Diabetes Status, Predisposing, Enabling, and Oral Health Illness Level Variables as Predictors of Preventive and Emergency Dental Service Use

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DIABETES STATUS, PREDISPOSING, ENABLING, AND ORAL HEALTH ILLNESS LEVEL VARIABLES AS PREDICTORS OF PREVENTIVE AND EMERGENCY DENTAL SERVICE USE

by

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DOCTOR OF PHILOSOPHY
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The purpose of this study was to clarify the relationship between diabetes and dental service use. This study addressed the question of whether individuals with diabetes are more or less likely to utilize dental services, measured in terms of preventive and emergency services during the past year. A cross-sectional study was conducted to assess the contributions of diabetes status to dental service use, relative to the contributions of Andersen and Newman Framework of Health Services Utilization dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year using a nationally representative sample from a 2001-2002 National Health and Nutrition Examination Survey (NHANES) dataset. A stratified multistage design was used to obtain a representative probability sample. A series of selection criteria was applied to comply with the purpose of the study. The target population of this study was U.S. civilian, non-institutionalized adults, who were 18 years of age or older. A total of 11,039 subjects participated in the 2001-2002 NHANES. Of those, 4,707 were eligible to participate in the study based on the inclusion and exclusion criteria. The appropriate procedures in Statistical Analysis Software (SAS®) were utilized to accommodate the NHANES sampling design and weights. The data analysis using Chi-Square Test reveals that individuals with diabetes (3%) were significantly ($p=0.0002$) less likely to utilize dental services in the past 12 months compared to individuals without diabetes.
diabetes (67%). Significant predictors in preventive service utilization model were: gender (OR=1.38, 95% CI: 1.16, 1.65), marital status (OR=0.72, 95% CI:0.56,0.91), age (OR=0.63,95% CI:0.45,0.88), education (OR=2.0, 95% CI:1.53,2.63), income (OR=5.21, 95% CI:1.69,15.98), regular source of care (OR=15.8, 95% CI:11.95, 20.91), dental insurance (OR = 1.53, 95% CI:1.15,2.04), self-reported pain (OR=0.75, 95% CI:0.56,0.99), and recommended care based upon oral exam findings (OR=0.30, 95% CI:0.23,0.41). Diabetics were less likely to obtain preventive service use than non-diabetics (OR=0.60, 95% CI: 0.40, 0.92). Significant predictors in emergency service utilization model were: unmarried status (OR=0.72, 95% CI: 0.54, 0.94), age (OR=0.63, 95% CI: 0.44, 0.89), education (OR=1.53, 95% CI: 1.13, 2.06), regular source of care (OR=6.7, 95% CI:4.77, 9.44), dental insurance (OR= 1.9, 95% CI:1.36, 2.65), self-reported painful tooth (OR=2.02, 95% CI:1.60, 2.57), and recommended care based upon oral exam findings (OR=0.72, 95% CI:0.54, 0.97). The results of this study indicate that diabetes status is a significant predictor of not having a preventive dental visit, even after controlling for age, gender, marital status, income, race/ethnicity, and education. This finding is a reason for concern due to the fact that the literature is full of studies showing the effect of diabetes on oral health and the effect of periodontitis on glycemic control among individuals with diabetes. Therefore, a regular dental visit for individuals with diabetes is necessary. Understanding the relationship between diabetes and periodontal diseases is important for individuals with diabetes to reduce oral complications, improve quality of life, and improve health outcomes. Integrating oral health with diabetes management care helps in clarifying this association.
To the man whom I love

To the man who supported and encouraged me during these years

I can fly higher, higher than an eagle

With you as the wind beneath my wings

To my wonderful husband Mohammad Tayyem, I love you

To my children

Sara, Khalil, Aida, and Judy

You put the smile on my face

I love you

To Dr. Shuman

You have played such an important part in my life and because of you; I am the person

that I am today

I have the best of all worlds by having you as my sweet and wonderful “second mom.”

I honor you because you have earned more than just that respect.

You have earned all of my love!
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CHAPTER I

INTRODUCTION

The mouth may be the first line of defense against infections as it is considered a gate to the rest of our bodies. According to the Department of Health and Human Services’ Surgeon Generals’ Report in 2000, systemic health is intimately related to oral health and quality of life (Surgeon Generals’ Report, 2000). Several studies report a strong relationship between systemic diseases and oral diseases (Azarapazhoor & Leake, 2006; Geismar et al, 2006; Gomes et al, 2007; & Hasegaw et al, 2003). Diabetes is a systemic condition associated with oral diseases and individuals with diabetes are more likely to have oral diseases than individuals without the disease. Oral complications as a result of diabetes include gingivitis (gum inflammation), periodontitis (inflammation affecting the supporting structures of the teeth), and subsequent bone destruction leading to tooth loss. Dental caries, dental abscesses, dry mouth (xerostomia), oral mucosa and tongue lesions such as candidiasis and oral peripheral neuropathy are all complications of diabetes (Finney & Gonzales-Campoy, 1997; Löe, 1993; Matthews, 2002; Preshaw & Bissett, 2013). In addition, studies suggest a two-way relationship between diabetes and periodontal disease in which each has a possible influence on the other (Chee, Park, & Bartold, 2013; Matthews, 2002; Preshaw & Bissett, 2013; Ruiz, Romito, & Dib, 2011; Teeuw, Gerdes, & Loose, 2010). Therefore, it is important to explore factors associated with dental service utilization among adults with diabetes. This study investigated factors that contribute to dental service utilization among individuals with diabetes during the past year. This study was organized into five chapters. Chapter I presented the problem statement, purpose of the study, the significance of the study, definitions of terms, study
limitations, research questions, and hypotheses. Chapter II of this study presented the literature review, which provided detailed information about Andersen Behavior Model of Health Services Utilization as well as defined and conceptualized the constructs of the model. Chapter III included an overview of the research methodology used for this study. Chapter IV presented the study results and a summary of the findings. The final chapter, Chapter V, discussed the study results, as well as presented policy implications and suggestions for future research.

**Problem Statement**

**Background**

Diabetes is a chronic disease characterized mainly by the insufficient production of insulin or inadequate response to it, leading to hyperglycemia. The most common forms of diabetes are type 1, type 2, and gestational diabetes. Type 1 diabetes results from the body’s failure to produce insulin. About 5% of Americans who are diagnosed with diabetes have type 1, which was previously known as juvenile or insulin-dependent diabetes, and occurs mainly in children and young adults. Type 2 diabetes, previously called noninsulin-dependent diabetes is a condition where the body fails to use insulin. The majority of Americans with diabetes, about 95%, are diagnosed with type 2. Gestational diabetes occurs during pregnancy to women who do not have a previous history of diabetes. It develops in 2-10% of pregnant women (Centers for Disease Control and Prevention [CDC], 2012).

Diabetes can have a negative impact on other parts of the body such as the heart, kidney, eyes, feet, as well as the oral cavity. Dental caries, dry mouth, oral candidiasis, and periodontal diseases all are oral cavity diseases that are considered oral complications of diabetes. Periodontal disease and diabetes were linked in the 1990s. There is a clear
association between diabetes and periodontal disease (Chee et al., 2013; Matthews, 2002; Preshaw & Bissett, 2013; Ruiz et al., 2011; Taylor & Borgenakke, 2008). Periodontal disease is characterized by a bacterial challenge that can instigate a destructive host response leading to periodontal attachment loss, bone loss, and possible tooth loss (Söder, Jin, & Kling, 2007).

“A biological interaction between periodontal disease and hyperglycemia has been reported, but the exact mechanisms involved in the pathogenesis of this condition during diabetes still remain unclear.” (Ruiz et al., 2011, p.2).

The number of periodontal diseases among individuals with diabetes is higher than that of healthy persons. Individuals with diabetes type 1 and type 2 were found in many studies to have significantly more clinical attachment loss. Also, diabetes affected bleeding scores, probing depths, and missing teeth (Matthews, 2002). Long term elevation of blood glucose levels result in the formation of advanced glycation end-products (AGEs), which is an irreversible product. AGEs increase the production of pro-inflammatory mediators such as interleukin-1-β, and prostaglandin E2, when bonded to the inflammatory monocytes and macrophages cell receptors. Increase in AGEs levels increases the susceptibility of endothelial cells and monocytes to stimuli, resulting in the production of inflammatory mediators. Accumulation of pro-inflammatory cytokines, especially in the gingival tissue, increase periodontal tissue break-down by destruction of collagen fibers, reduced tissue repair, and increased inflammation in the tissue (Chee et al., 2013; Kuo, 2007; Mealey, 2006; Preshaw & Bissett, 2013; Silva et al., 2008).

Furthermore, periodontal disease appears to complicate diabetes by making control of blood glucose levels more difficult. The infection affects insulin requirements and may lead to unstable diabetes (Mealey, 2006). Bacterial infection, especially by
Prophromanas gingivalis, plays an important role in periodontal diseases. The *P. gingivalis* produces lipopolysaccharide (LPS), which triggers the production of pro-inflammatory cytokines mediators. As one of the inflammatory mediators, Tumor necrosis factor-α (TNF-α) affects insulin resistance and makes it more difficult for the patient to control diabetes as there is an increase in glucose and insulin in blood levels (Kuo, 2007). Therefore, control of periodontal infections is critical for maintaining glycemic control of diabetic patients (Chee et al., 2013; Preshaw & Bissett, 2013; Teeuw, Gerdes, & Loose, 2010).

**Scope of the Problem**

In 2010 the estimated number of adults (20-79 years) diagnosed with diabetes worldwide was about 285 million (6.4%). The world prevalence of diabetes is expected to increase to 439 million (7.7%) adults by 2030 (Shaw, Sicree, & Zimmet, 2010). The highest prevalence of diabetes has been consistently reported in India, China, and the USA (Shaw et al., 2010). Data from the National Diabetes Statistics Report in 2014 estimated that 21 million people in the USA were diagnosed with diabetes and the estimated number of undiagnosed cases of diabetes was about 8.1 million. About 86 million people are pre-diabetic. It is estimated that the new cases for diabetes in American adults aged 20 years or older is 1.7 million each year (American Diabetes Association [ADA], 2014). Analysis of data from the National Health Interview Survey for 2007-2009 indicates that the prevalence of diagnosed diabetes among adults aged 20-44 years, 45-64 years, and 65 years or more is 2.6%, 11.7%, and 18.9% respectively. The rate of diabetes among adults aged 65 years or more is seven times that of individuals aged 20-44 years (CDC, 2012). Data from the National Diabetes Statistics Report, 2014,
confirmed that the diabetes prevalence in seniors compared to youth (under age 20) is 25.9% and 0.25% respectively (ADA, 2014). This suggests that diabetes rates increase with age. Further analyses indicate race is another factor associated with the rates of diabetes. Research indicates a higher likelihood of being diagnosed with diabetes among minorities. According to the National Diabetes Statistics Reports 2014, the prevalence of diabetes by race/ethnicity is 7.6% for non-Hispanic whites, 9% for Asian Americans, 13.2% for/ non-Hispanic blacks, and 12.8% for Hispanics. The Hispanic rates included 9.3% Cubans, 13.9% Mexican Americans, and 14.8% Puerto Ricans (ADA, 2014).

**Consequences of the Problem**

Every year in the U.S. about 69,071 individuals die from diabetes, which is considered the seventh leading cause of death in the United States. People with diabetes are at risk for death about twice that of the same age without diabetes (ADA, 2014). Additionally, people with diabetes are at risk for major chronic complications, such as coronary heart diseases, blindness, and kidney failure, as well as oral diseases. The control of periodontal infections is critical for maintaining long-term control of diabetes (Rodrigues, Taba, Novaes, & Souza, 2003; Teeuw et al., 2010). The control of oral diseases maintains the teeth in the oral cavity; retaining one’s natural teeth improves the quality of life by sustaining the ability to chew and digest food, and by improving one’s ability to interact socially with peers. Without teeth in the oral cavity, patients will have speech, appearance, and self-esteem concerns (Johansson & Matstrulson, 2006).

“Even though most oral diseases are not life threatening, they do result in pain, discomfort, and functional problems” (Kassak, Dagher, & Doughan, 2001, p.15).

The estimation of the indirect costs of oral disease in the USA is about 164 million lost hours of work, and 51.6 million missed hours of school each year (Gift, Resine, &
In Sonoma County, CA alone, the estimated annual indirect costs of oral disease in terms of time and loss of school funding due to absences is $14.6 million (Warmerdam, Caldwey, & Willert, 2014). In Canada, the annual indirect costs of oral disease is 40 million lost hours and estimated potential productivity loss of $1 billion (Hayes, Azarpazhooh, Dempster, Ravaghi, & Quinonez, 2013).

**Knowledge Gap**

Given that individuals with diabetes are at a higher risk for oral diseases (Matthews, 2002; Ruiz et al., 2011; Taylor & Borgnakke, 2008), regular preventive dental care is essential to maintaining optimum oral health. However, little is known about the pattern of dental services utilization among this vulnerable population. The relationship between diabetes status and dental services utilization has been understudied. Current literature reveals that individuals with diabetes are unaware of the relationship between diabetes and oral health (Allen et al., 2008). The researchers indicated that there is an association between individuals with diabetes and decreased use of dental services (Chaudhari et al. 2012; Macek, Talyor, & Tomar, 2008; Macek & Tomar, 2009). Other studies confirm this finding (Eke, Thornton-Evans, & Beckles, 2005; Tomar & Lester, 2000).

Previous literature did not include diabetic oral health status, such as dental caries and periodontal disease, as evaluated need variables determined by clinical examinations (Eke et al., 2005; Macek et al., 2008; Macek et al., 2009; Tomar & Lester, 2000). Another limitation of the previous research is that most of the studies with regard to diabetes status and dental service utilization used a cross-sectional survey based on self-reported information, without oral examination (Macek et al., 2008; Tomar & Lester,
These variables may be important in predicting dental services utilization among individuals with diabetes.

