow and migrate into subgingival compartments, creating an environment more selective towards highly pathogenic bacteria. In this situation, an exacerbated immune response affecting the periodontium is behind the progressive destruction of the attachment apparatus, including the junctional epithelium, the connective tissue attachment, the periodontal ligament, and the alveolar bone.

Clinical assessment and appropriate diagnosis is necessary for proper treatment planning and patient education. Individual health status, disease history, and risk factors should be determined to have a better understanding of the severity of disease and to offer personalized plans for treatment. SRP is considered the gold standard non-surgical treatment for periodontal disease. At times, it may be appropriate to include treatment with chemotherapeutic agents or surgical intervention. Many chronic conditions and behavioral risk factors can have an impact on periodontal disease progression and severity.

Periodontal Disease and Overall Health

Increasingly over the past few decades, researchers have established a link between the overall health of the body and

periodontal health. An association between several systemic conditions, such as cardiovascular disease, diabetes mellitus, and osteoporosis, and periodontal disease has been suggested in the literature. Due to these possible health associations, it is even more critical to assess individual systemic risk factors and take them into account when diagnosing and treating periodontal disease. Modifiable behavioral risk factors that impact periodontal health include smoking, oral hygiene, stress, and nutrition.

Behavioral Risk Factors

Oral Hygiene

Plaque, or biofilm, is a bacterial matrix that flourishes in the oral cavity and on the tooth structures. If not periodically disrupted, plaque will grow and eventually calcify in place to form calculus, which facilitates bacterial harboring in subgingival spaces (Newman et al. 2015, Dentino et al. 2013, Perry and Beemsterboer 2007). In historical studies, it was found that there is a direct correlation between oral hygiene and the amount of bacterial plaque on the tooth surface (Silness and Löe 1964, Löe et al. 1965). Studies have also shown a significant decline in probing depths (PD), greater attachment improvements, and less gingival inflammation with proper oral hygiene

alone (Axelsson et al. 2004). Determining an individual's oral hygiene habits can better help the clinician modify the individual's behavior and facilitate education concerning the complications that may result from neglected oral hygiene care.

Smoking

Tobacco use has been implicated as an etiological agent for various health issues such as cancer, lung disease, and heart disease. Individuals who use tobacco are also at a greater risk for developing periodontal disease. A systematic review of six studies found that individuals who smoke are approximately three times as likely to have severe or advanced periodontal disease than those who do not smoke (Papapanou 1996). Studies have also shown that the use of tobacco could be an important risk indicator in the progression of periodontal disease and response to conventional treatment.

Many studies have shown that smokers have significantly deeper PDs than non-smokers, greater CAL, greater bone loss, and fewer teeth present than nonsmokers (Tonetti 1998, Johnson and Hill 2004, Johnson and Guthmiller 2007). A study looking at the data from National Health and Nutrition Examination Survey (NHANES) III (1988-1994) data (Albandar et al. 2000) found that smokers have four times the risk of periodontal disease as do non-smokers. Researchers

estimated that approximately 40% of periodontal disease cases in the United States were attributable to smoking tobacco (Albandar et al. 2000).

Stress and Depression

Psychological stress is the emotional and physiological responses experienced when an individual encounters a situation in life that surpasses his/her ability to cope successfully (Warren et al. 2014). Clinical studies have shown the destructive influence of chronic psychological stress and depression on the body. Chronic stress and depression decreases immune responsiveness, causing more favorable environment for bacterial infections, thus a greater chance of periodontal disease destruction (Albandar 2002, Doyle and Bartold 2012). For example, a study found that individuals that were experiencing financial stress and an inability to cope with their situation were at a greater risk for more severe periodontal attachment and bone loss than those individuals with low levels of financial stress (Genco et al. 1999).

Nutrition

Nutrition has a large impact on the overall health of our bodies. Research has been conducted assessing vitamin C intake and possible

associations with periodontal disease. Historical studies found that diets that were deficient in vitamin C showed signs of generalized alveolar changes (Glickman 1948). Recent research using NHANES III (1988-1994) data has established an association between vitamin C and periodontal disease. It was found that individuals with low vitamin C consumption had an increased probability of developing periodontal disease in comparison to those with increased vitamin C intake (Nishida et al. 2000). Diets rich in whole grains have been associated with lower risk of diabetes and cardiovascular disease, which have also been associated with periodontal disease.

Periodontal Disease and Systemic Health Conditions

Periodontal disease has been associated with several other diseases and health conditions. Recent research indicates that inflammation may be responsible for the relationship between periodontal disease and systemic conditions. As mentioned earlier, a robust inflammatory response may lead to periodontal breakdown. Determining the relationship between systemic inflammatory conditions and periodontal disease may enable clinicians to more adequately diagnoses, treat, and educate their patients, in a context of contemporary personalized care.

Cardiovascular Diseases

Cardiovascular diseases (CVD) are the number one cause of death globally, accounting for more than 17.3 million deaths per year and this rate is expected to continue to increase (Mozaffarian et al. 2015). CVD include hypertension, myocardial infarction (MI), congestive heart failure (CHF), angina pectoris, and infective endocarditis (IE) (Newman et al. 2015). In recent years, there has been an increase in the amount of evidence connecting dental plaque bacteria and coronary conditions. It is thought that dental plaque bacteria travels through the blood vessels and the bacteria attach themselves to the vessel wall (endothelium).

Atherosclerosis is a disease whereby arterial plaque builds up inside of the arteries and over time the plaque hardens and narrows the arteries. This narrowing restricts the amount of oxygen-rich blood that can flow to the organs and other parts of the body. Over the last few decades, there is growing evidence conveying a relationship between dental bacteria and coronary heart diseases that progress as the result of atherosclerosis.

It has been demonstrated that atherosclerosis begins as an inflammatory reaction to bacterial infection. The inflammation sites attract accumulation of macrophages, T lymphocytes, B lymphocytes, and mast cells. The vessel walls are also covered by fats or plaque.

These plaque deposits then block the vessels and limit blood flow (Newman et al. 2015, Perry and Beemsterboer 2007). Atherosclerosis is the most common cause of heart attack and stroke.

There are several mechanisms by which dental plaque bacteria may prompt or worsen atherosclerotic developments, such as bacteria related to professional dental treatment and involvement of mediators activated by the dental plaques. There are common predisposing factors which influence both periodontitis and atherosclerosis. In a meta-analysis of 15 observational studies, it revealed that periodontal disease was associated with carotid atherosclerosis (Zeng et al. 2016).

Another study assessed atherosclerotic lesions to determine the atheroma plaques that were adhering to the arterial walls by means of biopsy. It was found that 80% of the lesions contained pathogens found to play an active role in the initiation and progression of periodontal disease (Chistiakov et al. 2016).

One review found an association between chronic periodontitis and a cerebrovascular accident, or stroke. It specifically reviewed the relationship between oral infection caused by dental plaque bacteria (Straka and Trapezanlidis 2013). Another study conducted by Geerts et al. (2004) found a significant association between periodontal disease and coronary artery disease. They found that 91% of patients with CVD had moderate to severe periodontitis, compared to 66%

healthy individuals (Geerts et al. 2004).

Diabetes

Diabetes mellitus is an endocrine alteration characterized by abnormal carbohydrate, fat and protein metabolism resulting from too much insulin or lack of insulin. There are three general categories of diabetes. Type 1, insulin dependent, results from an insulin deficiency, whereas Type 2 diabetes, or non-insulin dependent, is due to insulin resistance and is typically acquired in adult stages of life. The third type of diabetes is gestational and occurs during pregnancy (Ozougwu et al. 2013). Individuals suffering from diabetes have an increased risk for oral manifestations that could impact health. There is an increased risk for chronic inflammation that leads to chronic gingivitis, resulting in periodontal disease (Ship 2003).

Tsai and colleagues (2002) analyzed NHANES III data to evaluate prevalence of periodontal disease among individuals with Type 2 diabetes mellitus. It was found that individuals with poorly controlled diabetes have a higher prevalence of severe periodontal disease (Tsai et al. 2002). Selwitz et al. used NHANES III data to assess periodontal disease status in a nationally representative sample of 9,680 dentate adults between the ages of 30 to 90 years with individuals diagnosed with Type II diabetes mellitus (type II) and

those without diabetes. After adjusting for age, gender, and race/ethnicity, it was found that diabetics had a greater prevalence of CAL, more PDs greater than 5mm, and a greater percentage of BOP (Selwitz et al. 1998).

Another study that was conducted by Grossi et al. (1997) evaluated periodontal therapy and the reduction of glycated hemoglobin in diabetic patients. It was found that, when effective treatment of periodontal disease was completed, there was a significant reduction in periodontal inflammation which was associated with a reduction of glycated hemoglobin, indicating greater diabetic control (Grossi et al. 1997).

Obesity

Obesity is a major concern worldwide. Data from NHANES 2011-2014 show that approximately 36% of U.S. adults are obese (Ogden et al. 2015). Associations have been recognized between obesity and various health conditions: diabetes, hypertension, coronary heart disease, stroke, and cancer (Haslam and James 2005). Body fat harbors a large number of adipocytes and these cells produce molecules that affect the homeostasis of hormones (such as insulin) and cytokines, and eventually lead to low-grade systemic inflammatory status (Dentino et al. 2013).

Linden et al. (2007) evaluated the association between obesity and periodontal disease in 60 to 70-year-old men and concluded that periodontal disease and obesity were significantly associated. However, high body mass index (BMI) early in life did not predict periodontal disease development later on (Linden et al. 2007). Another study conducted by Ylöstalo et al. (2008) demonstrated that there was an association between weight and periodontal disease among non-diabetic and non-smoking individuals between the age of 30 to 49 years (Ylöstalo et al. 2008).

Pregnancy

Low birth weight (LBW) is associated with increased morbidity and mortality of infants. It has been estimated that 60-80% of neonatal deaths occur amongst LBW infants (UNICEF 2013). LBW puts infants at risk of having increased medical complications. Recent studies have suggested that women who are pregnant may be at a greater risk for preterm births and LBW infants if there is the presence of periodontal disease (Michalowicz et al. 2006).

Various systematic reviews have examined the relationship between periodontal disease and pregnancy outcomes. A meta-analysis completed by Vergnes and Sixou (2007) reviewed 17 studies for a total of more than 7,000 subjects. They established that there

was a significant association between periodontal disease and preterm or LBW infants (Vergnes and Sixou 2007).

One potential mechanism of action via which periodontal disease could disturb pregnancy outcomes is due to periodontal bacteremia. In a cross-sectional study, women who had LBW infants had significantly higher levels of bacteria in their subgingival plaque that are known to play a role in periodontal disease development and progression as compared to women who had babies of normal birth weight (Offenbacher et al. 1998). It was also observed that women who had low birth weight infants regularly had a greater prevalence of periodontal disease and greater severity of periodontal disease, as well as increased gingival inflammation, when compared with women who had normal birth weight infants (Offenbacher et al. 1998).