**Proposed Solution**

This study used a national representative dataset from the 2001-2002 National Health and Nutrition Examination Survey (NHANES) combining interviews and physical examinations to identify factors associated with dental services for individuals with diabetes. Predicting these factors may increase the likelihood of providing essential oral health services among adults with diabetes. This study considered diabetes status a separate domain in order to evaluate the contribution of diabetes status above and beyond the influence of predisposing, enabling, and illness variables. This study addressed the question of whether individuals with diabetes are more or less likely to utilize dental services, measured in terms of preventive and emergency services during the past year. This study sought to clarify whether diabetes may be differentially related to the use of preventive and emergency dental visits. This study is considered the first study to measure dental service utilization in terms of preventive and emergency services in this population. An analysis of factors associated with dental service utilization among individuals with diabetes can contribute to policy development by recognizing areas that will help to reduce barriers to dental service utilization and increase the likelihood of using preventive care among individuals with diabetes. Policy is needed to improve oral health among individuals with diabetes by increasing access to dental care services among this population.
Purpose of the Study

This study examined the nature of the relationship between diabetes and dental service use. The objective of this study was to assess the contributions of diabetes status to dental service use, relative to the contributions of Andersen and Newman Framework of Health Services Utilization dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year using a nationally representative sample from the 2001-2002 NHANES dataset. Data was included for U.S. civilian, non-institutionalized adults, 18 years of age or older. Data was collected via interview and health examinations. Besides examining the relative contribution of different domains of predictors to utilization of dental services, this study examined the relationship between diabetes status and dental service use. Therefore, this study examined whether the relationship between diabetes status and dental service utilization is direct or indirect.

When the relationship between diabetes status and dental service utilization is mediated by other variables in the model, the relationship becomes indirect. Individuals with diabetes are at a higher risk for oral diseases, dental caries and periodontal diseases, as well as dry mouth, ulcers, soreness, and infections. Such oral complications of diabetes might be hypothesized to mediate the relationship between diabetes status and the use of dental service (indirect influence of diabetes status- diabetes cause more oral health problems which directly influence service use). The other alternative would be that being diabetic is directly related to the decreased or increased use of dental services. Furthermore, the study examined the possibility that diabetes status may be differentially related to the use of preventive and emergency dental services. That is, individuals with
diabetes generally may show fewer preventive behaviors, therefore decreasing the use of preventive dental services. Together, oral complications of diabetes and the decreased likelihood of using oral preventive services, diabetes status may be positively associated with the use of emergency and other restorative services.

**Significance of the Study**

Diabetes is a major public health problem. There are 29.1 million children and adults in the United States who have diabetes—about 9.3% of the population (ADA, 2014). Further the prevalence of diabetes is increasing. In 2010 there were 25.8 million cases (Agency for Healthcare Research and Quality [AHRQ], 2008). In 2012, it was estimated that there are 1.7 million new cases every year (ADA, 2014). Diabetes is a costly disease. According to the American Diabetes Association’s Scientific Statement regarding the burden of diabetes, the cost of diagnosed diabetes yearly in the USA in 2013 was about $245 billion: $176 billion in direct medical costs and $69 billion in indirect costs, which included disability, loss of work, absenteeism, and premature mortality (ADA, 2013). The economic costs of diabetes increased by 41% between 2007 and 2012. The medical expenditures for individuals with diabetes are 2.3 times higher than that of individuals without diabetes. Medical care for individuals with diabetes is mainly provided by government insurance (62.4%) such as Medicaid, Medicare, and military benefits. About 34.4% of the cost of diabetes care is provided by private insurance and 3.2% is out-of-pocket expenses (ADA, 2013).

Uncontrolled diabetes can lead to significant chronic complications such as heart disease, stroke, blindness, lower-limb amputation, kidney failure, disability, and dental diseases. Oral complications of diabetes mellitus include xerostomia and dental diseases.
Diabetes also increases susceptibility to trauma, candidiasis, delayed wound healing, and altered taste sensation (Matthews, 2002; Preshaw & Bissett, 2013). The number of periodontal diseases among individuals with diabetes is higher than that of healthy people. Diabetes affects periodontal parameters such as bleeding scores, probing depths, clinical attachment loss, and missing teeth (Lalla et al., 2007; Löe, 1993; Matthews, 2002; Tanvir, Altamash, & Gustafsson, 2009). Furthermore, periodontal disease appears to complicate diabetes by making the control of blood glucose levels more difficult (Kuo, 2007; Mealey, 2006; Preshaw & Bissett, 2013; Taylor & Borgnakke, 2008).

Knowing the factors that are associated with dental care for individuals with diabetes might identify areas that may assist in reducing barriers to dental care utilization among individuals with diabetes. In addition, this study might guide where resources are needed to enhance access to dental services to reduce the incidence of oral diseases and increase tooth retention.

**Definition of Terms**

The following terms were defined for the purpose of this study:

1. **Predisposing factors**: Socio-cultural factors that pre-exist the illness, such as demographic, social structural, and beliefs variables. In this study predisposing factors are age, gender, race, marital status, and education.

2. **Enabling factors**: Factors that serve as conditions of obtaining care, such as family and community resources available to the individual. In this study enabling factors are income, dental insurance, and a regular source of dental care.

3. **Illness factors**: Functional and health problems that cause the need for health care services; such as individual perception of health and illness and the professional
assessment of the person’s need. In this study illness level (both perceived and evaluated illness) are the overall recommendation to seek dental care based upon oral examination findings, and perceived tooth pain.

4. **Diabetes**: A chronic disease characterized mainly by the insufficient production of insulin or inadequate response to it that leads to hyperglycemia. In this study a positive answer to the question “Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes” indicate a diagnosis of diabetes.

5. **Dental service utilization**: Use of dental services. In this study dental service utilization was visiting any oral health care provider within the last year, such as dentists, oral care specialists, dental therapists, and dental hygienists.

6. **Preventive dental visit**: Dental visit to prevent, identify (early diagnosis), and treat diseases. Any individual reporting “yes” to check-up or any preventive dental visit were included.

7. **Emergency dental visit**: A dental condition that requires urgent care, such as mouth-related injuries, bleeding, and severe pain. Individuals reporting an emergency dental visit who responded “yes” to an emergency visit or follow-up for known problem categories were included.

**Research Questions**

How much variation in dental service utilization is explained by diabetes status relative to the contributions of Andersen and Newman Framework of Health Services Utilization dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year?
**Specific Research Questions**

1. Are individuals with diabetes more or less likely to utilize dental services in the past year compared to individuals without diabetes?

2. What is the contribution of diabetes status relative to predisposing, enabling, and illness level variables that predict dental service utilization?

3. Is the relationship between diabetes and dental service utilization direct (being diabetic directly influences service use/nonuse) or indirect (oral health illness variables mediate the relationship between diabetes status and the use of dental service)?

**Hypotheses**

The following hypotheses were evaluated and tested at the 0.05 level of significance.

**Hypothesis One**

$H_0$: There is no statistically significant difference between individuals with diabetes and individuals without diabetes in the utilization of dental services in the past year.

**Hypothesis Two:**

$H_0$: There is no statistically significant difference in the contribution of diabetes status, predisposing, enabling, and illness level variables in prediction of dental service utilization in the past year.

**Hypothesis Three:**

$H_0$: The relationship between diabetes and dental service utilization is not mediated by oral health illness variables, as indicated by an absolute change in estimated odds ratio of less than 10% between models that are unadjusted and adjusted for mediators.
Recognizing that the use of dental service includes complex relationships between diabetic status, oral health status, and different socio-demographic and related variables, the Andersen and Newman Framework of Health Services Utilization (Andersen & Newman, 1973) was used to examine the contributions of predisposing, enabling, and illness variables with regard to use of dental service. Chapter II discussed in details the Andersen Model of Health Services Utilization with the focus on the Andersen and Newman Framework of Health Services Utilization.
CHAPTER II

REVIEW OF THE LITERATURE

Individuals with diabetes are more likely to have oral diseases than individuals without diabetes. The objective of this study was to assess the contributions of diabetes status to dental service use, relative to the contributions of Andersen Behavioral Model dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year using a nationally representative sample from the National Health and Nutrition Examination Survey.

A review of the Behavioral Model of Health Services Utilization will begin the discussion of this chapter with the focus on the Andersen and Newman Framework of Health Services Utilization. This chapter reviewed previous research in the area of dental service utilization and the relationship between the variables of main interest in this study. A review of what has been conducted in the prior research on the relationship between diabetes status and dental service utilization was discussed in this chapter.

Behavioral Model of Health Services Utilization

The Behavioral Model of Health Services Utilization originally was developed in the 1960s by Ronald Andersen (Andersen, 1968). Many additions to the original model were made without changing the basic components of the model (Aday & Andersen, 1974; Andersen, 2008). Many phases were developed since the first model (Aday & Andersen, 1974; Andersen, 1995; Andersen, 2008; Andersen & Newman, 1973). The first phase was developed in the 1960s and the focus in this phase was on the family as the unit of analysis. In this phase the intention was to understand the reason behind the use of health services in families and to define, measure, and test hypotheses regarding
inequality of access to health care. Potential, realized, equitable, and inequitable access were examples of multiple dimensions of access to care which were identified in this phase (Andersen, 2008). Potential access was identified as availability of enabling resources. Realized access was identified as the actual service use. Equitable access was defined as higher contributions of demographic and need variables relative to other variables in determining utilization of health services, whereas inequitable access occurs when contributions of other variables, such as social structure, health beliefs, and enabling resources determine the use of health services (Andersen, 2008). The model in this phase suggests that health services utilization by families can be predicted by their predisposition to that care, enabling resources that assist use of health services, and the need for that service which is either a perceived need by the family or one that has been determined by a health care professional (Andersen, 1968). The second phase was developed in the 1970s (Aday & Andersen, 1974; Andersen & Newman, 1973). The evolving in this phase was the addition of health care system measures. According to Andersen, the addition of the health care system was intended to show the importance of national health policy, resources, and organization as essential determinants of the population’s use of services (Aday & Andersen, 1974; Andersen & Newman, 1973). Phase 2 included the basic components regarding the population characteristics (predisposing, enabling, and need), health care system (policy, resources, and organization), use of health services (type, site, purpose, and time interval), and consumer satisfaction (convenience, availability, financing, provider characteristics, and quality). Adding the health status outcomes and recognizing individual health practices such as diet and exercise, and their effects on health outcomes, were the additions in phase three,
which was developed in the 1980s. This addition of health status outcomes-perceived and evaluated health- in this phase helped in defining more dimensions of access to care. Feedback loops were introduced in phase four, which was developed in the 1990s. This phase described the dynamic nature of the health services utilization model in which the relationships between outcome, predisposing factors, perceived need, and health behavior were specified (Andersen, 2008). The last phase, phase 5, was developed in the 2000s and the focus was on contextual (organization, provider-related characteristics, and community characteristics) and individual determinants and the interaction between medical provider and patient in regard to the process of health care delivery (Andersen, 2008).

This study used the Behavioral Model of Health Services Use of Andersen and Newman (1973), which is a follow up to the initial model. The Behavioral Model of Health Services Utilization is considered one of the most commonly used models that explore factors related to patients’ health services utilization. This model was selected for its ability to predict and explain the use of health services and was used to understand and clarify the relationships and contributions of individual factors and how these factors influence the utilization. The Andersen Behavioral Model of Health Services Utilization is a flexible model, which allows investigators to include different independent variables that relate to their research of interest (Andersen, 1995). The focus for this subsequent work, Andersen and Newman’s Framework of Health Services Utilization (1973), is on the individual as the unit of analysis in contrast to the initial model where the family is the unit of analysis (Andersen & Newman, 1973).
The Andersen and Newman Framework of Health Services Utilization

The Andersen and Newman Framework of Health Services Utilization considers the societal (technology and norms) and individual (predisposing, enabling, and illness) determinants with regard to use of services. According to this model, there are two relationships that link the societal determinants and individual determinants—direct and indirect relationships. The direct relationship occurs when societal determinants affect the individual determinants directly without mediators, whereas the indirect relationship occurs when the societal determinants affect the individual determinants through mediators (health service system: resources and organization). This model defined the characteristics of health services utilization: type, purpose, and unit of analysis. According to this model, utilization can be described by type: hospital, physician, drug and medication, dentist, nursing home, and other. Also, utilization can be described by purpose: primary, secondary, tertiary, and custodial. The last characteristic that describes utilization is the unit of analysis: contact, volume, and episodic care (Andersen & Newman, 1973).

To answer the research questions for this study, the focus was on the individual factors that determine the health care the individual receives. Andersen and Newman describe three components to explain an individual’s access to and use of health services (Andersen & Newman, 1973). The first component is predisposing factors, which are the socio-cultural factors that exist before the illness. The predisposing factors consist of demographic, social structural, and belief variables. These variables can predict the tendency to use health services, although they are not considered to be a direct reason for using health service. The individual predisposing factors include age and gender as
demographic characteristics; education, occupation, ethnicity, and social relationships as social structural characteristics; and attitudes, values, and knowledge related to health as beliefs (see Figure 1).

Figure 1. Individual Determinants of Health Services Utilization
Adapted from Andersen & Newman, 1973

The second component is enabling factors, which makes health services resources available to the individual. Enabling factors can be measured by family and community resources that serve as conditions of obtaining care. The family enabling factors include income, health insurance, and a regular source of care. The community enabling factors...
that affect the use of health services include availability of health professionals and facilities in a community in which the family lives (see Figure 1).

The third component is illness level which includes the functional and health problems that cause the need for health care services. The illness level consists of perceived illness, individual perception of health and illness, measured by disability, symptoms, and a self-report of general health status. The second factor of the illness level is evaluated illness through professional assessment of the individual’s need measured by symptoms and diagnosis. The illness level represents the most direct cause of health service use (Andersen & Newman, 1973) (see Figure 1).