Osteoporosis

Osteoporosis is an osseous disease that affects bone mass and leads to structural weakening of the skeleton, which predisposes patient to an increased risk of bone fractures. The loss of bone mass and the incidence of osteoporosis increases with older age. While both osteoporosis and periodontal disease are characterized by bone loss, there have been mixed findings regarding a clear association. Some studies have stated there was greater tooth loss, greater bone loss,

and edentulism in those individuals with osteoporosis (Yoshihara et al. 2005, Drozdzowska et al. 2006). While other studies demonstrated that tooth loss is not associated with osteoporosis (Earnshaw et al. 1998, Bollen et al. 2004).

Researchers have met challenges in identifying an association between periodontal disease and osteoporosis. This could be due to differences in measurement methods among studies and systemic co-factors not fully understood yet. Another difficulty is exploring associations between tooth loss studies and osteoporosis studies when the cause of the tooth loss may not be known or not related to periodontal disease (Newman et al. 2015).

Age

The distribution of the United States population has changed over the last century and is expected to continue with an increase in the elderly population. In 2050, the population aged 65 and over is expected to be around 83.7 million, which is almost double its estimated population of 43.1 million in 2012 (Ortman et al. 2014). Due to greater health knowledge and advances in preventive dentistry, it has been observed that there has been a decrease in overall tooth loss. Currently, it is estimated that 80% of this population have their own natural teeth, which is vastly different from the previously

edentulous generations (Lavigne 2015).

Aging takes its toll on the body. As individuals age, tissues become thin and there is a loss of elasticity (Newman et al. 2015, Perry and Beemsterboer 2007). This change could lend itself to an increase in bacterial entrance through the tissues and reduced resistance to trauma. Research in this area, regarding the relationship between age and periodontal disease, has been quite controversial. In fact, no direct link has been made with periodontal disease and aging. However, there are indications that aging has some influence on the configuration and function of the periodontium.

Cross-sectional studies and epidemiological studies have demonstrated an increase in the prevalence, the extent, and the severity of periodontal attachment loss with an increasing of age (Albandar et al. 1999, Albandar 2002). There has also been evidence that there is an association between severity of periodontal disease and age. Albandar et al. (1999) evaluated NHANES III data and found that mild periodontal disease was more prevalent in the older age individuals, and moderate periodontal diseases and advanced periodontal disease increased in prevalence to approximately 65 years of age.

Alzheimer's Disease

Periodontal disease is highly prevalent in the elderly population and has shown to increase in prevalence with age. It has been suggested that it may become more common in individuals with Alzheimer's disease because of a reduced function and the ability to take care of oral hygiene needs. A common finding for periodontal disease and Alzheimer's disease are the elevated levels of pro-inflammatory cytokines, which have been associated with an increased rate of cognitive decline in Alzheimer's disease and the destructive pattern of periodontal disease.

A study conducted in the UK (Ide et al. 2016) hypothesized that periodontal disease was associated with increased dementia severity and quicker cognitive decline in Alzheimer's patients. The study was over the span of six-months, observing 60 community-dwelling subjects with mild to moderate Alzheimer's disease. These individuals were assessed cognitively, had blood samples taken for systemic inflammatory markers, and dental health status determined at baseline, and then reevaluated at the end of the six-month period. It was determined that the presence of periodontal disease at baseline was not associated with baseline cognitive status but was associated with an increase in the rate of cognitive decline. The authors

hypothesize that this link between periodontal disease and cognitive decline may be facilitated by systemic inflammation (Ide et al. 2016).

Prevalence of Periodontal Disease

Periodontal disease has affected human oral health for centuries. The first description of periodontal disease was written in 2700-2600 BC in Nei Ching, a Chinese medical book (Dentino et al. 2013). Other narratives of symptoms associated with the disease, diagnoses, and treatments of periodontal disease have been discovered, and they indicate this disease has been prevalent throughout history. In modern times, the prevalence of periodontal disease has largely remained steady. However, due to epidemiologic considerations, it can be difficult to truly compare periodontal disease prevalence over time.

It is estimated that 47.2%, or 64.7 million, US adults have mild, moderate or severe periodontal disease. In adults 65 years of age and older, prevalence increases to 70% (Eke et al. 2012). A systemic review and meta-regression conducted by Kassebaum et al. (2014) sought to bring together epidemiologic data regarding severe periodontal disease in order to produce prevalence and incidence estimates for all countries, by age and sex for 1990 through 2010 (Kassebaum et al. 2014). The authors found a steady increase in incidence with age with a large increase in the third and fourth

decades of life; being the peak incidence of disease was around age 38 (Kassebaum et al. 2014).

One of the longest standing programs associated with collected information regarding periodontal disease information available in the United States is the National Health and Nutrition Examination Survey (NHANES). The NHANES is a database of studies that assess the health and nutritional status of the U.S. population combining interviews and physical examinations (Zipf et al. 2013). The NHANES dental examination, including periodontal evaluation, began in the early 1960s and has been continually conducted since. Although with limitations, this program allows for researchers to assess periodontal status in a large and representative population.

Trained and calibrated dentists conduct a brief periodontal examination on two sites per tooth: mid-buccal and mesio-buccal, in two randomly selected quadrants, including one quadrant in the maxillary arch and one in the mandibular arch. It is completed this way with the assumption that these quadrants are representative of the whole mouth, which may by true or not. Third molars are excluded due to the increased chance for already having been extracted and the high prevalence of tooth impaction. Clinical attachment loss (CAL) and PD are evaluated during this examination. Periodontal disease is diagnosed when an individual presents with at least two sites with CAL

greater than 4mm and at least one site with PD greater than 4mm. However, these situations did not have to be present in the same tooth or site (Zipf et al. 2013).

Based on NHANES data, Borrell et al. (2005) evaluated periodontal disease prevalence in the United States through the use of two sets of NHANES data: NHANES III (1988-1994) and NHANES 1999-2000. The study evaluated whether periodontal disease prevalence changed over time and varied among ethnic or racial groups.

Between the two surveys, the overall prevalence of periodontal disease in U.S. adults significantly decreased from 7.3% (NHANES III) to 4.2% (NHANES 1999-2000) ($p<.0001$). Bleeding, recession, CAL, and PD of 3 to 4mm decreased among all race/ethnic groups between the two survey data points. However, periodontal status of Mexican-Americans and non-Hispanic blacks remained poorer when compared with non-Hispanic whites (Borrell et al. 2005). Non-Hispanic blacks had the highest disease prevalence in NHANES III (11.4%) and the 1999-2000 NHANES (6.8%). Periodontal disease prevalence among Mexican-Americans decreased slightly from 6.9% to 4.6%. Prevalence was lowest among non-Hispanic whites, decreasing from 6.7% to 3.8% in 1999-2000. Overall, non-Hispanic blacks were 1.8 times as likely to have periodontal disease as non-Hispanic whites in both

surveys (Borrell et al. 2005).

Another study using NHANES data and conducted by Borrell et al. (2006), found that individuals with lower education and lower income were significantly more likely to live in neighborhoods that were classified as having the lowest socioeconomic status (SES). The prevalence of periodontitis for people over the age of 18 was 7.8%, with 6.8% among non-Hispanic whites, Mexican Americans with 7.9%, and 13.2% in non-Hispanic blacks ($p<.01$). Prevalence was also noted as higher among males, widows and those with lower education levels, those with low-incomes, living in low SES neighborhoods, those not having a dental visit within the last 5 years, those without health insurance, with diabetes, and individuals who currently smoked (Borrell et al. 2006).

Using newer NHANES data (2009-2010), Eke et al. (2012) estimated the prevalence, severity, and extent of periodontal disease in U.S. adults. CAL and PD were measured at six sites for each tooth with the exception of third molars. Over 47% of the study sample had periodontal disease; 9% had a mild form of the disease, 30% had moderate, and 9% had severe case types of periodontal disease. Eighty-six percent had one or more teeth with attachment loss greater than 3mm and 41% had probing depths greater than 4mm (Eke et al. 2012).

This study also found that 56% had 5% or more periodontal sites with greater than 3mm attachment loss and 18% had 5% or more periodontal sites greater than 4mm PDs. Periodontal disease was more prevalence in men, Mexican Americans, adults with less than a high school education, adults below 100% Federal Poverty Levels (FPL), and current smokers; consistent with previous epidemiologic studies (Eke et al. 2012). It is currently believed that data prior to NHANES 2009 and 2010 was underestimating the prevalence of periodontal disease among U.S. adults.

Measuring Periodontal Disease

Measuring periodontal diseases with standardized tools in epidemiological studies is extremely important in properly identifying disease incidence and prevalence. Indices are essential tools to measure, compute, and guide treatment in epidemiological and clinical situations, there are many factors that play a role in the pathogenesis, progression, extent, and severity of periodontal disease. Several periodontal indices have been created and implemented over time; attempting to include all pertinent facets. However, all of them present limitations. This study uses the Community Periodontal Index of Treatment Needs (CPITN) and the Periodontal Screening and Recording (PSR).

The World Health Organization (WHO) recognized the impact of periodontal disease on the world health and created an initiative to examine and advise on periodontal disease epidemiology and prevention (Ainamo et al. 1982). The CPITN was developed from a prototype examination, this was presented in the 'Technical Report Series #621' (Ainamo et al. 1982, Dhingra and Vandana 2011).

The CPITN evaluates the presence or absence of bleeding on probing, the presence of calculus, and periodontal pockets of varying depths. The CPITN scores range from 0 to 4, in increasing levels of periodontal involvement. A CPITN score of "x" is specified for sextants with less than two teeth. These scores correspond to recommended treatment need required in that sextant. The CPITN scoring system is presented on the left side of Table 2 at the end of the chapter.

The CPITN is unique in the fact that it uses a specifically designed WHO probe with a 0.5mm ball-tip, in comparison to the more commonly used periodontal probes without a ball-tip (Figure1). The unique design of the probe is to facilitate subgingival calculus detection, which plays an important role in the categorization of periodontal treatment needs that the CPITN implements.

The CPITN was designed to assess periodontal treatment needs, unlike many previous periodontal indices that evaluated periodontal status (Ainamo et al. 1982, Ainamo and Ainamo 1994, Dhingra and

Vandana 2011). The CPITN examines the teeth in sextants. To determine periodontal treatment needs at the person level, only the worst recording from all the sextants is recorded as one score. Due to the success and acceptance of the CPITN, as of 2011 there were over 500 publications that used the CPITN criteria (Dhingra and Vandana 2011).

In its widespread use, many researchers have adapted the index by slightly modifying it to better fit their research needs. One study conducted by Dye and Vargas used a modified CPITN to determine periodontal treatment needs among U.S. adults from NHANES III, aged 20 to 79 years (Dye and Vargas 2002). As previously discussed, the NHANES has its own protocol for periodontal disease assessment. Since the probes used in the NHANES and CPITN assessments are different, the index was modified to compensate for the 0.5mm difference between the typical CPITN probe with the ball-tip and the NIDR probe that is used for NHANES surveillance.

An individual was given a CPITN score for the worst tooth condition in the mouth. If a 4 to 5mm was noted at a site, CPITN was scored as a 3. If a greater than 6mm pocket was noted, then a CPITN score of 4 was assigned (Dye and Vargas 2002). In this modification, it is more likely that the score may underrepresent periodontal disease compared to the original CPITN protocol.

Dye and Vargas (2002) found that approximately 3% of US adults required scaling and root planing or more intensive periodontal therapy, with nearly 90% requiring routine dental cleanings. It was determined that being of older age, male, non-Hispanic black, of lower educational standing, a current smoker, or not having a dental visit in the last year increased the chance of requiring scaling and root planing or more intensive periodontal therapy (Dye and Vargas 2002).

The other periodontal index that was utilized in the project hereby presented is the Periodontal Screening and Recording Index (PSR). The PSR is a modified version of the CPITN used for periodontal screening. The PSR index divides the mouth into sextants and the greatest score in each sextant of the mouth is determined, similarly to the CPITN.

Also, similar to the CPITN is the use of a probe with a 0.5mm ball-tip and a band extending 3.5 to 5.5mm from the tip (Dhingra 2011, Landry 2002). PSR scores range from 0 to 4, with the possibility of each score having an asterisk (*) if there is additional periodontal abnormality. These abnormalities could include furcation involvements, mobility, or recession. A PSR score of “x” is specified for sextants with less than two teeth (Dhingra and Vandana 2011, Landry and Jean 2002). In Table 2, a comparison chart of the CPITN and PSR is presented, showing the similarities in assessment and recommended

treatment.

Summary

While periodontal indices are meant to give a quick overall idea of the periodontal health status of a population, all of them present inherent limitations. As stated previously, periodontal disease is multifactorial and it is difficult to determine the exact etiology upon a brief assessment. Due to this, many indices have been created. A limitation of the CPITN is that a score of 3 or 4 signifies probing depth present, but provides no information on BOP or calculus status. This could potentially mean that an individual with 4mm or 5mm in all sextants would still be scored a 3 even if no calculus and BOP is present. This does not give active status of disease. Both the PSR and CPITN can also underestimate the level of periodontal disease, since they involve partial recording protocols.

Despite these limitations, periodontal indices do help to provide an overall perspective on the periodontal status of a given patient, and they are less time-consuming and less susceptible to inter-examiner variability than a proper comprehensive periodontal examination. They are beneficial in determining or predicting treatment needs, which could have policy implications.

The literature presented in this section demonstrated how

previous studies have been conducted using the CPITN, converting valid national data; demonstrating that it is a valid way of assessing for periodontal disease treatment needs.

Periodontal Disease Burden

A primary concern in public health are the disparities that some populations endure. It is often found that lower SES individuals have decreased health compared to higher SES individuals. Lower SES individuals always are more likely to have difficulty accessing dental care. This could put them at an increased risk for developing adverse health conditions (Hobdell et al. 2003).

Dental Wellness Plan

With the promise of healthcare reform, President Barack Obama signed into legislation the Affordable Care Act (ACA) in 2010. Under the ACA, the state-federal program Medicaid may now provide health coverage to low-income individuals who were formerly not categorically eligible for Medicaid coverage. Medicaid, prior to 2014, only provided categorical health coverage for children, pregnant women, parents of dependent children, disabled individuals, and people over the age of 65 in the low-income population. Through this Medicaid expansion, the state of Iowa began to provide dental

coverage to the Medicaid expansion population through a program called the Dental Wellness Plan (DWP).

In order to be eligible for the DWP, individuals must be enrolled in Iowa Health and Wellness Plan (IHAWP), Iowa's Medicaid expansion healthcare program. The IHAWP provides comprehensive health care coverage to all adults between the ages of 19-64 years with income between 0-133% of the FPL. The DWP was implemented on May 1, 2014 (IPDH Fact Sheet 2014). This population is of particular significance because, before the Medicaid expansion initiatives, much of this population was previously uninsured and not well characterized.

The DWP implemented a unique earned benefits approach to covered services in order to encourage members to pursue preventive care. Members become eligible for additional covered services if they return for regular periodic recall exams. There are three "tiers" that members are able to achieve, with new benefits being covered at each tier: Core, Enhanced, and Enhanced Plus (Table 3).

The first tier of coverage, Core benefits, covers dental examinations, prophylaxis, and radiographs. Emergency services are available to cover extractions and oral surgery for oral complications, restorations for large cavities that are at least 50% of the way to the pulp, gum disease treatment for acute periodontal conditions, and

dentures for individuals without teeth who require dentures for daily function.

If the DWP member returns to the dental office within 6-12 months of an initial exam, then they become eligible for Enhanced benefits. This tier covers all Core benefits in addition to restorative services, root canals and other endodontic care, non-surgical periodontal treatment, denture adjustments and repairs, and oral surgery.

Again, if the individual returns 6-12 months after the second recall examination they gain coverage for the Enhanced Plus tier of benefits. This tier covers all Core and Enhanced benefits in addition to crowns, tooth replacements, and periodontal surgery. All services in the Enhanced Plus tier are subject to authorization prior to treatment. At any time, if a patient does not come back to the dental office within the 6 to 12-month window, the individuals loses their earned benefits and must restart at the initial Core tier (IPDH Fact Sheet 2014, Reynolds et al. 2015).

This novel form of healthcare now provides insurance to a previously uninsured population in the state of Iowa. In a recent study meant to understand customer experience with the DWP, approximately 82% of respondents stated that they did not previously have dental insurance (Reynolds et al. 2015). This is a concerning

number of individuals who may be suffering from periodontal disease, as well as other systemic diseases.

Implications for Dental Policy

Due to the overwhelming information available regarding health disparities among lower SES individuals, it becomes imperative that health policy focus on increasing access to care. Iowa offers unique dental coverage as a part of the state's Medicaid expansion program; information regarding this newly insured patient population may be useful for other states looking to increase dental coverage of Medicaid individuals.

Table 1. Clinical criteria in determination of periodontal case types

Case Type	PD (mm)	BOP (Y/N)	Bone Loss (%)	Mobility (Grade)	Furcation (Grade)	CAL (mm)	Visual Inflam-mation
0 Healthy	0-3	No	0	None	None	0	No
1 Gingivitis	0-4	Yes	0	None	None	0	Yes (Loc. or Gen.)
II Slight Chronic Periodontitis	4-5	Yes	10	I	1	1-2	Yes (Loc. or Gen.)
III Moderate Chronic Periodontitis	5-6	Yes	33	I and II	1 and 2	3-4	Yes (Loc. or Gen.)
IV Advanced Chronic Periodontitis	>6	Yes	>33	I, II, or III	1, 2, 3, or 4	>5	Yes (Loc. or Gen.)
V Aggressive Periodontitis	>6	Yes	>33	I, II, or III	1, 2, 3, or 4	>5	Yes (Loc. or Gen.)

PD = Probing depth
BOP = Bleeding on probing
CAL = Clinical attachment loss
Loc. = Localized defined as $\leq$30% of sites involved
Gen. = Generalized defined as >30% of sites involved

Figure 1. Community Periodontal Index of Treatment Needs (CPITN) probe compared to conventional periodontal probe

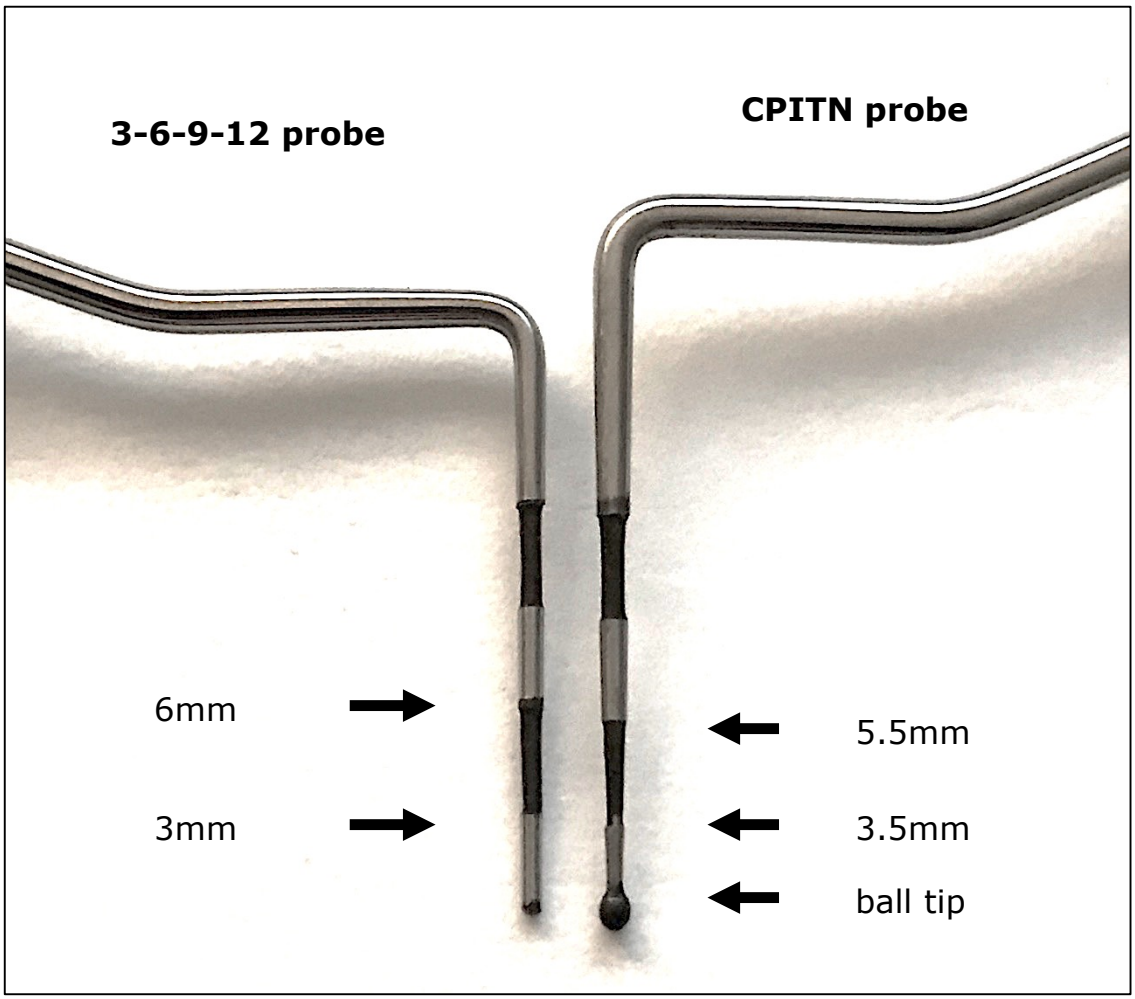

Table 2. Comparison of Community Periodontal Index of Treatment Needs (CPITN) and Periodontal Screening and Recording Index (PSR) Indices