Although the main question is whether diabetes status is related to increased or decreased use of preventive or emergency dental services, the relationship may be complicated because individuals with diabetes and using dental services have common socio-demographic and other correlates. So, the use of Andersen and Newman’s Behavioral Framework of Health Services Utilization examined the relative contribution of diabetes status to dental service use, relative to the contributions of Andersen and Newman Behavioral Framework components: predisposing, enabling, and illness level factors.

The predisposing factors selected for this study are age, gender, race, marital status, and education, as suggested by previous research. Enabling factors selected are income, dental insurance, and a regular source of dental care, which make health services resources accessible to the individual and serve as conditions of obtaining dental care. The illness level (both perceived and evaluated illness) that reflects the oral health status, which cause the need for dental service use will include the overall recommendation to
seek dental care based upon findings from oral examination and perceived tooth pain (see Figure 2).

![Figure 2. Selected Variables of Individual Determinants of Dental Services Utilization](image)

**Research on Predisposing Characteristics**

Predisposing factors are the socio-cultural characteristics of an individual that exist before the illness. In this model, predisposing factors consist of demographic and social structural variables. These characteristics can predict the propensity to use health services (Andersen & Newman, 1973).
Age

A number of studies have examined the relationship between age and dental service utilization. The results of these studies indicated that age is a predisposing factor related to dental service use. About 60% of adults aged 20-64 years reported a dental visit in the past 12 months according to data from the NHANES for 1999-2004. This analysis indicates that among adults aged 20-34 years, 35-49 years, and 50-64 years, 55%, 62%, and 63% respectively reported a dental visit in the past 12 months, which indicated an increase in likelihood of dental service use with increasing age (Dye et al., 2007). Many studies validate these findings (Christian, Chattopadhyay, Kingman, Boroudmand, Adams & Garcia, 2013; Gilbert, Duncan, & Vogel, 1998; Koletsi-Kounari, Tzavara, & Tountas, 2011; Roberts-Thomson, Stewart, & Do, 2011). Findings from the Health and Retirement Study found adults aged 55-64 years were the most likely to report a dental visit. Individuals aged 65-69 years with no dental coverage were the most likely to report a dental visit (Lee, Kim, Albert, & Nelson, 2014).

Gender

Studies examining the relationship between gender and dental services utilization found that gender is another predisposing factor related to dental service use. The analysis from the NHANES for 1999-2004 revealed that 64% of females utilized dental services within the past 12 months compared to 55% of males (Dye et al., 2007). Analyses of data from the National Health Interview Survey for 2012 indicate that among adult populations, about 44% reported a dental visit in the past six months, 17% reported a dental visit in the past year (>6 months, <=12 months), and for 13% it had been greater than a year since the last dental visit (Blackwell, Lucas, & Clarke, 2014). Further
analyses indicate a higher likelihood of dental service use in the past six months among females (47% versus 42% for females and males respectively) (Blackwell et al., 2014). These findings are consistent with other research (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Lee, Kim; Albert, & Nelson, 2014; Roberts-Thomson et al., 2011).

**Race/Ethnicity**

Studies relating race/ethnicity to dental care utilization were consistent in their results. Analysis from the NHANES for 1999-2004 indicated race/ethnicity is related to dental service use; White-non Hispanic, Black-non Hispanic, and Mexican American populations reported a dental visit in the past 12 months (64%, 50%, and 43% respectively) (Dye et al., 2007). Analyses of data from the National Health Interview Survey for 2012 indicate a higher likelihood of dental service use in the past six months among adult non-Hispanic compared to Hispanic populations (Blackwell et al., 2014). With respect to race, Gilbert et al. (1998) found statistically significant differences between Black and White populations in regard to dental utilization. Study results indicated a higher likelihood of dental care use among White compared to Black (84% to 59% respectively) populations. Many studies validate these findings (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski, Macek, & Moeller, 2002; Roberts-Thomson et al., 2011). Race, education, and income have a complex relationship in the utilization of dental services. After controlling for income level and education, race and ethnicity are significant factors in health-seeking habits and utilization of dental services, suggesting health disparities among certain races and ethnicities (Kaylor, Polivka, Chaudry, Salsberry, & Wee, 2011).
Marital Status

A limited number of studies have examined the relationship between marital status and dental service utilization. Multiple regression models were used to analyze data from the 2008 Health and Retirement Study on the influence of individual characteristics of dental service utilization among participants with and without dental coverage. The study revealed that users of dental services with or without dental insurance coverage were highly likely to be married (Manski, Moeller, & Chen, 2014). Analyses of data from the National Health Interview Survey for 2008 indicate a higher likelihood of dental service use in the past six months among married adults compared to other categories (widowed, divorced, never married, and living with a partner (Pleis, Lucas, & Ward, 2009).

Education

Studies relating education to dental service utilization found that education affects the likelihood of using dental services; people with higher education reported a higher use of dental services (Dye et al., 2007). Analyses from the National Health Interview Survey for 2012 indicated a higher likelihood of dental service use among adults with higher education (Blackwell et al., 2014). With regard to level of formal education, high school graduates were more likely to use dental services compared to individuals who did not graduate from high school (82% vs. 57% respectively) (Gilbert et al., 1998). Education was significantly related to dental services utilization, even after controlling for income level (Kaylor et al., 2011). Many studies validate these findings (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; Manski et al., 2014 & Roberts-Thomson et al., 2011).
Beliefs

Attitude toward performing the behavior is related directly to individuals’ evaluations of the behavioral outcomes or individuals’ behavioral beliefs. Attitudes, beliefs or knowledge about health care and disease might influence an individual’s behavior toward use of health services (Andersen & Newman, 1973). Knowledge and awareness about oral health contribute to good oral health behavior which positively affects the oral health status (Al-Ansari & Honkala, 2003). Knowledge is an important factor that might influence an individual’s belief. Knowledge about oral health complications from diabetes, periodontal diseases, caries, and dry mouth is important in preventing tooth decay and tooth loss. Lack of knowledge about the relationship between diabetes and oral diseases can result in poor oral health-related behavior.

According to Allen et al. (2008) individuals with diabetes were less knowledgeable about increased risk for periodontal disease compared with their knowledge of increased risk for other diabetes-associated complications. Also, the study results reveal that poor attitude towards oral health was found among individuals with diabetes (Allen et al., 2008). Current literature shows that more than 50% of individuals with diabetes had inadequate oral health knowledge related to diabetes, (Yue et al., 2009) which is confirmed with other studies (Allen et al., 2008).

An example of poor oral health-related behavior as documented by the literature is that individuals with diabetes were less likely to have visited a dentist in the past 12 months compared with individuals without diabetes (Chaudhari et al., 2012; Eke et al., 2005; Macek & Tomar, 2009; Tomar & Lester, 2000). Furthermore, individuals with diabetes were more likely to have visited a general health-care provider than an oral
health professional, which might indicate that oral health might be not the main concern for individuals with diabetes (Macek et al., 2008; Tomar & Lester, 2000).

Syrjala et al. found that individuals with diabetes had poor oral health-related behavior in terms of brushing and flossing, especially when combined with poor self-efficacy (Syrjala, Kneckt & Knuuttila, 1999; Syrjala, Ylostalo, Niskanen, & Knuuttila, 2004). Kanjirath, et al. found that individuals with diabetes were less likely to brush and floss compared with individuals without diabetes, suggesting poor oral health-related behavior (Kanjirath, Kim, Inglehart, & Habil, 2011).

The awareness of individuals with diabetes about the relationship between overall health and oral health should be increased. The relationship between diabetes and oral health needs to be discussed with individuals with diabetes to increase their awareness level and positively influence their behavior toward use of dental services.

Research on Enabling Factors

Enabling factors are resources that help individuals use health services. In this model, enabling factors consist of income, dental insurance coverage, and a regular source of care (Andersen & Newman, 1973).

Income

Income affects the likelihood of using dental services; people with higher income reported a higher dental service use (Blackwell et al., 2014; Dye et al., 2007; Manski et al., 2014). Additionally, individuals with low income have a higher likelihood of delayed or missed dental care (Shi & Stevens, 2005). Many studies validate these findings (Christian et al., 2013; Gilbert et. al., 1998; Kolets-Kounari et al., 2011; Manski et. al., 2002; Roberts-Thomson et al, 2011).
To examine the effect of income disparities on dental utilization, a study was conducted by Nasseh and Vujicic. This study compared dental utilization at the state level between adults below and above the poverty level using data from the Behavioral Risk Factor Surveillance System for 2002, 2004, 2006, 2008, and 2010. The study revealed that the gap in dental utilization changed between 2002 and 2010. In 12 states, the gap increased between adults below and above the federal poverty level. The rest of the states showed a large but stable gap in dental utilization. Four states and the District of Colombia showed a decrease in the gap between adults below and above the poverty level. The study concluded that at the state level adults with a low income have limited access to dental care than adults with high income (Nasseh & Vujicic, 2014).

**Dental insurance status**

Research has shown that dental insurance coverage is positively related to the use of dental care (Blackwell et al., 2014; Christian et al., 2013; Gilbert et al., 1998; Koletsis-Kounari et al., 2011; Manski et al., 2002; Mueller & Monheit, 1988; Roberts-Thomson et al., 2011). A small number of Americans have dental insurance compared to the large number with medical insurance. The number of Americans without health insurance coverage for 2013 was 42 million (Smith & Medalia, 2014) compared to the 130 million of Americans without dental insurance (Lee, Lewis, Saltzman, & Starks, 2012).

A study examined the 1996 Medical Expenditure Panel Survey (MEPS) data to determine the impact of private dental insurance coverage on the utilization and expenses of dental services. Analysis of the MEPS data indicated a higher likelihood of dental service use in 12 months among participants with dental coverage compared to participants without dental coverage. Further analysis indicated that the number of dental
visits and mean expenses among participants with dental coverage were significantly higher than that among participants without dental coverage ($417.20 vs. $298.70 respectively). Furthermore, the results revealed a significantly higher likelihood of private dental coverage among younger participants, Whites, and those with higher education and income. Gender did not significantly impact the likelihood of an individual having private dental coverage. Regardless of private dental insurance coverage, persons with higher income and education levels, females, and Whites (compared to non-Hispanic Blacks or Hispanics) were more likely to have used dental care in the past 12 months (Manski et al., 2002).

Mueller & Monheit aimed to study the effect of dental insurance coverage on dental services demand among White adults aged 16-64 years. The data for this study was obtained from the National Medical Care Expenditure Survey (NMCES) for 1977. Information about the health insurance benefits was obtained by an additional survey component, Insurance/Employer Survey. The demand was measured by access to care and amount of services related to dental care. Access to care was defined as visiting a dentist at least once in the past 12 months. Amount of services used was defined as total expenses for dental visits. Analysis of this data highlighted the importance of dental insurance in access to dental care. Further analysis revealed that private dental insurance coverage increased the likelihood of having expensive dental care, such as bridges and crowns compared to basic dental services, such as x-rays, which was usually received regardless of insurance status. This result suggests that dental coverage is a significant factor in seeking and using dental services (Mueller & Monheit, 1988).
Another study (Manski & Cooper, 2007) aimed to explore the impact of medical insurance coverage (with or without dental care coverage) on dental services utilization. The study was conducted on 32,681 persons who participated in the Medical Expenditure Panel Survey (MEPS) for 2003. Participants with dental insurance were more likely to report a dental visit compared to participants without dental insurance. Further analysis indicated that participants with private medical insurance after controlling for dental insurance status, demographic, and socioeconomic variables were more likely to report dental use than participants without private medical insurance. The study results revealed a positive association between dental and medical coverage with the likelihood of dental services utilization (Manski & Cooper, 2007).

Another study explored factors related to dental insurance status and dental services utilization among women aged 18-44 years. Data for this study was obtained from the National Health and Nutrition and Examination Survey (NHANES) for 2003-2004. The sample size was 1,071. Age, race/ethnicity (Black, Hispanic, or White), marital status, and education were the predisposing variables included in this study. The enabling variables for this study were dental insurance and income. For this study, dental insurance was categorized into private (reference), Medicaid, or uninsured. Need variables included perceived and evaluated need. Perceived need was identified by questioning whether there was a time women needed dental care but could not get it. Evaluated need was identified by recommendations for seeking care by oral health professionals, which included immediately, in the next two weeks, or earliest convenience. Health status- excellent, very good, good, fair, or poor-was considered as a confounding variable for this analysis. Analysis for this data revealed that with regard to
dental insurance status, women with Medicaid or no insurance were less likely to be older, more educated, married, and to have more income than women covered by private insurance (Kaylor, Polivka, Chaudry, Salsberry, & Wee, 2011). Hispanic women were more likely to be without insurance, where Black women had a propensity to be insured by Medicaid. Type of dental insurance-private, Medicaid, or no insurance-was associated with dental care use in the past 12 months, with a lower likelihood of dental service use among uninsured women. Predictors of dental visit in the past 12 months among Medicaid-insured women were marital status and evaluated need. Further analysis among women with no dental insurance indicated a lower likelihood of dental visits in the past 12 months among Black or Hispanic populations, less educated (less than high school diploma), as well as among those with low income and unmet dental need. Race, education, and income have a complex relationship in regard dental services utilization. Even after controlling for income level, education and race/ethnicity still significantly related to dental services utilization especially for those with 100% and 200% of 2004 federal poverty level suggesting racial/ethnicity disparities. Results revealed that about 40% of women aged 18-44 years did not have dental insurance. Also, results suggested lesser likelihood of having dental insurance among females with less education, low income, and dental need (Kaylor et al., 2011).