CPITN	Diagnosis	Recommended Treatment	Diagnosis	PSR
0	Healthy tissues, no BOP → no pockets >3mm, black band fully visible	None	Healthy tissues, no BOP, PD 1-3mm	0
1	BOP, no pockets >3mm, black band fully visible	OHI	BOP, PD 1-3mm	1
2	Calculus/overhangs, no pockets >3mm, black band fully visible	OHI + Prophy	Calculus/ overhangs, PD 1-3mm	2
3	Pockets >3mm & <5mm, black band partially visible	OHI + Prophy + SRP	Pockets 4-5mm → **FULL Perio Chart Indicated in Sextant**	3
4	Pockets >5mm, black band NOT visible	OHI + Prophy + SRP + Surgery prn	Pockets >6mm → **FULL Perio Chart Indicated in Sextant**	4
		Comprehensive Perio Exam to evaluate	Clinical abnormalities → **FULL Perio Chart Indicated in Sextant**	*
X	Fewer than 2 teeth function in sextant	Exclude from needs assessment	Fewer than 2 teeth function in sextant	X

PD = Probing depth
BOP = Bleeding on probing
CAL = Clinical attachment loss
OHI = Oral hygiene instruction
Prophy = Prophylaxis
SRP = Scaling and root planing
PRN = When needed

Table 3. Iowa Dental Wellness Plan (DWP) Benefit Structure

Eligibility	• Iowa Health and Wellness Plan members ages 19-64 • Income between 0-133 percent of the Federal Poverty Level • Not otherwise eligible for Medicaid or Medicare
Benefits Covered	**Core**: Members are eligible for core benefits upon enrollment in the Dental Wellness Plan. • **Diagnostic** and preventive services - exams, cleanings, radiographs. • **Emergency Services**: problem focused exams, extractions/oral surgery and anesthesia. • **Stabilization Services**: restorations for large cavities, periodontal disease treatment for acute problems, and dentures for those without teeth or to restore function and denture adjustments and repairs. **Enhanced**: Members are eligible by completing a recall exam within 6-12 months of initial exam. • **All Core benefits plus** restorative services, root canals and other endodontic care, non-surgical periodontal disease treatment, denture adjustments and repairs, certain oral surgery services, and other designated adjunctive services. **Enhanced Plus**: Members are eligible by completing a second recall exam within 6-12 months of first recall exam. • **All Core and Enhanced Benefits plus** crowns, tooth replacements and periodontal surgery. Enhanced Plus benefits will be subject to prior authorization. • Benefits are maintained by adhering to a recall exam every 6 to 12 months.

*IDPH DWP Fact Sheet

CHAPTER III

METHODS

Overview

The objective of this study was to assess periodontal treatment needs and explore the relationships that exist between treatment need, systemic health conditions, and socio-behavioral factors among the Medicaid expansion population in the state of Iowa. A secondary data analysis of electronic health records (EHR) data from the University of Iowa College of Dentistry was conducted. Univariate and bivariate analyses were completed with the proposed variables. Logistic regression models were used to analyze relationships between predictors and treatment need.

Study Aim

The aim of this secondary data analysis was to investigate and determine periodontal treatment needs of a Medicaid expansion population in the state of Iowa, while evaluating for systemic health conditions and socio-behavioral factors associated with clinical periodontal records and EHR data was utilized. The study population included patients seen at the University of Iowa College of Dentistry (UI COD) in the Oral Diagnosis (OD) clinic. Comparison groups of

interest included patients insured by DWP, along with patients insured by the traditional Medicaid State Plan, patients with private dental insurance, and self-pay patients.

Research Questions

1. Do DWP patients have greater treatment needs for periodontal disease when compared with patients with Medicaid, private insurance, or self-payers?
2. Are patients with greater periodontal disease treatment needs more likely to present with various systemic medical conditions than patients with less periodontal disease treatment needs?

Hypotheses

1. Dental Wellness Plan patients will have greater treatment needs for periodontal disease, assessed using the CPITN, than patients with Medicaid, private insurance, or self-payers.
2. Patients with higher periodontal disease needs, assessed using the CPITN, will be more likely to exhibit various systemic medical conditions than patients with lower periodontal disease treatment needs.

IRB Approval

An application was submitted and approval was obtained via expedited review from the University of Iowa Institutional Review Board (IRB-01) on September 9, 2016. Project #201609717 was accepted on September 16, 2016.

Data Analysis

Statistical analyses were conducted using SPSS version 24.

Data Source

Data for this study came from the University of Iowa College of Dentistry EHR system, AxiUm. All patient information is presented in aggregate; no personal identifiers were included in the final report. Data from the EHR were obtained by the Director, Technology and Media Services at the University of Iowa College of Dentistry, Charles McBrearty. Mr. McBrearty retrieved the EHR data and presented the data in Excel spreadsheets, then the data was imported into SPSS for statistical analysis.

Inclusion Criteria

Patients of record at the UI COD were included in the study if they received a comprehensive oral evaluation (CDT D0150) between

May 1, 2014 – April 30, 2016 in the OD clinic. The specific range of dates was chosen to encompass the first two years of implementation of the DWP program. Patients were included if they were between the ages of 19 to 64 years to encompass the entire age range covered by the DWP. In order to be included in this study, patients were required to have at least six teeth present based on the protocol used by Dye et al. (2002).

To capture patient characteristics and periodontal treatment needs upon entrance to the University of Iowa College of Dentistry, patient flow throughout the college was important to consider. New or inactive patients funnel through the Admissions Clinic to appropriate clinics. Children and adolescents go to the Pediatric Clinic and those with special needs are seen in the Special Care Clinic. All other patients are first seen in the Admissions Clinic. From Admissions, they are sent to one of two clinics, OD or the Family Dentistry Clinic (FAMD). We chose to limit this study to patients seen in OD in order to keep data consistent and reduce variability among clinic procedures.

Exclusion Criteria

Individuals were excluded from the chart review if they were treated in the clinic on a "limited" basis, meaning a limited oral evaluation was completed to evaluate a specific concern and the

individual did not receive a full mouth examination. Patients were excluded if they were below the age of 19 or 65 and older. This eliminated individuals that the DWP does not provide coverage for. Individuals were also excluded if they had less than six teeth present.

Sample Size

Upon initial data extraction, a sample size of 5,188 patients from FAMD and OD were collected. EHR of patients that did not match the inclusion criteria for the study were removed, resulting in 1,876 patient charts remaining. Of the 1,876 charts, 18 charts were removed from the study due to missing periodontal information in the EHR and another 18 charts were removed due to duplicate charts present in the dataset. The final sample consisted of 1,840 patient charts with complete periodontal data.

Dependent Variable

The dependent variable for this study was a dichotomized version of the CPITN. An individual CPITN score was derived from PSR scores that were collected at the initial comprehensive examination appointment by third-year dental students in the OD clinic. Table 2, presented in Chapter II, illustrates similarities between the PSR and CPITN.

The PSR is assessed by evaluation of each tooth in a sextant, assessing six sites per tooth: disto-buccal, buccal, mesio-buccal, disto-lingual, lingual, and mesio-lingual. The highest or deepest probing depth is recorded for that sextant.

The sextants consist of the upper right (UR), upper anteriors (UA), upper left (UL), lower left (LL), lower anteriors (LA), and lower right (LR). The score for each sextant depends on PD, presence of BOP, and the presence of calculus or restoration overhangs found on the teeth in that given sextant.

When PSR data were collected in the clinic, periodontal measurements were truncated to the millimeter and were made with a non-WHO probe (without a ball-tip end), using either 3-6-9 marked Marquis periodontal probe, a variation of the UNC-12/15 probe with 1-2-3-4-etc. marks, or a 1-1-1-2-2-1-1 marked Williams probe. The PSR completed in the OD clinic compensates for the use of a non-WHO probe with a 0.5mm ball-tip end by rounding to the nearest millimeter. A score of either 0, 1, 2, 3, or 4, with a possible asterisk (*) for abnormalities found, was recorded for each sextant.

The PSR data retrieved in the EHR were then transformed into CPITN data. Data for this study’s CPITN was derived by recoding the PSR by the removal of any asterisks present and transforming the PSR into the CPITN for each sextant. A full mouth CPITN score was then

derived by determining the highest CPITN score in the mouth. From there, the CPITN score was dichotomized into two categories: SRP not indicated (CPITN 0-2) and SRP indicated (CPITN 3-4) (Figure 2). CPITN scores of 0-2 indicate that periodontal disease is not present in the individual and periodontal therapy is not warranted. A CPITN score of 3 or 4 indicate that periodontal disease is present and requires scaling and root planing (SRP).

Independent Variables

The independent variables for this study included various self-reported patient medical and dental history included in the EHR. Independent variables were categorized into three domains: Demographics, Health Conditions, and Socio-behavioral Factors (Table 4).

A total of 39 variables were extracted from the EHR initially. The Demographic domain included: age, sex, race/ethnicity, and insurance type.

Health Conditions included: body mass index (BMI), heart attack or heart disease, stroke, congestive heart failure, hypertension, immunosuppressive conditions, steroid therapy, radiation therapy, chemotherapy, SLE (lupus), rheumatoid arthritis, HIV, diabetes, thyroid disease, arthritis (osteo or rheumatoid), salivary status, and

prior periodontal treatment. Health Conditions variables also included responses to the following questions:

- "Do you have or have you ever been treated for cancer?"
- "Do your gums bleed when you brush your teeth?"

The Socio-behavioral domain included: history of addiction to a chemical substance with individual responses to: alcohol, prescription drugs, heroin, meth, cocaine, and other, "Have you ever smoked?" with the following responses: former smoker, smokes rarely, smokes occasionally, smokes every day, and smokes more than 10 cigarettes/day. Socio-behavioral domain variables also included responses to the following questions:

- "Chief Complaint (Why are you seeking dental care?)"
- "Do you have regular check-ups?"
- "When was your last dental exam?"
- "Has fear ever prevented you from seeking dental treatment?"

Univariate Analysis

Descriptive statistics were calculated for the 1,840 subjects in the study population. Statistics generated include frequencies, valid percent responses, and are reported by domain in Appendix A. Several characteristics originally analyzed in the form of raw numbers were

transformed into percentages.

Based on univariate analysis, to better describe the characteristics of the study population some variables were transformed. Due to disproportionate distributions on responses regarding heart disease/heart attack (n=51), stroke (n=13), and congestive heart failure (n=9), these variables were collapsed into one category: cardiovascular diseases (CVD).

The variable immunosuppressive conditions included any positive response for steroid therapy, radiation therapy, chemotherapy, SLE (lupus), rheumatoid arthritis, and HIV.

Also, history of addiction to a chemical substance with positive responses to alcohol, prescription drugs, heroin, meth, cocaine, and other, were categorized as history of addiction to a chemical substance.

Age groups were categorized into five different groups: 19-24, 25-34, 35-44, 45-54, 55+ for descriptive and bivariate analysis. Body mass index (BMI) was imported from AxiUm as a continuous variable. BMI was then categorized into four levels, based on CDC guidelines (CDC 2015): less than 18.5 was considered underweight, 18.5 to 24.9 was labeled normal/healthy weight, 25 to 29.9 was considered overweight, and equal to or greater than 30 was categorized as obese.

The variable, smoking status, was categorized based on a series

of questions from the EHR. In the EHR, individuals are prompted with the question "Have you ever smoked?", requiring a yes/no response. From there, further description of smoking habits is asked of the individual: former smoker, smokes rarely, smokes occasionally, smokes everything, and smokes more than 10 cigarettes/day. From the obtained variables, according to CDC smoking status categories (CDC 2009), these variables were collapsed into three levels: current smoker, former smoker, and never smoker.

Furthermore, the variable "date of last exam" was excluded due to the non-verifiable nature of the response. In the EHR, the modality of recording this variable was an open text box, resulting in great inconsistencies in how the response was recorded. Reason for seeking dental care was also not evaluated due to the nature of the response. The EHR allowed for open text field, rendering assessment of the responses difficult to decipher.

EHR variables that were selected as appropriate for bivariate analysis based on univariate screening are presented in Appendix B.

Bivariate Analysis

Based on univariate analyses, a total of 18 variables related to patient characteristics were chosen for the bivariate analysis. Bivariate analyses were completed to determine factors associated with the

need for SRP. Associations considered to be significant ($p \leq .1$) were used to develop the final multivariable logistic regression model. The bivariate relationships with person-level CPITN scores are reported in Appendix B.

From the bivariate analysis, it was found that 15 of the 18 variables demonstrated statistically significant associations with full mouth CPITN scores. The variable race/ethnicity was eliminated from the final model due to a substantial number of missing data (n=168) and disproportionate distribution with approximately 84% falling into the White category. The variables "Do your gums bleed when you brush your teeth?" and "Check the types of dental treatment you have experienced: Periodontal (gum) treatment" were also removed from the final model due to the fact that they are highly related to the outcome of interest.

The immunosuppressive category was found to be statistically nonsignificant association with our outcome of interest, thus not utilized in the final model. Due to the associations that have been found in the literature, CVD was retained and used in the final model although it proved to be nonsignificant in the bivariate analysis.

To summarize the bivariate analysis: 12 variables showing statistically significant in the bivariate analysis were used to build the final logistic regression model.

Multivariable Logistic Regression

Multivariable logistic regression models were performed to explore the variables that could predict the need for SRP. A p-value of less than 0.5 was used as a criterion for statistical significance.

Figure 2. Dichotomized Community Periodontal Index for Treatment Needs (CPITN) outcome

CPITN	Diagnosis	
0	Healthy tissues, no BOP → no pockets >3mm, black band fully visible	***SRP not indicated***
1	BOP, no pockets >3mm, black band fully visible	
2	Calculus/overhangs, no pockets >3mm, black band fully visible	
3	Pockets >3mm & <5mm, black band partially visible	***SRP indicated***
4	Pockets >5mm, black band NOT visible	
X	Fewer than 2 teeth function in sextant	

BOP = Bleeding on probing
SRP = Scaling and root planing

Table 4. Independent variables initially obtained from the electronic health record: demographics, health conditions, and socio-behavioral factors

Demographics	Health Conditions	Socio-behavioral Factors
• Age	• Body mass index (BMI)	• Dental fear
• Sex	• Diabetes	• Date of last exam
• Race/ ethnicity	• History of cancer treatment	• Not receiving regular dental check-ups
• Insurance type	• Hypertension	• Smoking status: Former smoker Smokes rarely Smokes occasionally Smokes every day Smokes more than 10/day
	• Cardiovascular Disease (CVD): Heart attack/disease Stroke Congestive heart failure	
	• Immunosuppressive conditions Steroid therapy Radiation therapy Chemotherapy SLE (lupus) Rheumatoid arthritis HIV	• Chemical abuse substance Alcohol Prescription drugs Heroin Meth Cocaine Other
	• Thyroid disease	• Reason for seeking dental care
	• Salivary dysfunction	
	• Arthritis (osteo or rheumatoid)	

CHAPTER IV

RESULTS

In the two years evaluated in this study, May 1, 2014 – April 30, 2016, there were a total of 1,840 newly admitted patients to the OD clinic that met the inclusion criteria. The outcome of interest for this study is a patient's CPITN score at initial evaluation, dichotomized as (0-2 = not indicated for SRP) and (3-4 = indicated for SRP).

Table 5 shows CPITN scores reported by sextant for the study population. Person-level CPITN scores are presented in Table 6. In the study population, 846 (46%) were not indicated for scaling and root planing (SRP) and 994 (54%) were indicated for SRP using the person-level dichotomized CPITN score (Table 7).

Descriptive statistics and frequency histograms were generated to depict characteristics of subjects gathered from EHR stored in AxiUm at the University of Iowa College of Dentistry (UI COD). The results were used to screen possible variables for inclusion in the bivariate and logistic regression analyses.

Univariate and Bivariate Analyses

Males (n=805) represented 44.0% of the study population and females (n=1035) embodied 56.0%. Age was classified into five

categories for descriptive analysis and was distributed as follows: 19 to 24 years (18.0%), 25 to 34 years (24.0%), 35 to 44 years (18.0%), 45 to 54 years (18.0%), 55 to 64 years (22.0%). Data frequencies are presented in whole numbers and valid percentages in Appendix A1.

Insurance type was classified into four categories: Dental Wellness Plan (DWP), private, self-pay, and Medicaid. Frequencies are presented in whole numbers and valid percentages in Appendix A1.

Race/ethnicity was categorized into five categories: American Indian (.3%), Asian (5.6%), Black (8.6%), Islander (.1%), White (76.3%), and Unknown (9.1%). Descriptive results are presented in whole numbers and valid percentages in Appendix A1. After bivariate analysis, a decision was made to eliminate race/ethnicity variable from the final multivariable logistic regression models due to a disproportionate distribution.

Associations between each of the three Demographic Domain variables and person-level CPITN score were evaluated using chi-square tests. Variables showing significant associations with the outcome variable ($p \leq .1$) were considered as candidates for the final logistic regression model. Bivariate results are presented in Appendix B1. As all three of these variables were statistically significant, they were selected as candidates for building the final multivariable logistic regression model.

In the bivariate analysis evaluating the associated between insurance type and the need for SRP, it was found that over 50% of DWP (56.9%), self-pay (55.7%), and Medicaid (56.4%) patients were indicated for SRP. Nearly, 50% (49.7%) of privately insured individuals were indicated for SRP.

Univariate analysis of the initial set of Systemic Health Domain variables resulted in all ten Systemic Health Domain variables advancing to the bivariate analysis (Appendix B2). Descriptive results for Systemic Health Domain are presented in whole numbers and valid percentages in Appendix A2. The variable describing hypertension (yes or no) presented with a total of 365 (19.9%) self-reporting a diagnosis of hypertension.

Approximately 8.4% of the study population reported a diagnosis of diabetes, 4.3% had past treatment for cancer, 33.2% experienced bleeding when brushing, and 5% had a past history of periodontal therapy. Approximately 67% of the patient population fell into the overweight or obese categories for BMI. Roughly 3.5% of the study population reported a diagnosis of cardiovascular diseases (CVD). Descriptive results for Systemic Health Domain after variable manipulations are presented in whole numbers and valid percentages in Appendix A3.

Chi-square test was used to assess the association between each of the ten Systemic Health Domain variables and person-level dichotomized CPITN score. The results are presented in Appendix B2. Although the variable, CVD, was not statistically significant, it was chosen for inclusion in the final logistic regression model due to associations reported between CVD and periodontal disease in the literature. Five of the ten Systemic Health Domain variables showing statistical significance in bivariate analysis were selected for developing the final logistic regression model, except for the two variables: gum bleed when brushing and history of periodontal treatment. Although they showed to be statistically significant in the bivariate analysis, they were eliminated from the final model due to be too similar to our outcome of interest.

Regarding Socio-Behavioral Domain factors, four variables were included in the bivariate and logistic regression analyses. The variable describing history of chemical substance abuse (yes or no) presented with a total of 88 (4.7%) responding they had past addiction. Twenty-four percent of the study population stated that they were current smokers, approximately 21% were past smokers and 55% were never smokers. A large portion of the study population did not receive regular dental check-ups with only 27.2% reported that they seek

regular care. Approximately 23% stated that fear prevented them from seeking dental treatment.

Chi-square test was used to assess the association between the four socio-behavioral variables and person-level CPITN score, and results are presented in Appendix B3. All four of these variables were statistically significant and they were selected as candidates to develop for the final logistic regression model.

Multicollinearity diagnostics were conducted on all independent variables in order to identify highly correlated or associated between two or among more independent variables in the logistic regression models. The goal was to determine how well each one of a number of independent variable can most effectively be utilized to predict the outcome variable in the logistic regression model and to avoid problems with multicollinearity that can mislead results.

Correlations and associations were considered to be high for variables with a variance inflation factor (VIF) of 5 and above, as VIF of 5 or greater indicates multicollinearity. Tolerance values were also evaluated; a tolerance of less than .20 would indicate a multicollinearity problem. All variables 13 variables evaluated were within the determined thresholds. All 13 variables had a tolerance level greater than .20 and VIF factors under 5, thus all were included in the final multivariable logistic regression model.

Multivariable Logistic Regression Models

After evaluating univariate statistics, bivariate analysis, and multicollinearity among possible independent variables, 13 variables were chosen for inclusion in the final multivariable logistic regression model. These variables are presented in Appendix B and are listed in the previous chapter. They include three Demographic Domain characteristic variables, six Systemic Health Domain variables, and four Socio-Behavioral Domain characteristics. Due to the missing values for some variables, the final model included a total of 1,259 observations. A Hosmer and Lemeshow test was constructed to assess goodness of fit of the model. It was found to be not significant (x^2 = 10.51, 8 df, p = .23).