**Regular source of care**

A number of studies have examined the relationship between the regular source of care and dental care utilization. Analysis of data from the National Health Interview Survey (NHIS) for 2000 (Shi & Stevens, 2005) aimed to predict unmet health care needs accounting for race/ethnicity, income, health insurance, and regular source of care that
are related to access to care. The sample size was 32,374 adults aged 18 years and older. The independent variables for this study were risk factors for poor access: race/ethnicity (a non-modifiable factor), income, health insurance, and a regular source of care (modifiable factors). Income and health insurance, enabling resources, reflect the means to pay for needed health care services. According to Shi & Stevens, having a regular source of care is another enabling resources which means

"a person has established a link with an accessible source of health services and potentially someone from whom they can receive their needed care" (Shi & Stevens, 2005, p.2)

Having a regular source of care may generate demand for service by serving as a reminder for the need for health services and the start of their delivery (Shi & Stevens, 2005). For this study, the presence of a regular source of care was identified as individuals who responded “yes” to the following question: “Is there a place that you usually go to when you are sick or need advice about your health?” The unmet health care needs due to cost with regard to medical care, dental care, mental care, and prescriptions were the dependent variables. The study results revealed that lack of a regular source of care is related to a higher likelihood of delayed or missed medical and dental care, and with delays in filling prescriptions (Shi & Stevens, 2005).

**Research on Illness Level**

Illness factors include self-reported health status and professionally diagnosed disease status. The illness factors of an individual are the immediate cause of health service use (Aday & Andersen, 1974; Andersen & Newman, 1973). In this model, illness factors consist of perceived need and oral health concerns based on an oral health
professional clinical diagnosis. Perceived need for dental care is a factor that influenced the use of dental care (Gilbert et al., 1998; Roberts-Thomson et al., 2011).

Gilbert et al. (1998) conducted a study describing determinants of dental use related to predisposing, enabling, and need factors among dentate adults. The design for this study was a longitudinal cohort study in which the participants were followed for two years. Adults aged 45 years or older, who had a minimum of one tooth, and lived in north Florida were included in this study. Baseline and follow-up (after 24 months) measurements were conducted for the participants including an in-person interview and dental examination with telephone interviews at six-month intervals. The overall sample for this study was 788 participants. For this study, the predisposing variables were age, race, gender, typical approach to dental visit, area of residence (rural vs. urban), education, perceived general health, and dental attitude. The enabling variables were dental insurance availability, income, poverty status, present financial situation, and ability to pay (unexpected) $500 in dental expenses. The need variables were perceived variables, evaluated variables, oral pain variables, oral functional limitation related to teeth, mouth or denture problems variables, oral disadvantage related to teeth, mouth or denture problems variables and self-rated oral health. Broken filling, tooth fracture, cavities, abscess, infected gums, bleeding, tooth mobility, tooth stain, and bad breath were the perceived need. Number of remaining teeth, root fragments, caries fillings, filling fractures, tooth fractures, severe root defects, severe teeth mobility, and attachment loss were the evaluated need variables. Oral pain and discomfort variables were tooth pain and sensitivity. Difficulty speaking or pronouncing words and chewing difficulty were oral function limitation variables. Oral disadvantage variables were the avoidance of
laughing, talking, chewing hard food, and eating with others, concern about appearance, and trouble sleeping. Study results showed that 77% of the sample reported at least one dental visit in the past 24 months. Further analysis indicated a higher likelihood of dental use among older individuals, White, female, urban residents, those with higher education, those with high perceived general health, high income level, and presence of dental insurance. Analysis of this data revealed that oral health conditions such as broken filling, caries, abscess, toothache, broken tooth, loose tooth, and perceived need for using dental care were predictors of dental care visit.

**Research on Emergency and Preventive Services Utilization**

Dental care can be categorized into preventive and emergency. Primary, secondary, and tertiary are parts of preventive dental care. Primary preventive dental care is aimed at preventing oral disease from occurring, such as fluoridated toothpaste, dental sealants, and drinking water fluoridation. Secondary preventive dental care includes early disease diagnosis, which aims to control or limit harmful effects of the disease, such as screening for dental cavities, periodontal disease, and oral cancer. Treatment of oral diseases after they occurred is a tertiary preventive dental care. Examples of tertiary preventive dental care are fillings, crowns and bridges (missing teeth replacement), and treatment of periodontal disease (Doty & Weech-Maldonado, 2003). Fortunately, most oral diseases can be prevented. Unfortunately, once they occur, the physical intervention of an oral health professional is needed (Allukian, 2008). Oral disease prevention is highly related to individuals’ willingness to maintain good oral hygiene and regular dental visits. Maintaining routine dental care is impacted by limited access to dental care, presence of dental insurance, out-of-pocket costs, and fear and
anxiety about receiving dental care (Lee et al., 2014; Manski & Cooper, 2007; Mueller & Monheit, 1988; Shi & Stevens, 2005; Woolfolk, Lang, Borgnakke, Taylor, Ronis, & Nyquist, 1999). Lack of or inadequate dental insurance and high out-of-pocket costs are the most common barriers for limited dental care use (Lee et al., 201; Manski & Cooper, 2007; Mueller & Monheit, 1988; Shi & Stevens, 2005). Therefore, individuals without dental insurance, underinsured, and with low income levels may have limited access to regular dental care (Yu, Bellamy, Schwalberg, & Drum, 2001). The result may be a decrease in preventive services utilization. The lessened likelihood to use preventive dental services may result in poorer oral health conditions and a higher likelihood to turn to the emergency department as an alternative source for dental care (Allareddy, Rampa, Allareddy, & Nalliah, 2014; Lee et al., 2014).

Doty et al. conducted a study to determine the factors that influence the use of preventive dental care among different race/ethnicity groups using data from the Medical Expenditure Panel Survey for 1996. Information about the dependent variable was obtained from the question “on average, how often do you receive a dental checkup?” Regarding race/ethnicity, participants were divided into five groups: non-Hispanic Whites, non-Hispanic Blacks, Mexican American, Other Hispanic (Puerto Rican, or Cuban), and Other race ethnicity (Asian American, American Indians, Aleuts/Eskimos, and Pacific Islanders). Regarding insurance status, participants were divided into private insurance, public insurance, and uninsured. Study results revealed a lower likelihood of using preventive dental care among racial/ethnic minorities after controlling for gender, age, education, and health status. However, controlling for income level and insurance eliminate the disparities in using preventive dental care among racial/ethnic minorities.
Analyses of the study indicate a moderating effect of insurance on the relationship of race/ethnicity to preventive dental care use. The study concluded that enabling resources are important factors in reducing the disparities among racial and ethnic groups and increasing the access to preventive dental care. However, this study used medical insurance as a proxy for dental insurance (Doty & Weech-Maldonado, 2003).

Meyerhoefer at al. (2012) estimated the probability of using preventive services such as exams, cleanings, and x-rays, basic restorative services, such as restorations and extractions, and major restorative services, such as crown and root canals using a modeling approach. This study was based on data from the Medical Expenditure panel Survey for 2001-2006 combined with dental procedure price data from the American Dental Association Survey. Study results revealed that the presence of dental coverage increase the likelihood of using dental care services in general. However, the likelihood of preventive care use was higher than basic and major restorative dental services among individuals with dental coverage. The use of preventive and restorative services surprisingly was insensitive to out-of-pocket price for individuals with dental coverage. In addition, the study results revealed that individuals with a bachelor’s degree or higher were more likely to receive preventive services (compared with individuals with less than a high school diploma), as well as Whites (compared to Blacks and Hispanics), females, and children (compared to adult), which suggests that education, race, gender, and age are key factors and strong predictors of using preventive services (Meyerhoefer, Zuvekas, & Manski, 2012).

A Nationwide Emergency Department Sample (NEDS) dataset for 2008 to 2010 was used to provide an estimate of emergency visits for dental problems in hospital
settings. Participants who were diagnosed on the basis of International Classification of Diseases (ICD-9) with dental caries, pulpal lesions, periapical lesions, gingival conditions, periodontal conditions, and mouth cellulites or abscess were included in this study. An increase from 2008 through 2010 in the emergency department related to dental conditions has been noticed in this analysis with the total of dental care-related emergency visits at about 4,049,361 visits. The study results revealed that individuals without insurance represented the biggest proportion of all dental condition-related emergency department visits followed by individuals who were insured by Medicaid (40% and 30%, respectively) (Allareddy et al., 2014).

A study was conducted aimed at comparing dental utilization between individuals with private dental insurance (Delta Dental Plan) and individuals with public insurance (Medicaid), which offered a comprehensive dental benefit package for eligible participants aged 21-64 years at the time of the study. The evaluation of dental utilization was based on data from Iowa Medicaid and Delta Dental claims files for fiscal year 1998 with the focus on tertiary care, such as endodontic treatment and tooth extractions. Findings from the analyses indicated a higher likelihood of dental service use among individuals with Delta Dental Plan compared to individuals with Medicaid. The study results revealed that about 5%, 81%, 6%, and 7% of Delta Dental insurance recipients used endodontic therapy; operative/restorative service, periodontal services, and tooth extractions, compared to 9%, 65%, 16, and 27% respectively for Medicaid insurance recipients. The high likelihood of using tertiary dental services among Medicaid insurance recipients indicates poor oral health status at the time of care, although they
were younger age group participants compared to Dental Plan participants (Sweet, Damiano, Rivera, Kuthy, & Heller, 2005).

Lee et al. conducted a study to examine trends in utilization of emergency departments for dental problems from 2001 to 2008. Analysis of data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) was used to compare the emergency department utilization for dental issues to emergency visits for asthma. Asthma was chosen specifically because it is identified by Agency of Health Research and Quality (AHRQ) as a prevention quality indicator (PQI), “conditions for which outpatient care can potentially prevent the need for hospitalization, or for which early intervention can prevent complications or more severe disease” (Lee et al., 2012, p.81). This comparison intentionally was used to reflect the access to dental care versus the access to medical care over the specific period of time. The study results revealed that dental care visit rates increased 59% from 2001 to 2008, while asthma visit rates were stable with no overall change. Also, dental-related visits still increased at a faster rate compared to overall emergency department visits. Increasing dependence on emergency departments to resolve dental problems suggests the limited access to dental care compared to access to medical care. In addition, the analysis indicates that adults aged 18-44 years, uninsured, and Blacks were related significantly with the increase in emergency department dental visits (Lee, Lewis, Saltzman, & Starks, 2012).

**The Use of Dental Services with a Focus on Individuals with Diabetes**

Diabetes is a chronic disease associated with oral diseases. Individuals with diabetes are more likely to have periodontitis and tooth loss than individuals without diabetes (Eke et al., 2005; Löe, 1993; Matthews, 2002; Mealy, 2006; Taylor &
Borgnakke, 2008; Ruiz et al., 2011). Oral health is related to systemic health and quality of life. Oral health affects quality of life by affecting the individual’s functioning (biting, chewing, speaking), psychological status (appearance and self esteem), and social well-being. Also, diet, nutrition, sleep, school, and work are all negatively affected by impaired oral health (Jahansson & Matstrulson, 2006; Surgeon Generals’ Report, 2000).

Current literature shows that individuals with diabetes are unaware of the relationship between diabetes and oral health (Allen et al., 2008). The researchers indicated that individuals with diabetes have been found to be associated with decreased use of dental services (Chaudhari et al., 2012; Eke et al., 2005; Macek & Tomar, 2009; Tomar & Lester, 2000).

A study by Tomar and Lester (2000) aimed to compare dental service use between individuals with diabetes and individuals without diabetes using data from the Behavioral Risk Factor Surveillance System (BRFSS) for 1995-1998. Analyses of data of 105,718 dentate adults aged 25 years or older indicate that individuals with diabetes were less likely to visit a dental provider for dental care in the past 12 months (65 % versus 73 % for diabetic and non-diabetes respectively). Furthermore, this study confirms the findings of Macek et al. (2008) regarding the higher likelihood of visiting a health care provider for diabetes care and for foot examination among individuals with diabetes compared to visiting a dental health provider. Also, the results confirm the disparity among race-ethnicity characteristics, as well as among socio-economic groups in regard to dental service utilization (Tomar & Lester, 2000). The possible reasons for not utilizing dental services as reported by the participants were, no perceived need to visit dental health provider, followed by cost and fear or anxiety (Tomar & Lester, 2000).
An analysis of BRFSS data for 1999 and 2004 aimed to describe dental service utilization in the past 12 months among diabetic adults aged 18 years and older, without comparison to individuals without diabetes. The results of these analyses indicate that the median percentage of dentate diabetics who reported a dental visit in the past year adjusted for age was 67.3% in 2004 compared to 65.9% in 1999. However, this increase as of 2004 did not reach the national health objectives for 2010, which was targeting to increase the percentage of adults with diabetes who use dental care to 71%. Further analyses indicated a higher likelihood of dental visits among Whites-non Hispanic adults with diabetes aged 65 years and older, as well as among individuals with a higher income and education, and who had health insurance. In addition, smoking status and the completion of diabetes management course (with never/former smoking status and have taken the class) were positively related to dental care visits among individuals with diabetes. This study confirms the findings of previous studies regarding the association between race/ethnicity, education, income, and health insurance status as predictors of dental care visit. The study concluded that awareness program about the relationship between oral health and diabetes is needed (Eke et al., 2005).

Analysis of data from the National Health Interview Survey (NHIS) for 2003 (Macek, Taylor, & Tomar, 2008) indicates that dentate adults with diabetes were less likely to visit a dentist in the past 12 months compared to dentate adults without diabetes after controlling for confounders (60% versus 68% for diabetic and non-diabetic, respectively). Further analysis indicated a lower likelihood of dental visits among adults with diabetes aged 25 to 44 years, among females, among Hispanics (compared to non-Hispanic-Blacks and non-Hispanic Whites), and as among individuals with lower income
and education and with no private health insurance. The results showed that the relationship between diabetes status and dental care utilization was gender-specific. Females with diabetes were significantly less likely to receive dental care compared to females without diabetes, where as males had no significant association. The result of a gender-specific relationship between diabetes status and dental care utilization was inconsistent in other studies (Eke et al., 2005; Tomar & Lester, 2000). In addition, further analysis highlighted that individuals with diabetes were less likely to visit a dentist compared with other health care visits (82%, 72%, 67%, and 64% medical care visit for diabetes care, foot care, eye care, and dental care respectively) (Macek et al., 2008).