First Multivariable Logistic Regression Model

To answer the first research question, we ran a multivariable logistic regression model to explore whether insurance type had a significant impact on CPITN score by controlling age and gender, the results are presented in table 8. The model included three variables from the Demographic Domain: age, gender, and insurance type. This analysis revealed that insurance type did affect CPITN significantly (p=.007), while age (p=<.0001) and gender (p=<.0001) also showed statistically significant.

Moreover, it was found that there was no statistical different in need for SRP between the Medicaid population and the DWP population after controlling for age and gender. However, privately insured and self-pay patients were significantly less likely than DWP patients to require SRP (OR=.72, p=.01; OR=.73, p=.02, respectively).

Age and gender were also significantly associated with the need for SRP, showing odds ratios with similar direction and magnitude as seen in the full model. The odds of being indicated for SRP increased 4.5% as age increased by 1 year. In regards to gender, the odds of being indicated for SRP among males was 1.96 times the odds for females. Results are presented in Table 8.

Final Multivariable Logistic Regression Model

The results of final multivariable logistic regression model predicting dichotomized CPITN score are presented in Table 9. The final logistic regression model revealed that five predictor variables were statistically significant contributors ($p<.05$) to the outcome variable: age, gender, diabetes, smoking status, and having regular dental check-ups.

Two Demographic variables that were statistically significant: age ($p<.0001$) and gender ($p<.0001$). The Systemic Health Domain contained one statistically significant variable diabetes ($p=.031$), while

the Socio-Behavioral variables had two variables shown to be statistically significant: smoking status (p<.0001) and regular dental check-ups (p<.0001).

Within the Demographic Domain, the odds ratio compares the likelihood of a males requiring scaling and root planing (SRP) to females. When holding all other variables constant, the odds of needing SRP among males was 1.98 times as likely as for females.

The odds of needing SRP increased 3.8% as age increased by 1-year. For individuals with a reported history of diabetes, the odds of needing SRP were 1.73 times as likely as for those without a diagnosis of diabetes (OR=1.73, CI=1.052-2.843, p<.0001).

Moreover, individuals without regular dental check-ups were associated with 1.59 greater odds of being indicated for SRP than those with regular dental check-ups (OR=1.59, CI=1.21-2.1, p<.0001).

The odds of being indicated for SRP among never smokers was .529 times the odds of current smokers, or a 52.9% decrease in the odds when compared to current smokers (OR=.471, CI=.343-.647, p<.0001). In regards to former smokers, it was found that they had 39.9% decrease in the odds of being indicated for SRP when compared to current smokers (OR=.601, CI=.412-.875, p<.008).

Additional Multivariable Logistic Regression Model

Additional models were explored to determine whether certain variables had an impact on the final results in Table 9. Due to the self-reported, unreliable nature of the BMI, and large number of missing responses for that variable, bivariate analysis on BMI and CPITN score was conducted on only individuals that had BMI data. When BMI was removed from the final model, the final model remained unchanged with regard to no differences noted in significances and the magnitude or direction of the odds ratios (Appendix C, Table C1).

Two other variables that were evaluated for their relevance in the final model were CVD and salivary dysfunction. CVD was found not to be statistically associated with the need for SRP, however, was used in the final model due to significance in the literature. When CVD was removed from the model, the final model remained unchanged with no differences noted in significances and the magnitude or direction of the odds ratios (Appendix C, Table C2). Salivary dysfunction was evaluated due to unclear parameters surrounding the variable. Again, when salivary dysfunction was removed from the model, the final model remained unchanged with no differences noted in significances and the magnitude or direction of the odds ratios (Appendix C, Table C3).

Table 5. Sextant-level Community Periodontal Index of Treatment Needs (CPITN) scores (N=1,840)

Sextant CPITN Score	Upper Right N (%)	Upper Anterior N (%)	Upper Left N (%)	Lower Left N (%)	Lower Anterior N (%)	Lower Right N (%)
0	188 (10.5)	322 (17.9)	194 (10.9)	143 (7.9)	124 (6.8)	137 (7.6)
1	455 (25.5)	623 (34.6)	453 (25.4)	476 (26.2)	231 (12.7)	443 (24.5)
2	563 (31.6)	594 (33.0)	626 (35.1)	626 (34.5)	1212 (66.4)	592 (32.7)
3	466 (26.1)	213 (11.8)	418 (23.5)	486 (26.8)	210 (11.5)	527 (29.1)
4	112 (6.3)	46 (2.6)	91 (5.1)	85 (4.7)	49 (2.7)	111 (6.1)

Table 6. Person-level Community Periodontal Index of Treatment Needs (CPITN) scores (n=1840)

FM CPITN Score	Frequency	Percent
0	39	2.1%
1	152	8.3%
2	655	35.6%
3	738	40.1%
4	256	13.9%

Table 7. Person-level dichotomized Community Periodontal Index of Treatment Needs (CPITN) scores (n=1840)

Dichotomized FM CPITN Score	Frequency	Percent
SRP not indicated	846	46%
SRP indicated	994	54%

Table 8. First multivariable logistic regression model for factors associated with the need for scaling and root planing (SRP) (N=1,840)

Variable	Odds Ratio Estimate (95% CI)	P-value
Age	1.045 (1.038, 1.053	**<.0001***
Gender		**<.0001***
Males	1.956 (1.603, 2.386)	
Females	1.00	
Insurance		**.007***
Private	.723 (.564, .926)	**.010***
Self-Pay	.725 (.553, .951)	**.020***
Medicaid	1.095 (.784, 1.531)	.594
DWP	1.00	

*significant at p<0.05

Table 9. Final multivariable logistic regression model for factors associated with the need for scaling and root planing (SRP) (N=1,259)

Variable	Odds Ratio Estimate (95% CI)	P-value
Age	1.038 (1.027, 1.048)	**<.0001***
Gender		**<.0001***
Males	1.979 (1.539, 2.544)	
Females	1.00	
Insurance		.401
Private	.836 (.613, 1.140)	
Self-pay	.937 (.668, 1.315)	
Medicaid	1.172 (.775, 1.772)	
DWP	1.00	
BMI	.997 (.979, 1.015)	.707
CVD		.191
Yes	.643 (.331, 1.246)	
No	1.00	
Hypertension		.324
Yes	1.193 (.840, 1.695)	
No	1.00	
Diabetes		**.031***
Yes	1.730 (1.052, 2.843)	
No	1.00	
History of cancer treatment		.757
Yes	1.100 (.600, 2.018)	
No	1.00	
History of addition to a chemical substance		.751
Yes	1.110 (.583, 2.116)	
No	1.00	
Smoking Status		**<.0001***
Never	.471 (.343, .647)	**<.0001**
Former	.601 (.412, .875)	**.008**
Current	1.00	
Does not have regular dental check-ups		**<.0001***
No	1.59 (1.21, 2.1)	
Yes	1.00	
Fear has prevented seeking dental treatment		.307
Yes	1.166 (.868, 1.566)	
No	1.00	
Salivary Dysfunction		.557
Yes	.879 (.572, 1.351)	
No	1.00	

*significant at p<0.05

CHAPTER V

DISCUSSION

The primary goal of this study was to determine periodontal treatment needs of a Medicaid expansion population in the state of Iowa, while evaluating for systemic health conditions and socio-behavioral factors using a secondary data analysis of clinical periodontal data collected by the University of Iowa College of Dentistry. This was accomplished through a chart review of the EHR at the University of Iowa College of Dentistry and Dental Clinics.

Dependent Variable

Periodontal disease can be categorized in several ways. A decision was made to use the Community and Periodontal Index for Treatment Needs (CPITN) as the determinant of periodontal disease as the best way to determine community level treatment needs. CPITN scores were dichotomized into whether SRP was indicated at the person-level or not. Recent studies have used the CPITN index to evaluate existing periodontal disease surveillance data. Dye and Vargas transformed NHANES III data into CPITN scores to determine level of periodontal treatment needs (Dye and Vargas 2002).

A primary hypothesis of this project was that DWP patients

would have an increased need for periodontal treatment. This was based on the notion that DWP patients may be less likely to have received previous comprehensive dental treatment since most did not have previous insurance coverage (Reynolds et al. 2015).

Interestingly, it was found that approximately 50% of individuals in each insurance type categories were indicated for SRP. So, while being in the DWP program was not found to be significantly related to the need for SRP in the final multivariable logistic regression model, all insurance populations were highly indicated for SRP.

An important characteristic of periodontal disease, is that it is individualized. The historical study conducted by Löe et al. (1986) evaluated periodontal disease and tooth loss in male Sri Lanka tea workers that had never had previous dental treatment or prevention programs. It was found that even though the group was very similar in their lack of previous dental care, wide ranges of severity of periodontal disease existed (Löe et al. 1986). This exemplified the individual host's susceptibility to periodontal disease. This could be an explanation to our finding that the DWP patient population of this study, who may be more likely to not have access to previous dental care exhibited similar treatment needs to those individuals with other insurance options.

Expanding on that, all other insurance types have the capability

or option to pay for the periodontal treatment. Iowa Medicaid, for example, will cover the cost of SRP treatment, while private insurers typically cover some portion of the treatment depending on the insurance plan. Patients in the DWP program, however, have to wait to receive a SRP, a treatment that is known to be of value to these patients. This raises the question as to the value of delaying the treatment of periodontal disease for DWP members when we know that it has been associated with other chronic health conditions?

We also know that many individuals are not staying in the DWP program or advancing to the Enhanced tier where SRP can be completed and covered by the program. This can be due to the individual becoming ineligible for coverage (about half are no longer eligible after two years in the DWP) or failing to maintain their professional dental check-ups every 6-12 months, thus having to start the waiting period over again. Many individuals are leaving the program with untreated disease and this is problematic for the long-term health of the individual.

Logistic Regression Models

Prior to controlling for systemic health conditions and socio-behavioral factors, it was determined that the Dental Wellness Plan (DWP) and Medicaid population were not significantly different from

each other in the need for scaling and root planing (SRP). This is not surprising as DWP is a Medicaid expansion program and a comparable population. Individuals in DWP are labeled as low-income, however, were not categorically eligible for Medicaid prior to the Medicaid expansion.

That said, they still fall into the low-income category. There is also fluctuation that can occur between Medicaid and DWP beneficiaries. Individuals who become ineligible for DWP may be picked up by Medicaid if they become categorically eligible (e.g., pregnant women) or individuals in Medicaid may increase their income and become eligible for DWP. These are thought to be two similar populations in terms of need for dental care when they enter either program.

For the final multivariable logistic regression models, the 13 variables selected from the previous analyses were entered into the model. Five of the variables were significantly associated with the dependent variable ($p<.05$) to the final model.