To explain the lower likelihood of dental service utilization among individuals with diabetes compared to individuals without diabetes, Macek et al. (2009) hypothesized that painful and expensive periodontal treatment due to periodontitis might deter individuals with diabetes from using dental care. Furthermore, this study examined whether the relationship is gender-specific as reported by Macek et al. in 2008. An analysis of NHANES data for 1999 and 2004 aimed at describing dental service utilization in the past 12 months among adults aged 25 years and older revealed that diabetes status was significantly related to dental service utilization independent of periodontitis status. Also, the results revealed that no interaction between gender and diabetes status has been found. (Macek & Tomar, 2009).

Chaudhari et al. (2012) confirmed the findings that individuals with diabetes have been found to be associated with decreased use of dental services. Also, Chaudhari et al. found that individuals with diabetes were less likely to use prophylaxes, restorations, and
crowns and more likely to receive periodontal maintenance, non-surgical periodontal treatment tooth extractions, and removable prosthetics.

Recognizing that the use of dental service includes complex relationships between diabetic status, oral health status, and different socio-demographic and related variables, the Andersen and Newman Framework of Health Services Utilization (Andersen & Newman, 1973) was used to highlight the contributions of predisposing, enabling, and illness variables with regard to use of dental service. While diabetic status could be regarded as a predisposing variable (past illness that predisposes the individual to poorer health), diabetic status was treated as a separate domain in evaluating the contribution of diabetes status separate from the influence of other predisposing, enabling, and illness variables.

In addition to mentioning the relative contribution of different domains of predictors to utilization of dental services, the proposed study will examine the relationship between diabetes status and dental service use. In other words, this study examined whether the relationship between diabetes status and dental service utilization is direct or indirect, such as whether it is mediated by other variables in the model where diabetes causes more oral health problems which directly influence service use.

In summary, the literature indicates an increase in likelihood of dental service use with increasing age. Gender is another factor related to dental service use; research reveals that females reported a greater number of dental visits compared to males. Further research indicates race/ethnicity is related to dental service use. Education and income affect the likelihood of using dental service; people with higher education and income
reported a higher dental service use. Perceived need with regard to dental service and presence of dental insurance are also factors influencing the use of dental service.
CHAPTER III

METHODOLOGY

The aim of the study was to assess how much variation in dental service utilization is explained by diabetes status relative to the contributions of Andersen Behavioral Model dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year. This study addressed the question of whether individuals with diabetes are more or less likely to utilize dental services, measured in terms of preventive and emergency services during the past year. The focus for this study was on identifying factors that are associated with dental service for individuals with diabetes. This study used data obtained from the 2001-2002 NHANES.

Background information about NHANES was discussed in this chapter. This chapter included an overview of the research methodology used for this study including the research design, setting, subjects, human rights protection, and statistical analysis plan.

The National Health and Nutrition Examination Survey History

The NHANES is a program that started in the 1960s to assess a national representative sample of American adults and children on health and nutritional status. NHANES was established to act in accordance with the 1956 National Health Survey Act, which “provided the legislative authorization for a continuing survey to provide current statistical data on the amount, distribution, and effects of illness and disability in the United States” (NHANES, 2014, History). NHANES is under the umbrella of the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention. The first National Health Examination Survey, NHES I, targeted adults aged 18-79 years on specific chronic conditions. NHES II and NHES III targeted
children aged 6-11 and 12-17 years with a focus on children’s growth and development. In the 1970s a continuous survey combining a National Nutrition Surveillance System with the National Health Examination Survey was recommended in response to the importance of relationships between health status and nutrition, resulting in the development of NHANES. The first NHANES, NHANE I, was deployed from 1971 to 1975 to represent a national sample of Americans aged 1-74 years. NHANE II, from 1976 to 1980, targeted Americans six months of age to 74 years. Both, NHANES I and NHANES II, focused on collecting data by interviews, as well as physical and clinical tests used to gather information on the health and nutrition status of the selected sample. In NHANES I and NHANES II, however, comparable data for minority groups within the USA was not collected.

In order to provide comparable data for different ethnic groups NHANES III was conducted between 1988 and 1994. Black Americans and Mexican in age groups 1-5 years and over 60 years old were over sampled. In addition, environmental effects on health were incorporated into NHANES III. From 1999 to the present, the NHANES survey has been a continuous survey collecting data about non-institutionalized American citizens in two-year cycles with a focus on health and nutrition variables that match current diseases and health needs.

About 5,000 individuals are examined each year from different counties across the United States to provide a representative sample of the American population; every participant in this survey represents approximately 50,000 other American residents. The NHANES overall objectives are: 1) estimate the number and percentage of individuals with specific diseases and risk factors, 2) monitor trends of specific diseases; 3) monitor
trends that relate to environmental exposure and risk behaviors, 4) analyze risk factors, 5) examine the relationship between diet, nutrition, and health, and 6) investigate new public health concerns and new innovations (National Health and Nutrition Examination Survey, 2014).

**Study Design**

This study was a cross-sectional using data extracted from the 2001-2002 NHANES. The analyses of this study was restricted to the 2001-2002 NHANES dataset, since it is the most recent NHANES dataset that included detailed dental data that can address the research questions. The NHANES is a continuous standardized population-based survey that collects data from a combination of interviews and physical examinations every year. The data gathered is to provide information about U.S. residents on health and nutritional status of non-institutionalized adults and children.

The NHANES obtains information about diagnosed and undiagnosed conditions via physical examinations, diagnostic procedures, and laboratory tests (NHANES, 2014). Data is collected on various chronic conditions, risk factors, heredity, life style, and environmental exposures. These conditions and factors include the following: anemia, cardiovascular disease, diabetes, obesity, eye diseases, hearing loss, infectious diseases, kidney disease, nutrition, obesity, oral health, osteoporosis, physical fitness and physical functioning, reproductive history and sexual behavior, respiratory disease, sexually transmitted diseases, and vision.

The oral health protocol in the NHANES survey was designed and implemented with collaboration between the National Institute of Dental and Craniofacial Research
(NIDCR), the National Center for Chronic Disease Prevention and Health Promotion’s Division of Oral Health (DOH), and the National Center for Health Statistics (NCHS).

**Sample Description**

The target population for the 2001-2002 NHANES survey is U.S. civilian, non-institutionalized adults, who are 18 years of age or older. A stratified multistage design was used to obtain a representative probability sample of the civilian non-institutionalized population of the United States based on the selection of counties, blocks, households, and individuals within households. A list of private residence [dwelling unit (DU)] addresses located in the selected sampling area was identified. From that list, a sample was selected to carry out the interviews. A vacant/not a DU form was completed in case the selected address was not a residence. Before data collection, an introductory letter that described the study was sent to each selected household to introduce the survey. Eligible individuals in each listed household were identified by screening procedures administered by the interviewers. In each eligible family, one adult responded to the family questionnaire. Eligible individuals in each listed household were scheduled for MEC examination. Consent forms for the household interview and examination consents were obtained from all participants. Parents or legal guardians were required to sign consent forms for participants younger than 18 years. Also, participants aged 12 years or older had to sign the examination consent forms to be included in the MEC examination (NHANES, 2014). Participants under the age of 16 or participants unable to self-report had an authorized adult provide the needed information, while participants aged 16 and older provided information directly to the interviewer.
NHANES over-sampled subgroups of the population to produce reliable statistics (NHANES, 2014). The NHANES survey in 1999-2004 oversampled African Americans, Mexican Americans, individuals between 12-19 years of age, and individuals 60 years of age and older (Dye et al., 2007). Participants in NHANES received free transportation to and from the mobile center to encourage participation. In addition, participants were given monetary compensation and a medical report of the examination findings. The NHANES program did not provide clinical treatment or intervention for the participants, but contact information for a primary care physician or referrals to a local physician for follow-up were provided.

A series of selection criteria were applied to comply with the purpose of the study. The present study excluded the following from NHANES data: participants younger than 18 years of age, and individuals with congenital heart murmurs, heart valve problems, congenital heart disease, or bacterial endocarditis, rheumatic fever, renal dialysis, hemophilia, pacemaker, automatic defibrillator, or artificial material in the heart such as valve replacement. Also excluded were those with a history of hipbone or joint replacement and those requiring antibiotic premedication prior to dental treatment.

**Setting**

The NHANES survey has two main parts; the interview and the health examinations. The interview occurred in the participant’s home and the mode of administration was in-person. The household interview consisted of questions related to demographic, socioeconomic, dietary, and health topics. The health examinations were performed in the MEC, which was equipped with high technology. The MEC was available on survey locations all over the country during the survey period and consisted
of four trailers divided into rooms to protect the participant’s privacy. Trailer 1 housed the reception area, vision room, balance/hair and fitness. Trailer 2 contained rooms for physical examination, MEC interview, dietary interview, and lower extremity diseases. Trailer 3 contained space for drawing blood samples, laboratory, label/shipping area, and staff lounge. Total body composition, body measures, dental examination, and hearing tests were located in Trailer 4. The MEC operated five days a week and had two-four sessions daily Monday through Friday.

The NHANES survey team included a physician, dentist, medical technician, health technician, and health interviewers (NHANES, 2014). The health examinations consisted of medical, dental, physiological measurements, and laboratory tests (see Figure 3).

Figure 3. Mobile Examination Center (MEC) Diagram
Adapted from NHANES
Interviewer Training and Quality Control Monitoring

The NHANES interviewers, both household and MEC interviewers, completed a comprehensive two-week training program in preparation for administration of the interview. Role-playing exercises, practice interviews, training in personal computer use, and training in interview system software use were parts of the NHANES interviewers’ training. After the training and prior to administration of the questionnaires to participants, pretesting was conducted in the field. Pretesting of the actual exam session included calibration and practicing MEC procedures known as a dry run day. Volunteers participated in the training sessions. The dry-run day allowed for verification that equipment functioned properly, supplies were ample, the facility operated properly, and staff was adequately prepared.

Oral health data quality was monitored by periodic intense training on examination procedures, standard application of examination criteria, and periodic calibration of dental examiners. As a part of quality control monitoring, any editing was done by a field office staff person (not by the interviewer) and validated by contacting the participants to examine intra-examiner reliability. Feedback was provided as needed to interviewers. In the case of participants’ unrealistic responses, NHANES Computer-Assisted Personal Interviewing (CAPI) systems notified the interviewers to validate the answers.

Data Collection Procedures

The NHANES oral health component assessed the prevalence of dental caries, periodontal disease, edentulism, sealants, fluorosis, traumatic injury, and temporomandibular joint (TMJ) and facial pain. Oral health status was obtained from the
home interview and dental examination. The in-home interview covered oral health perception, dental visit history, and dry mouth condition. The dental examination included tooth count, dental caries, dental sealant, dental incisor trauma, and periodontal status. The dental examinations were performed in the MEC dental examination room (see Figure 4) by qualified dentists who were calibrated three times a year by a reference examiner to enhance reliability of the assessment (NHANES, 2014).

Figure 4. Mobile Examination Center Dental Examination Room
Adapted from NHANES
The MEC data were collected via the Integrated Survey and Information System (ISIS). This system allowed the users to record the interview and examination data. Also, ISIS tracked completed and uncompleted parts of the examination. Editing of collected data and quality control was performed by ISIS.

The average length for full examination was about three and half hours for adult participants. The oral health exam was conducted for eligible participants aged two years and older. Several components were included in the oral examination, depending on the participant’s age and medical condition (see Table 1). For example, periodontal assessment was performed on participants aged 13 years or older, while the tooth count was performed on participants aged two years or older. Dental examinations were performed by a licensed dentist (examiner) and dental examination data were entered to the ISIS system by a dental recorder (recorder).

Table 1
Oral Health Components Guidelines

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eligibility and Pain</strong></td>
<td></td>
</tr>
<tr>
<td>Medical Exclusion Questions</td>
<td>13+</td>
</tr>
<tr>
<td>Orofacial Pain</td>
<td>10-69</td>
</tr>
<tr>
<td><strong>Dentition</strong></td>
<td></td>
</tr>
<tr>
<td>Tooth Count</td>
<td>2+</td>
</tr>
<tr>
<td>Caries: Coronal</td>
<td>2+</td>
</tr>
<tr>
<td>Caries: Root</td>
<td>18+</td>
</tr>
<tr>
<td>Sealants</td>
<td>2-34</td>
</tr>
<tr>
<td>Fluorosis- Dean’s index</td>
<td>6-49</td>
</tr>
<tr>
<td>Incisor Trauma</td>
<td>6-29</td>
</tr>
<tr>
<td><strong>Periodontal</strong></td>
<td></td>
</tr>
<tr>
<td>Loss of Attachment</td>
<td>13+</td>
</tr>
<tr>
<td>Bleeding on Probing</td>
<td>13+</td>
</tr>
</tbody>
</table>
The dental examination data were collected via a visual-tactile examination. The dental examination for tooth count assessment, which identifies the presence or absence of the teeth, involves examining both upper and lower jaws starting with the upper right quadrant and ending with the lower right quadrant. To assess the presence of dental caries, the dentist examined the participants using a non-magnifying mirror, dental explorer (number 23), and compressed air. Dental caries assessment included two parts: coronal caries and root caries. The coronal caries assessment started from the upper right quadrant and ended with the lower right quadrant. Anterior teeth were examined in the following order: lingual, facial, mesial, and distal; and the posterior teeth were examined from the lingual, occlusal, facial, mesial, and distal. The number of decayed, missing, and filled surfaces (DMFS) index was used to assess the presence and the severity of dental caries. Based on the tooth condition, a code was assigned to each tooth. To assess the prevalence of root caries and root fillings, root caries assessment was conducted for participants aged 18 years and older on a maximum of 28 teeth.