Most of the variables that were significantly associated with the need for SRP during the bivariate analysis did not remain associated with these in the logistic regression analysis. Cardiovascular disease (CVD) was not significantly associated in the bivariate analysis, however, it was maintained in the final model (and still not

significantly related to need for SRP) due to significant associations that had been found in the literature (DeStefano et al. 1993, Leng et al. 2015). The lack of a relationship between CVD and need for SRP is an interesting finding in the current study population due to the previous literature suggesting an association between periodontal disease and CVD.

Many recent studies have evaluated a relationship between CVD and periodontal disease by measuring systemic antibodies to designated periodontal pathogens (Kuramitsu et al. 2001, Demmer and Desvarieux 2006). Results from these studies have shown positive associations between periodontal disease and CVD. A possible reason for this difference in our study could be due to recall bias or potentially undiagnosed health conditions.

An important point to consider with the current data used for this study is that variables are based on self-reported medical history and recalling of information. There is always a level of response bias that can occur in this scenario. Or, if individuals in DWP have not had previous dental insurance they may also not have had medical coverage as well. This could lend to many undiagnosed medical problems in DWP individuals.

Two significant associations were noted within the Socio-Behavioral Domain. Smoking status and receipt of regular dental

check-ups were found to be significantly associated with the need for SRP. The association between smoking status and increased risk for periodontal disease has been widely researched. Studies have shown that there are associations between missing teeth or bone loss and the use of smoking tobacco (Albandar et al. 2000, Molloy et al. 2004).

The five variables found to be significantly associated with the need for SRP have been found to be associated in other prevalence and clinical studies. Eke et al. (2012) evaluated NHANES 2009-2010 data to determine the prevalence of periodontal disease in the United States and found that 64.7 million adults (47%) over the age of 30 had some form of periodontal disease. Males were found to have a higher prevalence of periodontal disease (56.4%) than females, 64.2% of those 64.7 million were current smokers and 65.4% were below the FPL. Our findings for those that were indicated for SRP (54%) and our significantly associated predictor variables are comparable.

A limitation to the current study is the use of self-reported medical history and dental history data. Patients were asked to recall information regarding their health, behaviors, and dental utilization patterns. These data have the potential to be skewed if individuals have not sought dental or medical treatment in years and are required to rely on vague memories.

An underestimation of medically diagnosed conditions are possible if respondents have not utilized medical care and are undiagnosed. An overestimation of good behavior or healthy conditions could be a result of social desirability bias.

Another limitation to the study is the way patients flow through the clinics in the University of Iowa College of Dentistry. The goal was to capture a patient's first comprehensive oral evaluation (D0150) at the dental school to evaluate periodontal treatment needs within a set time-period. This could underestimate periodontal treatment needs of individuals who only seek care on a limited basis. Individuals seeking care only on a limited basis may enter the clinic when in pain or discomfort, never seeking comprehensive care and only treating the current problem. If these individuals suffer from periodontal disease and are not actively treating the disease in compressive care, we may be underestimating the prevalence of periodontal disease.

Within the University of Iowa College of Dentistry, patients are screened in Admissions and sent to appropriate clinics: Pediatrics, Geriatrics & Special Needs, Family Dentistry, and Oral Diagnosis. This study focuses on the Oral Diagnosis clinic in order to reduce variability among providers; however, within this single clinic, periodontal screening is completed by assigned students under faculty supervision. The periodontal screenings are conducted by third year dental

students with limited experience in this area. Student's capabilities and level of understanding could lead to under diagnosis rather than over diagnosis.

Periodontal probes also vary within the clinic with students able to use the periodontal probe they prefer. Students' periodontal probing depths are evaluated by supervising faculty and 1mm is considered acceptable interrater variation within the clinic. Also, only focusing on one clinic could lead to an underestimation of periodontal treatment needs if more complex cases are seen in other clinics. Further studies evaluating these clinics could help to give a better overall view of periodontal treatment needs in this patient population.

While there are a few limitations that can be expected with self-reported electronic health records (EHR) review data, there are strengths accompanying as well. The EHR data are stored on AxiUm, a dental charting software, that is used consistently throughout the college. This provides access to a large dataset and within our inclusion criteria, we had a large study population (n=1,840).

The DWP provides comprehensive dental care coverage to adults between the ages of 19-64 years with income between 0-133% of the Federal Poverty Level (FPL) in Iowa. This population is of significance because much of this population was previously uninsured and not well characterized, prior to the Medicaid expansion. This study provides

unique insight into the oral health and periodontal needs of this population. Additional evaluation of the DWP program is currently underway in studies evaluating consumer experiences with self-reported health measures, provider experience, and cost outcomes. health measures, provider experience, and cost outcomes.

An interesting finding with important policy implication is the association between not receiving regular dental check-ups and the need for SRP. In a recent evaluation of consumer experience with the DWP, approximately 82% of respondents stated that they did not previously have dental insurance (Reynolds et al. 2015). This is a concerning number of individuals who may be suffering from periodontal disease, as well as other systemic diseases, and may not be receiving treatment. With the connections that have been established between periodontal disease and systemic health conditions, it is important to treat periodontal disease as a possible way to help control conditions such as diabetes mellitus.

The programmatic structure of DWP is a unique earned benefits approach to increase covered services to encourage members to pursue preventive dental care. Members become eligible for additional covered services if they return for regular periodic recall exams. SRP, the gold standard for initial periodontal disease treatment, is not

covered for those who need the treatment for at least 6 months and up to 1 year.

This delaying of treatment could exasperate systemic health conditions and worsen the periodontal health of these individuals. This lends itself to further policy consideration and potential evaluation of the cost-effectiveness of the earned benefits model of the DWP program.

The results of this study raise other important questions about the utilization of dental care, some of which are being evaluated in other studies about the DWP program. For example, an important question is the proportion of patients that are utilizing the enhanced benefits approach before they fall out of the program. A recent, mapping completed by the University of Iowa Public Policy Center, found that approximately only 5% initial DWP enrollees have made it to the most comprehensive coverage tier after two years (McKernan et al. 2017). Again, a significant concern that many individuals with periodontal disease have yet to have treatment to help prevent the progression of disease.

While this study found that there were significant associations between the need for SRP and age, gender, diabetes mellitus, smoking status, and receipt of regular dental check-ups, further evaluation of other UI COD clinics could give more insight into other significant

findings. Additional research evaluating this unique population could also provide more insight into the dental conditions that a previously uninsured population may have and require treatment for.

CHAPTER VI

CONCLUSION

The goal of this study was to investigate and determine periodontal treatment needs of a Medicaid expansion population in the state of Iowa, including potential relationships to systemic health conditions and socio-behavioral factors, by conducting a secondary data analysis using clinical periodontal data collected from the EHR at the University of Iowa College of Dentistry.

Our hypothesis was that DWP patients would exhibit greater need for periodontal disease than other populations. This hypothesis was related to previous research that indicated that DWP patients may not have had previous routine dental care prior to enrolling in DWP. Our study found, however, that being in the DWP program was not significantly different than individuals with other insurance types regarding the need for SRP. However, despite DWP program enrollment not being statistically different, approximately 50% of all patients, regardless of insurance type, indicated a need for SRP. This has important policy implications for DWP patients who are required by the earned benefit model of the program to delay treatment for 6-12 months. Future studies on the implications of the DWP earned benefit model for members with periodontal disease, particularly on their oral

health status, cost-effectiveness of delaying treatment and impact on their overall health status should be conducted.

APPENDIX A

EHR VARIABLE FREQUENCIES

Table A1. Demographic Domain frequencies

Variable	Frequency	Valid Percent
Age (n=1840)		
19-24 years	330	18.0%
25-34 years	443	24.0%
35-44 years	332	18.0%
45-54 years	332	18.0%
55-64 years	403	22.0%
Gender (n=1840)		
Male	805	44.0%
Female	1035	56.0%
Race/Ethnicity (n=1672)		
Native American	5	.3%
Asian	103	5.6%
Black	159	8.6%
Pacific Islander	2	.1%
White	1403	76.3%
Unknown	168	9.1%
Insurance type (n=1840)		
DWP	499	27.0%
Private	644	35.0%
Self-pay	470	26.0%
Medicaid	227	12.0%

Table A2. Systemic Health Domain frequencies

Variable	Frequency	Valid Percent
BMI (n=1365)		
Underweight	33	2.4%
Normal/Healthy	425	31.1%
Overweight	435	31.9%
Obese	472	34.6%
Heart attack/disease (n=1837)		
Yes	51	3.0%
No	1786	97.0%
Stroke (n=1840)		
Yes	13	.7%
No	1827	99.3%
Hypertension (n=1838)		
Yes	365	19.9%
No	1473	80.1%
Congestive heart failure (n=1839)		
Yes	9	.5%
No	1830	99.5%
Immunosuppressive conditions (n=1836)		
Yes	74	4.0%
No	1762	96.0%
Steroid therapy (n=74)		
Yes	23	31.1%
No	51	68.9%
Radiation therapy (n=74)		
Yes	12	16.2%
No	62	83.8%
Chemotherapy (n=74)		
Yes	15	20.3%
No	59	79.7%

Table A2. Continued

Variable	Frequency	Valid Percent
Systemic lupus erythematosus (Lupus) (n=74)		
Yes	4	5.4%
No	70	94.6%
Rheumatoid arthritis (n=74)		
Yes	17	23.0%
No	57	77.0%
HIV (n=74)		
Yes	1	1.4%
No	73	98.6%
Diabetes (n=1840)		
Yes	154	8.4%
No	1686	91.6%
Thyroid disease (n=1840)		
Yes	146	7.9%
No	1694	92.1%
History of cancer treatment (n=1836)		
Yes	79	4.3%
No	1757	95.7%
Gum bleed when brushing (n=1823)		
Yes	605	33.2%
No	1218	66.8%
History of periodontal (gum) treatment (n=1341)		
Yes	67	5.0%
No	1274	95.0%
Salivary dysfunction (n=1798)		
Yes	180	10.0%
No	1618	90.0%

Table A3. Systemic Health Domain frequencies after variable manipulation

Variable	Frequency	Valid Percent
BMI (n=1365)		
Underweight	33	2.4%
Normal/Healthy	425	31.3%
Overweight	435	31.9%
Obese	472	34.6%
Cardiovascular disease (CVD) (n=1836)		
Yes	64	3.5%
No	1772	96.5%
Hypertension (n=1838)		
Yes	365	19.9%
No	1473	80.1%
Immunosuppressive conditions (n=1836)		
Yes	74	4.0%
No	1762	96.0%
Diabetes (n=1840)		
Yes	154	8.4%
No	1686	91.6%
Thyroid disease (n=1840)		
Yes	146	7.9%
No	1694	92.1%
History of cancer treatment (n=1836)		
Yes	79	4.3%
No	1757	95.7%
Gums bleed when brushing (n=1823)		
Yes	605	33.2%
No	1218	66.8%
History of periodontal (gum) treatment (n=1341)		
Yes	67	5.0%
No	1274	95.0%
Salivary dysfunction (n=1798)		
Yes	180	10.0%
No	1618	90.0%