Periodontal evaluation consisted of two parts of measurements-clinical attachment loss and bleeding on probing. Clinical attachment loss is the distance from the cemento-enamel junction to the base of the sulcus (in millimeters), whereas bleeding on probing is the presence of blood after using a periodontal probe to measure a sulcus depth. The distal, mid-facial, and the mesial probing sites on fully erupted permanent teeth, with the exception of the wisdom teeth, in two randomly selected quadrants were used in the periodontal evaluation. The two quadrants were selected randomly by a computer program. The periodontal evaluation was performed from posterior to anterior in the randomly selected quadrants. A color-banded periodontal probe graduated at 2, 4,
6, 8, 10, and 12 millimeters was used for periodontal measurements. Measurements were rounded to the lowest whole millimeter. Based on the dental findings, each participant was assigned a recommendation letter after the completion of the examination.

Data collection procedures for NHANES 2001-2002 involved using an advanced computer system. Household interview and MEC questionnaires were translated into Spanish, when applicable, and were administered in Computer-Assisted Personal Interviewing (CAPI). This system consisted of notebook computers with electronic pens, eliminating manual coding operations. Participants were asked to complete the MEC questionnaires after the completion of the household interview. The household interview consisted of screener modules, family questionnaire, and a sample person questionnaire. Screener modules determined the eligibility of the household and their relationships to each other. Information about demographics, food security, health insurance, housing characteristics, income, pesticide use, smoking, and tracking were collected in the family questionnaire. Sample person questionnaire asked questions at the individual level such as, blood pressure, diabetes, hospital utilization and access to care, oral health, and immunization. The MEC questionnaires consist of two parts: a personal interview by a trained interviewer followed by Audio-Computer-Assisted Self Interview, which protects the participants’ privacy by allowing the participants to enter their own responses to certain sensitive questions such as alcohol, drugs, and sexual behavior. The data were transmitted electronically into the main database system once completed. For the participants who were unable to travel to the MEC, 50 years and older or less than one year, home examination were offered (NHANES, 2014).
**Instrumentation**

In this study, adults with self-reported diabetes are identified as individuals who responded “yes” to the following question: “Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?” Self-reported dental service use was the dependent variable in this study. Dental service use was quantified by the two variables based on questions from the survey (last dental visit, and main reason for this visit). The dental visit was derived from the question “About how long has it been since you last visited a dentist? Include all types of dentists, such as, orthodontists, oral surgeons, and all other dental specialists, as well as dental hygienists.” Participants indicated the length of time since the most recent dental visit. Possible categorical responses to this question are: six months or less (≤ 6 months ago); more than 6 months but less than year; (6 months but ≤1 year ago); more than one year but less than two year; (1 year but≤ 2 years ago); more than two years but less than three years; (2 years but≤ 3 years); more than three years but less than five years; (3 years but≤ 5 years ago); more than five years (>5 years ago), and never.

A dental visit was measured using a dummy variable where either the participant visited the dentist in the past year coded (=1) or not coded (=0). A follow up question about the main reason for the dental visit was included. The main reason for the last dental visit was derived from the question, “What was the main reason you last visited the dentist?” Possible categorical responses to this question are: a checkup scheduled by the participant; a checkup scheduled by the dentist; an emergency visit; a maintenance or follow-up visit for a known problem; and “other”.

In order to differentiate the use of dental services in relation to preventive versus emergency dental services in the past year, a three-category measure was constructed. For this study, participants were identified as individuals reporting a preventive dental visit who responded yes to check-up or “other” categories (=1). Participants were identified as individuals reporting an emergent dental visit who responded yes to emergency visit or follow-up for known problem categories (=2). Individuals reporting no dental visit during the last year were identified as a reference category (=0).

**Measures of variables in each domain.**

This section identified predisposing factors, enabling, and illness variables by category along with the associated measurements for each.

**Predisposing Variables**

- **Age:** Measured by the participants reported age in years. Age was classified into different categories.
  1. 18-28
  2. 29-38
  3. 39-48
  4. 49-58
  5. 59-68
  6. >68

- **Gender:** Measured using a dummy variable contrasting males (=1) to females (=0).

- **Marital status:** Measured using a dummy variable contrasting married (=1) to all others (=0).

- **Education:** Classified into more than high school (=1) or high school or less (=0).

- **Race/ethnicity:** Classified into five categories.
  1. Mexican American
2. other Hispanic
3. non-Hispanic Whites
4. non-Hispanic Black
5. other race-including multi-racial

Enabling Factors

- Income: Examined by looking at annual household income. The annual household income was measured by the participants reported income in American dollars and was classified into 11 categories.

1. \( \leq 4,999 \)
2. 5,000-9,999
3. 10,000-14,999
4. 15,000-19,999
5. 20,000-24,999
6. 25,000-34,999
7. 35,000-44,999
8. 45,000-54,999
9. 55,000-64,999
10. 65,000-74,999
11. \( \geq 75,000 \)

- Dental insurance: The presence of dental insurance coverage was derived from the question “Does the insurance you have cover any part of dental care?” This was measured using a dummy variable contrasting presence of dental insurance coverage (=1) to absence of dental insurance coverage (=0).

- Regular source of care: Derived from the question “Is there a particular dentist or dental clinic that you usually go to if you need dental care or dental advice?” This was measured using a dummy variable contrasting presence of regular dentist (=1) to absence of regular dentist (=0).

Illness Level Factors

- Perceived need: The perceived need was derived from the questions “During the past 30 days have you experienced a toothache or painful tooth, (including
pain with biting or chewing, or sensations to hot, or cold or sweets)? This was measured using a dummy variable contrasting presence of pain for one or more days during the 30 days (=1) to absence of pain during the 30 days (=0).

- Evaluated need: Examined by looking at the examiner’s clinical judgment based on the findings from the oral examination. The evaluated need was derived from
  - Clinical judgment on “overall recommendation for care” based on the clinical judgment to 1. See a dentist immediately 2. See a dentist within the next two weeks 3. See a dentist at your earliest convenience or 4. Continue your regular routine care. The “overall recommendation for care” was measured using the first three responses as indicator for oral health concern and was coded (=1) compared to the fourth response which indicates absence of this concern (=0).

**Data Analysis**

Since the outcome variable is a categorical variable, logistic regression analysis was performed to examine the relationship between dental service utilization and diabetes among the adult U.S. population. Specifically, given that the dental service use (dependent variable) has three categories, multinomial (polychotomous) logistic regression was used. To assess the contribution of diabetic status to dental service use relative to predisposing, enabling, and illness variables, a hierarchical (blockwise) entry of predictor variables was used. In hierarchical (blockwise) entry predictors are selected
based on past research and entered in a sequence. The order of entry of the predictor variables are based on their importance in predicting the outcome.

For this study, the predisposing variables (demographics) were entered first, followed by enabling (insurance & access to service) variables, followed by diabetes status. The oral health need variables were entered in the last block. This approach of analysis allowed for assessing the amount of variance explained in dental service utilization by each block of predictors and for examining mediation variables.

The appropriate procedures in Statistical Analysis Software (SAS®) were utilized to accommodate the NHANES sampling design and data weights, such as SURVEYFREQ and SURVEYLOGISTIC. The recommended cluster (SDMVPSU), strata (SDMVSTRA) and weights (WTMEC2YR) for 2001-2002 NHANES data were utilized so the parameter estimates would be representative of the target population.

Descriptive statistics included means and standard error for continuous variables as well as frequencies and percentages for categorical variables. All p-values were reported and the significance level set at 0.05. All analyses were performed using SAS® software version 9.3. (SAS® software version 9.3, SAS Institute Inc., Cary, NC, USA). All multivariable logistic regression models were adjusted for the following a priori confounders: gender, income, education, age, marital status, and race/ethnicity.

**Protection of Human Subjects**

1. In May 2015, the College of Health Sciences Human Subjects Review Committee, Old Dominion University Institutional Review Board (IRB) approved: *Diabetes Status, Predisposing, Enabling, and Oral Health Illness Level*
Variables as Predictors of Preventive and Emergency Dental Service Use
(number 757668-1).

2. Potential Risks: The information gathered in this study is to determine relative contributions of Andersen Behavioral Model dimensions (predisposing, enabling, and illness variables) in predicting dental care utilization among individuals with diabetes during the past year. This study contains no known risks to the subjects who participated in the survey. The interview questions related to this study did not contain any sensitive information related to the participants or their names.

3. Potential Benefits: Knowing the factors that are associated with dental care use for individuals with diabetes might identify areas that may assist in reducing barriers to dental care utilization among this population. This study might guide where resources are needed to enhance access to dental services to reduce the incidence of oral diseases and increase the amount of tooth retention. In addition, by identifying these factors, stake holders and policy makers might initiate new policies, fund research initiatives, and establish educational programs that assist in improving this population’s health status.

4. Consent Procedure: The participants in the study were provided informed consent explaining the reason, purpose, procedure, and nature of the study. In addition, the participants were informed that they have the choice to refuse to participate or to withdraw from the study at any time without penalty.

5. Protection of Subjects’ Rights: Participants’ information remained confidential in this study. Names of participants were not used or published in this study; all data was reported in group form.
6. Risk-Benefit Ratio: This study contained no known risks to subjects who agreed to participate. The study aimed to predict factors associated with dental utilization among individuals with diabetes to increase the amount of tooth retention, and enhance quality of life. Ultimately, the benefits outweigh any potential risks.
CHAPTER IV

RESULTS AND DISCUSSION

A cross sectional study was conducted to examine the contributions of diabetes status to dental service use, relative to the contributions of Andersen and Newman Framework of Health Services Utilization dimensions (predisposing, enabling, and illness variables) in predicting dental service utilization during the past year using a nationally representative sample from the 2001-2002 NHANES dataset. The recommended weights (WTMEC2YR) for 2001-2002 NHANES data are utilized so the parameter estimates would be representative of the target population. The following results are discussed in relationship to the original research questions.

Results

Descriptive Statistics

A total of 11,039 subjects participated in the 2001-2002 NHANES. Of those, 4,707 were eligible to participate in the study based on the exclusion criteria: participants less than 18 years of age, individuals with congenital heart murmurs, heart valve problems, congenital heart disease, or bacterial endocarditis, rheumatic fever, renal dialysis, hemophilia, pacemaker, automatic defibrillator, or artificial material in the heart such as valve replacement. Also excluded are those with a history of hipbone or joint replacement and those requiring antibiotic premedication prior to dental treatment.

In terms of predisposing variables, a descriptive summary of the sample is provided in Table 2. Predisposing factors selected for this study are age, gender, race, marital status, and education. The sample is 18 to 68 years with an average age of 37.6 ± 0.61 years. The majority (65%) of the participants were younger than 48 years old. The
sample was predominantly female (52%), married (58%), with 52% reporting more than a high school education. In terms of race/ethnicity, the sample was predominantly non-Hispanic White (73%).

Table 2
Predisposing Variables of the Subjects (n=4,707)

<table>
<thead>
<tr>
<th>Predisposing Variables</th>
<th>n</th>
<th>%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2,214</td>
<td>48</td>
</tr>
<tr>
<td>Female</td>
<td>2,493</td>
<td>52</td>
</tr>
<tr>
<td>Education</td>
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<tr>
<td>High school or less</td>
<td>3,072</td>
<td>48</td>
</tr>
<tr>
<td>More than high school</td>
<td>1,633</td>
<td>52</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>907</td>
<td>5</td>
</tr>
<tr>
<td>Other Hispanic</td>
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<td>6</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>2,186</td>
<td>73</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>1,202</td>
<td>11</td>
</tr>
<tr>
<td>Other Race-Including Multi-Racial</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>1,783</td>
<td>58</td>
</tr>
<tr>
<td>All others</td>
<td>2,136</td>
<td>42</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-28</td>
<td>757</td>
<td>18</td>
</tr>
<tr>
<td>29-38</td>
<td>561</td>
<td>21</td>
</tr>
<tr>
<td>39-48</td>
<td>613</td>
<td>26</td>
</tr>
<tr>
<td>49-58</td>
<td>540</td>
<td>21</td>
</tr>
<tr>
<td>59-68</td>
<td>528</td>
<td>13</td>
</tr>
<tr>
<td>&gt;68</td>
<td>43</td>
<td>1</td>
</tr>
</tbody>
</table>

*Weighted percentage is used in this table

In terms of enabling variables- income, dental insurance, and a regular source of dental care- the majority of the respondents (47%) reported an annual household income between $ 25,000 and $74,999. The presence of a regular dentist was reported by 77%
(3,501) of respondents. About 76% (3,714) of the respondents reported having dental insurance. Table 3 shows in details the enabling variables for the study subjects.

Table 3
Enabling Variables of the Subjects (n=4,707)

<table>
<thead>
<tr>
<th>Enabling Variables</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Household Income</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=4,999</td>
<td>75</td>
<td>1</td>
</tr>
<tr>
<td>5,000-9,999</td>
<td>190</td>
<td>3</td>
</tr>
<tr>
<td>10,000-14,999</td>
<td>259</td>
<td>4</td>
</tr>
<tr>
<td>15,000-19,999</td>
<td>284</td>
<td>5</td>
</tr>
<tr>
<td>20,000-24,999</td>
<td>237</td>
<td>4</td>
</tr>
<tr>
<td>25,000-34,999</td>
<td>472</td>
<td>8</td>
</tr>
<tr>
<td>35,000-44,999</td>
<td>465</td>
<td>10</td>
</tr>
<tr>
<td>45,000-54,999</td>
<td>450</td>
<td>12</td>
</tr>
<tr>
<td>55,000-64,999</td>
<td>414</td>
<td>10</td>
</tr>
<tr>
<td>65,000—74,999</td>
<td>280</td>
<td>7</td>
</tr>
<tr>
<td>&gt;=75,000</td>
<td>1,263</td>
<td>35</td>
</tr>
<tr>
<td><strong>Dental Coverage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has Dental Insurance</td>
<td>3714</td>
<td>76</td>
</tr>
<tr>
<td>No Dental Insurance</td>
<td>993</td>
<td>24</td>
</tr>
<tr>
<td><strong>Regular Dentist for Care</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Regular Dentist</td>
<td>3501</td>
<td>77</td>
</tr>
<tr>
<td>Absence of Regular Dentist</td>
<td>1206</td>
<td>23</td>
</tr>
</tbody>
</table>

*Weighted percentage is used in this table

In terms of illness variables, perceived need as measured by self-reported tooth pain was reported by 26% (1,223) of respondents. Evaluated illness variable as measured by the overall recommendation to seek dental care based upon findings from oral examination was observed in 44% (2,241) of respondents. Table 4 shows the illness variables of the subjects.
Table 4  
Illness Variables of the Subjects (n=4,707)

<table>
<thead>
<tr>
<th>Illness Variables</th>
<th>n</th>
<th>%*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived Need</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has Painful Tooth</td>
<td>1223</td>
<td>26</td>
</tr>
<tr>
<td>No Painful Tooth</td>
<td>3484</td>
<td>74</td>
</tr>
<tr>
<td><strong>Evaluated illness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has Oral Concern</td>
<td>2241</td>
<td>44</td>
</tr>
<tr>
<td>No Oral Concern</td>
<td>2466</td>
<td>56</td>
</tr>
</tbody>
</table>

*Weighted percentage is used in this table

With regard to use of dental services, the data indicates that about 70% (3,299) of respondents reported a visit to the dentist in the past 12 months. Of these visits, the majority were preventive visits 52% (2,463), with the remainder being emergency visits 18% (836). Table 5 shows the dental service utilization of the participants.

Table 5  
Dental Service Utilization Status of the Participants (n=4,707)

<table>
<thead>
<tr>
<th>Dental Service Utilization Status</th>
<th>n</th>
<th>%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit Dentist Last Year</td>
<td>3,299</td>
<td>70</td>
</tr>
<tr>
<td><strong>Main Reason for Dental Visit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventive Visit</td>
<td>2463</td>
<td>52</td>
</tr>
<tr>
<td>Emergency Visit</td>
<td>836</td>
<td>18</td>
</tr>
<tr>
<td>No Dental Visit Last Year</td>
<td>1408</td>
<td>30</td>
</tr>
</tbody>
</table>

* Weighted percentage is used in this table  
** For the participant who had a dental visit in the last year (n=3,299; ~70%)
Using Chi-Square analyses (see Table 6) the data reveals a higher likelihood of dental service use among older individuals, but the relationship was not statistically significant \((p<0.06)\). Further analysis indicates a significantly higher likelihood of dental service use in the past 12 months among females (37\% versus 33\% for females and males, respectively), among non-Hispanic Whites (54\%), among married individuals (41\% versus 28\% for married and all others, respectively), and among individuals with higher education (39\% versus 31\% for more than high school and high school or less, respectively). The likelihood of dental service use by higher income individuals in the past 12 months was significantly different than use by individuals with low income.

Table 7 shows the use of dental services in the last year with relation to gender, age, race/ethnicity, income, marital status, education, diabetes status, insurance status, regular dentist, perceived, and evaluated need.

The data analysis reveals a significantly higher likelihood of dental service use in the past 12 months among individuals with dental insurance (56\% versus 15\% for presence of dental insurance and absence of dental insurance, respectively). Further analysis highlighted the importance of the presence of a regular dentist. The analysis indicates a significantly higher likelihood of dental service use in the past 12 months among individuals reporting a regular dentist (64\%) compared to (7%) reporting the absence of a regular dentist. Perceived need for care as measured by self-reported tooth pain was related to dental service use in the past 12 months, but the relationship was not statistically significant. Individuals who reported a painful tooth in the last 30 days were associated with decreased likelihood of dental service use (18\% versus 52\% for presence and absence of painful tooth, respectively). Evaluated illness, measured by the overall
recommendation to seek dental care based upon findings from oral examinations, was significantly related to dental service use in the past 12 months. Individuals with oral concern had a lower likelihood of utilizing dental service (25% versus 45%) with absence of oral concern.

Table 6
Chi-Square Values Applied to Dental Services Use in the Last Year with Relation to Gender, Age, Race/Ethnicity, Income, Marital Status, Education, Diabetes Status, Insurance Status, Regular Dentist, Perceived, and Evaluated Need

<table>
<thead>
<tr>
<th>Variable</th>
<th>Chi-Square</th>
<th>DF*</th>
<th>P-Value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>4.80</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>Age Groups</td>
<td>10.30</td>
<td>5</td>
<td>0.06</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td>28.79</td>
<td>4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Income</td>
<td>94.67</td>
<td>10</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Marital Status</td>
<td>6.30</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>Education</td>
<td>12.66</td>
<td>1</td>
<td>0.0004</td>
</tr>
<tr>
<td>Diabetes Status</td>
<td>13.62</td>
<td>1</td>
<td>0.0002</td>
</tr>
<tr>
<td>Insurance Status</td>
<td>20.64</td>
<td>1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Regular Dentist</td>
<td>49007.50</td>
<td>1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Perceived Need</td>
<td>0.018</td>
<td>1</td>
<td>0.89</td>
</tr>
<tr>
<td>Evaluated Need</td>
<td>50.91</td>
<td>1</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* Degree of freedom
**P<.05 significant values
Table 7
Dental Services Use in the Last Year with Relation to Gender, Age, Race/Ethnicity, Income, Marital Status, Education, Diabetes Status, Insurance Status, Regular Dentist, Perceived, and Evaluated Need

<table>
<thead>
<tr>
<th>Dental Service Use*</th>
<th>n**</th>
<th>%***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1785</td>
<td>37</td>
</tr>
<tr>
<td>Male</td>
<td>1514</td>
<td>33</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>1229</td>
<td>41</td>
</tr>
<tr>
<td>All others</td>
<td>1419</td>
<td>28</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-28</td>
<td>482</td>
<td>12</td>
</tr>
<tr>
<td>29-38</td>
<td>366</td>
<td>13</td>
</tr>
<tr>
<td>39-48</td>
<td>404</td>
<td>18</td>
</tr>
<tr>
<td>49-58</td>
<td>367</td>
<td>15</td>
</tr>
<tr>
<td>59-68</td>
<td>329</td>
<td>8</td>
</tr>
<tr>
<td>&gt;68</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>618</td>
<td>3</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>121</td>
<td>3</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>1648</td>
<td>54</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>779</td>
<td>7</td>
</tr>
<tr>
<td>Other Race</td>
<td>133</td>
<td>3</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or less</td>
<td>2108</td>
<td>31</td>
</tr>
<tr>
<td>More than high school</td>
<td>1191</td>
<td>39</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=4,999</td>
<td>32</td>
<td>0.4</td>
</tr>
<tr>
<td>5,000-9,999</td>
<td>122</td>
<td>2</td>
</tr>
<tr>
<td>10,000-14,999</td>
<td>152</td>
<td>2</td>
</tr>
<tr>
<td>15,000-19,999</td>
<td>161</td>
<td>3</td>
</tr>
<tr>
<td>20,000-24,999</td>
<td>146</td>
<td>2</td>
</tr>
<tr>
<td>25,000-34,999</td>
<td>313</td>
<td>5</td>
</tr>
<tr>
<td>35,000-44,999</td>
<td>311</td>
<td>7</td>
</tr>
<tr>
<td>45,000-54,999</td>
<td>301</td>
<td>8</td>
</tr>
<tr>
<td>55,000-64,999</td>
<td>318</td>
<td>7</td>
</tr>
<tr>
<td>65,000-74,999</td>
<td>195</td>
<td>5</td>
</tr>
<tr>
<td>&gt;=75,000</td>
<td>1033</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Presence of dentist</td>
<td>No regular dentist</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Regular Dentist</td>
<td>2917</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>382</td>
<td>6</td>
</tr>
<tr>
<td>Dental Insurance</td>
<td>2717</td>
<td>56</td>
</tr>
<tr>
<td>Presence of dental insurance</td>
<td>582</td>
<td>14</td>
</tr>
<tr>
<td>No dental insurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain Status</td>
<td>841</td>
<td>18</td>
</tr>
<tr>
<td>Has painful tooth</td>
<td>2458</td>
<td>52</td>
</tr>
<tr>
<td>No painful tooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Recommendation</td>
<td>1309</td>
<td>25</td>
</tr>
<tr>
<td>Has concern</td>
<td>1990</td>
<td>45</td>
</tr>
<tr>
<td>No concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes Status</td>
<td>134</td>
<td>3</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3165</td>
<td>67</td>
</tr>
<tr>
<td>No diabetes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Dental service use for any dental services

**Individuals who had a dental visit in the last 12 months; n=3299 (~70% of all participants)

***Weighted percentage is used in this table

**Primary Analysis**

Research question one.

Are individuals with diabetes more or less likely to utilize dental services in the past year compared to individuals without diabetes?

The data analysis using the Chi-Square Test reveals that individuals with diabetes (3%) were significantly \( p=0.0002 \) less likely to utilize dental services in the past 12 months compared to individuals without diabetes (67%) (see Table 8).
Table 8
Dental Services Use in the Last Year with Relation to Diabetes Status

<table>
<thead>
<tr>
<th>Diabetes Status</th>
<th>Yes</th>
<th>No</th>
<th>Chi-Square</th>
<th>DF**</th>
<th>P-Value***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n(%)</td>
<td>n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>134(3)</td>
<td>101(2)</td>
<td>13.62</td>
<td>1</td>
<td>0.0002</td>
</tr>
<tr>
<td>No</td>
<td>3,165(67)</td>
<td>1,307(28)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Weighted percentage is used in this table  
** Degree of freedom  
***P<.05 significant values

Research question two.

What is the contribution of diabetes status relative to predisposing, enabling, and illness level variables that predict dental services utilization?

Dental service use, the dependent variable for this study, had three categories; therefore, a multinomial logistic regression was applied using SURVEYLOGISTIC procedures that involved two simultaneous regression models. The first regression model predicts differences between dental service use, preventive visit (category 1) and no dental visit (reference category). The second regression model predicts differences between dental service use, emergency visit (category 2) and no dental visit (reference category). Findings for preventive or emergency dental service use in the past 12 months are presented in Table 9 and Table 10.
Preventive service utilization.

Looking at predisposing characteristics to predict differences in preventive service use (see Table 9) the following variables were significant: gender (OR=1.38), unmarried status (OR=0.72), age (OR=0.63), and education (OR=2.0). There was a lower likelihood of preventive service use among younger respondents and those not married (all others category) and higher likelihood among females and those with higher education.

Among enabling variables, income was a significant predictor of preventive service use, with a lower likelihood of preventive service use among individuals with low income and a higher likelihood among individuals with higher income. The presence of a regular dentist and dental insurance were significant predictors (OR=15.8, OR = 1.53 for presence of regular dentist and dental insurance, respectively). The likelihood of preventive service use in the past 12 months increased among individuals that reported having a regular dentist and dental insurance.

A self-reported painful tooth was a significant predictor (OR=0.75) among illness level variables. The likelihood of preventive service use decreased among those with tooth pain. In addition, recommended care based upon findings from the oral exam was significantly associated with a lower likelihood (OR=0.30) of preventive service use among individuals with oral concern.

Diabetes status was significantly associated with preventive service use (OR=0.60). Diabetics were less likely to obtain preventive service use than non-diabetics. With regard to diabetes status, the data indicate that the majority 95% (4472)
of the sample were non diabetic with only 5% (235) of respondents reporting having diabetes.

*Emergency service utilization.*

Looking at predisposing characteristics to predict differences in emergency service use (see Table 10) the following variables were significant: unmarried status (OR=0.54), age (OR=0.63), and education (OR=1.53). There was a lower likelihood of emergency service use among younger respondents and those not married (all others) and a higher likelihood among those with higher education.

Among enabling variables, the presence of a regular dentist and dental insurance were significant predictors (OR=6.7, OR= 1.9 for presence of regular dentist and dental insurance, respectively), with increased likelihood of emergency service use in the past 12 months among individuals reported having a regular dentist and dental insurance.

Among illness level variables, a self-reported painful tooth was a significant predictor (OR=2.02), with increased likelihood of emergency service use among those with tooth pain. In addition, recommended care based upon findings from the oral exam was significantly associated with a decreased likelihood of emergency service use among individuals with oral concern (OR=0.79).