Table A4. Socio-behavioral Domain frequencies

Variable	Frequency	Valid Percent
History of addiction to a chemical substance (n=1832)		
Yes	86	4.7%
No	1746	95.3%
Alcohol (n=80)		
Yes	32	40.0%
No	48	60.0%
Prescription drugs (n=80)		
Yes	7	9.0%
No	73	91.0%
Heroin (n=80)		
Yes	1	1.0 %
No	79	99.0%
Meth (n=80)		
Yes	10	12.5%
No	70	87.5%
Cocaine (n=80)		
Yes	9	11.0%
No	71	89.0%
Other (n=80)		
Yes	6	7.5%
No	74	92.5%
Smoking Status (n=1385)		
Never	765	55.0%
Former	386	21.0%
Current	334	24.0%
Regular dental check-ups (n=1813)		
Yes	493	27.2%
No	1320	72.8%
Fear has prevented seeking dental treatment (n=1822)		
Yes	416	22.8%
No	1406	77.2%

APPENDIX B

BIVARIATE ANALYSIS

Table B1. Bivariate analysis of demographic variables by dichotomous Community Periodontal Index of Treatment Needs (CPITN)

Variable	CPITN (0-2) N (%)	CPITN (3-4) N (%)	Total N (%)	P-value
Age (n=1840)				**<.0001***
19-24 years	232 (27.4)	98 (9.9)	330 (17.9)	
25-34 years	248 (29.3)	195 (19.6)	443 (24.1)	
35-44 years	129 (15.2)	203 (20.4)	332 (18.0)	
45-54 years	117 (13.8)	215 (21.6)	332 (18.0)	
55-64 years	120 (14.2)	283 (28.5)	403 (21.9)	
Gender (n=1840)				**<.0001***
Female	544 (64.3)	491 (49.4)	1035 (56.3)	
Male	302 (35.7)	503 (50.7)	805 (43.8)	
Race/Ethnicity (n=1672)				**.005***
Native American	3 (.4)	2 (.2)	5 (0.3)	
Asian	60 (7.8)	43 (4.8)	103 (6.2)	
Black	58 (7.5)	101 (11.2)	159 (9.5)	
Pacific Islander	2 (.3)	0 (.0)	2 (.1)	
White	648 (84.0)	755 (83.8)	1403 (83.9)	
Insurance Type (n=1840)				**.055***
DWP	215 (25.4)	284 (28.5)	499 (27.31)	
Private	324 (38.3)	320 (32.2)	644 (35.0)	
Self-pay	208 (24.6)	262 (26.4)	470 (25.5)	
Medicaid	99 (11.7)	128 (12.9)	227 (12.3)	

*significant at $p<0.10$ using chi-square test

Table B2. Bivariate analysis of Systemic Health Conditions and patient-level Community Periodontal Index of Treatment Needs (CPITN) dichotomous outcome

Variable	CPITN (0-2) N(%)	CPITN (3-4) N(%)	Total N(%)	P-value
BMI (n=1365)				**<.0001***
Underweight	15 (2.5)	18 (2.4)	33 (2.4)	
Normal/Healthy	215 (35.7)	210 (27.5)	425 (31.1)	
Overweight	196 (32.6)	239 (31.3)	435 (31.9)	
Obese	176 (29.2)	296 (38.8)	472 (34.6)	
Hypertension (n=1838)				**<.0001***
Yes	121 (14.3)	244 (24.6)	365 (19.9)	
No	725 (85.7)	748 (75.4)	1473 (80.1)	
CVD (n=1836)				.378
Yes	26 (3.1)	38 (3.8)	64 (3.5)	
No	819 (96.9)	953 (96.2)	1772 (96.5)	
Immunosuppressive conditions (n=1836)				.334
Yes	30 (3.6)	44 (4.4)	74 (4.0)	
No	815 (96.4)	947 (95.6)	1762 (6.0)	
Diabetes (n=1840)				**<.0001***
Yes	41 (4.8)	113 (11.4)	154 (8.4)	
No	805 (95.2)	881 (88.6)	1686 (91.6)	
Thyroid Disease (n=1840)				.289
Yes	61 (7.2)	85 (8.6)	146 (7.9)	
No	785 (92.8)	909 (91.4)	1694 (92.1)	
History of cancer treatment (n=1836)				**.004***
Yes	24 (2.8)	55 (5.6)	79 (4.3)	
No	822 (97.2)	935 (94.4)	1757 (95.7)	
Gum bleed when brushing (n=1823)				**<.0001***
Yes	238 (28.4)	367 (37.3)	605 (33.2)	
No	601 (71.6)	617 (62.7)	1218 (66.8)	
History of periodontal (gum) treatment (n=1341)				**<.0001***
Yes	16 (2.5)	51 (7.3)	67 (5.0)	
No	623 (97.5)	651 (92.7)	1274 (95.0)	
Salivary Dysfunction (n=1789)				**.005***
Yes	65 (7.9)	115 (11.9)	180 (10.0)	
No	763 (92.1)	855 (88.1)	1618 (90.0)	

*significant at p<0.10 using chi-square test

Table B3. Bivariate analysis of Socio-behavioral Factors and patient-level Community Periodontal Index of Treatment Needs (CPITN) dichotomous outcome

Variable	CPITN (0-2) N (%)	CPITN (3-4) N (%)	Total N (%)	P-value
History of addiction to a chemical substance (n=1832)				**.019***
Yes	29 (3.4)	57 (5.8	86 (4.7)	
No	814 (96.6)	932 (94.2)	1746 (95.3)	
Smoking Status (n=1385)				**<.0001***
Never	392 (64.3)	373 (48.1)	765 (55.2)	
Former	105 (17.2)	229 (29.5)	334 (24.1)	
Current	113 (18.5)	173 (22.3)	286 (20.6)	
Regular dental check-ups (n=1813)				**.012***
Yes	250 (30.0)	243 (24.8)	493 (27.2)	
No	582 (70.0)	738 (75.2)	1320 (72.8)	
Fear has prevented seeking dental treatment (n=1822)				**.0001***
Yes	160 (19.2)	256 (25.9)	416 (22.8)	
No	675 (80.8)	731 (74.1)	1406 (77.2)	

*significant at $p<0.10$ using chi-square test

APPENDIX C

ADDITIONAL ANALYSES

Table C1: Multivariable logistic regression model for factors associated with the need for scaling and root planing (SRP) without BMI variable (N=1,301)

Variable	Odds Ratio Estimate (95% CI)	P-value
Age	1.038 (1.028, 1.049)	**<.0001***
Gender		**<.0001***
Males	1.963 (1.533, 2.514)	
Females	1.00	
Insurance		.376
Private	.845 (.623, 1.146)	
Self-pay	.919 (.659, 1.282)	
Medicaid	1.193 (.794, 1.791)	
DWP	1.00	
CVD		.194
Yes	.645 (.333, 1.250)	
No	1.00	
Hypertension		.368
Yes	1.170 (.831, 1.648)	
No	1.00	
Diabetes		**.037***
Yes	1.683 (1.033, 2.742)	
No	1.00	
History of cancer treatment		.890
Yes	1.043 (.574, 1.896)	
No	1.00	
History of addition to a chemical substance		.598
Yes	1.187 (.626, 2.251)	
No	1.00	
Smoking Status		**<.0001***
Never	.495 (.362, .676)	**<.0001**
Former	.609 (.421, .879)	**.008**
Current	1.00	
Does not have regular dental check-ups		**<.0001***
No	1.67 (1.278, 2.183)	
Yes	1.00	
Fear has prevented seeking dental treatment		.284
Yes	1.171 (.877, 1.563)	
No	1.00	
Salivary Dysfunction		.578
Yes	.888 (.585, 1.349)	
No	1.00	

Table C2: Multivariable logistic regression model for factors associated with the need for scaling and root planing (SRP) without CVD variable (N=1,263)

Variable	Odds Ratio Estimate (95% CI)	P-value
Age	1.037 (1.026, 1.047)	**<.0001***
Gender		**<.0001***
Males	1.987(1.546, 2.553)	
Females	1.00	
Insurance		.417
Private	.833 (.611, 1.136)	
Self-pay	.931 (.664, 1.306)	
Medicaid	1.155 (.765, 1.742)	
DWP	1.00	
BMI	.997 (.979, 1.015)	.755
Hypertension		.385
Yes	1.167 (.824, 1.64)	
No	1.00	
Diabetes		**.027***
Yes	1.748 (1.065, 2.871)	
No	1.00	
History of cancer treatment		.720
Yes	1.116 (.661, 2.038)	
No	1.00	
History of addition to a chemical substance		.903
Yes	1.040 (.554, 1.954)	
No	1.00	
Smoking Status		**<.0001***
Never	.475 (.346, .652)	**<.0001**
Former	.608 (.418, .884)	**.009**
Current	1.00	
Does not have regular dental check-ups		**.001**
No	1.604 (1.220, 2.108)	
Yes	1.00	
Fear has prevented seeking dental treatment		.319
Yes	1.161 (.865, 1.559)	
No	1.00	
Salivary Dysfunction		.599
Yes	.891 (.581, 1.368)	
No	1.00	

Table C3: Multivariable logistic regression model for factors associated with the need for scaling and root planing (SRP) without salivary dysfunction variable (N=1,288)

Variable	Odds Ratio Estimate (95% CI)	P-value
Age	1.038 (1.028, 1.048)	**<.0001***
Gender		**<.0001***
Males	1.950 (1.523, 2.498)	
Females	1.00	
Insurance		.502
Private	.837 (.616, 1.137)	
Self-pay	.927 (.664, 1.295)	
Medicaid	1.109 (.740, 1.661)	
DWP	1.00	
BMI	.994 (.976, 1.012)	.517
CVD		.137
Yes	.612 (.320, 1.648653	
No	1.00	
Hypertension		.347
Yes	1.180 (.835, 1.668)	
No	1.00	
Diabetes		**.019***
Yes	1.803 (1.100, 2.956)	
No	1.00	
History of cancer treatment		.619
Yes	1.165 (.638 2.126)	
No	1.00	
History of addition to a chemical substance		.698
Yes	1.136 (.597, 2.163)	
No	1.00	
Smoking Status		**<.0001***
Never	.498 (.364, .680)	**<.0001**
Former	.628 (.435, .909)	**.014**
Current	1.00	
Does not have regular dental check-ups		**.001**
No	1.574 (1.201, 2.064)	
Yes	1.00	
Fear has prevented seeking dental treatment		.467
Yes	1.113 (.834, 1.486)	
No	1.00	

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