Diabetes status was not significantly associated with emergency service use (OR=0.65). However, diabetics were less likely to obtain emergency service use than non-diabetics.
Table 9
Multiple Logistic Regression Analysis Predicting Preventive Dental Service Use in the Past 12 Months

<table>
<thead>
<tr>
<th>Predisposing Characteristics</th>
<th>95% CI</th>
<th>B(SE)</th>
<th>Odds Ratio</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td><strong>0.16</strong>*(0.04)</td>
<td>1.38</td>
<td>1.16</td>
<td>1.65</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td></td>
<td>-0.16*(0.06)</td>
<td>0.72</td>
<td>0.56</td>
<td>0.91</td>
</tr>
<tr>
<td>Married</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-38</td>
<td></td>
<td>-0.30*(0.10)</td>
<td>0.63</td>
<td>0.45</td>
<td>0.88</td>
</tr>
<tr>
<td>39-48</td>
<td></td>
<td>0.01(0.12)</td>
<td>0.84</td>
<td>0.62</td>
<td>1.13</td>
</tr>
<tr>
<td>49-58</td>
<td></td>
<td>0.05(0.20)</td>
<td>0.87</td>
<td>0.56</td>
<td>1.35</td>
</tr>
<tr>
<td>59-68</td>
<td></td>
<td>-0.17(0.10)</td>
<td>0.70</td>
<td>0.46</td>
<td>1.04</td>
</tr>
<tr>
<td>&gt;68</td>
<td></td>
<td>0.17(0.33)</td>
<td>0.99</td>
<td>0.46</td>
<td>2.13</td>
</tr>
<tr>
<td>18-28</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td></td>
<td>0.07(0.25)</td>
<td>0.77</td>
<td>0.46</td>
<td>1.27</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td></td>
<td>-0.03(0.15)</td>
<td>0.68</td>
<td>0.50</td>
<td>0.94</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td></td>
<td>-0.12(0.21)</td>
<td>0.63</td>
<td>0.41</td>
<td>0.97</td>
</tr>
<tr>
<td>Other Race**</td>
<td></td>
<td>-0.25(0.27)</td>
<td>0.55</td>
<td>0.30</td>
<td>1.02</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td></td>
<td>0.34*(0.07)</td>
<td>2.01</td>
<td>1.53</td>
<td>2.63</td>
</tr>
<tr>
<td>High school or less</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Enabling Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,000-9,999</td>
<td></td>
<td>-0.08(0.24)</td>
<td>1.89</td>
<td>0.56</td>
<td>6.38</td>
</tr>
<tr>
<td>10,000-14,999</td>
<td></td>
<td>-0.5* (0.20)</td>
<td>1.24</td>
<td>0.46</td>
<td>3.36</td>
</tr>
<tr>
<td>15,000-19,999</td>
<td></td>
<td>-0.3(0.22)</td>
<td>1.51</td>
<td>0.44</td>
<td>5.17</td>
</tr>
<tr>
<td>20,000-24,999</td>
<td></td>
<td>-0.59*(0.26)</td>
<td>1.13</td>
<td>0.36</td>
<td>3.5</td>
</tr>
<tr>
<td>25,000-34,999</td>
<td></td>
<td>0.02(0.18)</td>
<td>2.09</td>
<td>0.65</td>
<td>6.68</td>
</tr>
<tr>
<td>35,000-44,999</td>
<td></td>
<td>0.25(0.2)</td>
<td>2.64</td>
<td>0.96</td>
<td>7.23</td>
</tr>
<tr>
<td>45,000-54,999</td>
<td></td>
<td>0.16(0.20)</td>
<td>2.41</td>
<td>0.69</td>
<td>8.35</td>
</tr>
<tr>
<td>55,000-64,999</td>
<td></td>
<td><strong>0.72</strong>*(0.23)</td>
<td>4.25</td>
<td>1.23</td>
<td>14.6</td>
</tr>
<tr>
<td>65,000-74,999</td>
<td></td>
<td>0.10(0.29)</td>
<td>2.27</td>
<td>0.63</td>
<td>8.20</td>
</tr>
<tr>
<td>&gt;=75,000</td>
<td></td>
<td>0.93*(0.11)</td>
<td>5.21</td>
<td>1.69</td>
<td>15.98</td>
</tr>
<tr>
<td>&lt;=4,999</td>
<td></td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>Reference</td>
<td>1.39*(0.07)</td>
<td>15.8 Reference</td>
<td>11.95 Reference</td>
<td>20.91 Reference</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Regular Dentist</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>presence of dentist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No regular dentist</td>
<td></td>
<td>1.39</td>
<td>15.8</td>
<td>11.95</td>
<td>20.91</td>
</tr>
<tr>
<td><strong>Dental Insurance</strong></td>
<td></td>
<td>0.21*(0.07)</td>
<td>1.53</td>
<td>1.15</td>
<td>2.04</td>
</tr>
<tr>
<td>Presence of dental insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No dental insurance</td>
<td></td>
<td>0.21</td>
<td>1.53</td>
<td>1.15</td>
<td>2.04</td>
</tr>
</tbody>
</table>

**Illness level variables**

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>-0.14*(0.07)</th>
<th>0.75 Reference</th>
<th>0.56 Reference</th>
<th>0.99 Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has painful tooth</td>
<td></td>
<td>-0.14</td>
<td>0.75</td>
<td>0.56</td>
<td>0.99</td>
</tr>
<tr>
<td>No painful tooth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall Recommendation</strong></td>
<td></td>
<td>-0.58*(0.07)</td>
<td>0.30</td>
<td>0.23</td>
<td>0.41</td>
</tr>
<tr>
<td>Has concern</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No concern</td>
<td></td>
<td>-0.58</td>
<td>0.30</td>
<td>0.23</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Diabetes Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td>-0.25*(0.10)</td>
<td>0.6</td>
<td>0.40</td>
<td>0.92</td>
</tr>
<tr>
<td>No diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The reference category is service non-users
*P<.05 significant values are bold
**Other Race including multi racial
Table 10
Multiple Logistic Regression Analysis Predicting Emergency Dental Service Use in the Past 12 Months

<table>
<thead>
<tr>
<th></th>
<th>B(SE)</th>
<th>Odds Ratio</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Predisposing Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.08(0.06)</td>
<td>1.17</td>
<td>0.93</td>
<td>1.47</td>
</tr>
<tr>
<td>Male</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All others</td>
<td>-0.17*(0.07)</td>
<td>0.72</td>
<td>0.54</td>
<td>0.94</td>
</tr>
<tr>
<td>Married</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29-38</td>
<td>-0.30*(0.14)</td>
<td>0.63</td>
<td>0.44</td>
<td>0.89</td>
</tr>
<tr>
<td>39-48</td>
<td>0.13(0.18)</td>
<td>0.98</td>
<td>0.71</td>
<td>1.32</td>
</tr>
<tr>
<td>49-58</td>
<td>0.11(0.18)</td>
<td>0.95</td>
<td>0.60</td>
<td>1.5</td>
</tr>
<tr>
<td>59-68</td>
<td>-0.16(0.17)</td>
<td>0.73</td>
<td>0.49</td>
<td>1.06</td>
</tr>
<tr>
<td>&gt;68</td>
<td>0.07(0.5)</td>
<td>0.92</td>
<td>0.25</td>
<td>3.32</td>
</tr>
<tr>
<td>18-28</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican American</td>
<td>-0.00(0.24)</td>
<td>0.83</td>
<td>0.54</td>
<td>1.27</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>0.27(0.16)</td>
<td>1.09</td>
<td>0.75</td>
<td>1.57</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>-0.05(0.24)</td>
<td>0.78</td>
<td>0.43</td>
<td>1.45</td>
</tr>
<tr>
<td>Other Race**</td>
<td>-0.40(0.32)</td>
<td>0.55</td>
<td>0.25</td>
<td>1.23</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td>0.21*(0.07)</td>
<td>1.53</td>
<td>1.13</td>
<td>2.06</td>
</tr>
<tr>
<td>High school or less</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td><strong>Enabling Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,000-9,999</td>
<td>0.31(0.3)</td>
<td>2.16</td>
<td>0.66</td>
<td>7.14</td>
</tr>
<tr>
<td>10,000-14,999</td>
<td>-0.35(0.28)</td>
<td>1.11</td>
<td>0.3</td>
<td>3.97</td>
</tr>
<tr>
<td>15,000-19,999</td>
<td>-0.09(0.25)</td>
<td>1.44</td>
<td>0.48</td>
<td>4.26</td>
</tr>
<tr>
<td>20,000-24,999</td>
<td>-0.07(0.19)</td>
<td>1.47</td>
<td>0.5</td>
<td>3.98</td>
</tr>
<tr>
<td>25,000-34,999</td>
<td>0.16(0.2)</td>
<td>1.86</td>
<td>0.6</td>
<td>5.81</td>
</tr>
<tr>
<td>35,000-44,999</td>
<td>0.01(0.2)</td>
<td>1.61</td>
<td>0.62</td>
<td>4.13</td>
</tr>
<tr>
<td>45,000-54,999</td>
<td>-0.05(0.23)</td>
<td>1.49</td>
<td>0.48</td>
<td>4.64</td>
</tr>
<tr>
<td>55,000-64,999</td>
<td>0.17(0.2)</td>
<td>1.89</td>
<td>0.68</td>
<td>5.19</td>
</tr>
<tr>
<td>65,000-74,999</td>
<td>0.13(0.25)</td>
<td>1.82</td>
<td>0.68</td>
<td>4.84</td>
</tr>
<tr>
<td>&gt;=75,000</td>
<td>0.25(0.13)</td>
<td>2.05</td>
<td>0.78</td>
<td>5.40</td>
</tr>
<tr>
<td>&lt;=4,999</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
</tbody>
</table>
Research question three.

Is the relationship between diabetes and dental service utilization direct (having diabetes directly influences service use/nonuse) or indirect (oral health illness variables mediate the relationship between diabetes status and the use of dental service)?

Two statistical analyses were applied to determine the nature of the relationship between diabetes and dental service use. A bivariate-relationship analysis between diabetes and dental service use was applied first. The bi-relationship statistical analysis between diabetes and dental service utilization variables provides an OR estimate for unadjusted models. The bi-relationship statistical analysis reveals a significant ($p < 0.0003$) bi-relationship with OR= 1.34 for emergency model and OR= 1.65 for
preventive model. The second statistical step to determine the nature of the relationship between diabetes and dental service utilization was controlling for the illness level variables, painful tooth and presence of oral health concern. This analysis reveals that the adjusted models have OR= 1.31 and OR= 1.53 for emergency and preventive models, respectively. The statistical analyses indicate that the absolute change in estimated odds ratio is less than 10% between models that are unadjusted (OR=1.34;1.65) and adjusted (OR=1.31;1.53) for mediators for both emergency and preventive models, respectively. The statistical results indicate a direct relationship between diabetes and dental service use.

**Discussion**

The study’s purpose was to identify factors associated with dental services use for individuals with diabetes and to clarify the relationship between diabetes status and likelihood of emergency and preventive dental service use using a national representative dataset from the 2001-2002 NHANES, combining interviews and physical examinations. The Andersen and Newman Framework of Health Services Utilization dimensions (predisposing, enabling, and illness variables) was appropriate for use in predicting preventive and emergency dental services utilization during the past year.

**Descriptive characteristics.**

With regard to use of dental services and demographic characteristics, the data indicates that the majority of the respondents reported a dental visit in the past 12 months. This result is similar to the study by Dye et al. (2007). An increase in likelihood of dental service use with increasing age was found and is consistent with those reported by others (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Roberts-Thomson, 2011). The study analyses reveal a higher likelihood of dental service use in
the past 12 months among females similar to those reported in other research (Blackwell et al. 2014; Christian et al. 2013; Dye et al., 2007; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Lee et al. 2014; Roberts-Thomson et al., 2011). Study results indicate a higher likelihood of dental service use among non-Hispanic Whites compared to non-Hispanic Blacks or other minorities, reflecting disparities among different racial and ethnic groups reported in the literature (Christian et al. 2013; Dye et al., 2007; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; Roberts-Thomson et al., 2011). The study analyses reveal a higher likelihood of dental service use in the past 12 months among married adults compared with other categories. The finding is consistent with studies by Manski et al., 2014; and Pleis et al., 2009. Adults with higher education are more likely to use dental services than those with lesser education which is consistent with the results reported by Blackwell et al., 2014; Christian et al. 2013; Dye et al., 2007; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; Manski et al., 2014; Roberts-Thomson et al., 2011).

With regard to use of dental services and enabling factors, the data indicates that individuals with higher income reported a greater likelihood of dental service use in the past 12 months compared to individuals with low income. Many studies are consistent with these findings, such as Christian et al., 2013; Gilbert et. al., 1998; Koletsi-Kounari et al., 2011; Manski et. al., 2002; & Roberts-Thomson et al, 2011. With regard to dental insurance, the study findings reveal a higher likelihood of dental service use in the past 12 months among individuals with dental insurance. This result is similar to the studies by Blackwell et al., 2014; Christian et al, 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; Mueller & Monheit, 1988; & Roberts-Thomson et al.,
2011. With regard to the presence of a regular source of dental care, the analyses indicate a higher likelihood of dental service use in the past 12 months among individuals reporting the presence of a regular dentist. This result with regard to presence of regular source of dental care is similar to the study by Shi & Stevens (2005).

With regard to use of dental services and illness factors, the data indicates that individuals with perceived need as measured by self-reported tooth pain was related to dental service use in the past 12 months. However, individuals with a painful tooth in the last 30 days were less likely to utilize dental services. The evaluated illness variable as measured by the overall recommendation to seek dental care based upon findings from an oral examination, was also related to dental service use in the past 12 months. Unlike reports by Gilbert et al., 1998; Roberts-Thomson et al., 2011, individuals in the current study with oral concerns were associated with a decreased likelihood of utilizing dental services. This result might be due to the use of different illness level measures, such as broken filling, bad breath, root fragments, difficulty chewing hard foods, and satisfaction level.

With regard to diabetes status, the data indicate that the majority 95% (4,472) of the sample were non-diabetic with only 5% (235) of respondents reporting having diabetes. In 2002, the total number of diagnosed cases of diabetes in the USA was about 12.1 million (4.2% of the population) (ADA, 2003). The study results regarding the proportion of diabetic individuals in the sample correlates with the proportion of diabetic individuals in the United States in 2002, which confirms that the sample was representative of the population. These findings will be discussed in depth with relation to the research questions in the following section.
Research question one.

Are individuals with diabetes more or less likely to utilize dental services in the past year compared to individuals without diabetes? Results reveal that individuals with diabetes were less likely to visit a dentist in the past year compared to individuals without diabetes. These findings regarding dental services use among individuals with diabetes are similar to the studies by Chaudhari et al. 2012; Eke, 2005; Macek, Talyor, & Tomar, 2008; Macek & Tomar, 2009; Tomar & Lester, 2000 in which those individuals with diabetes were less likely to visit a dentist in the past year. The lack of knowledge about the relationship between diabetes and oral health among individuals with diabetes was suggested by Allen et al. (2008). Individuals with diabetes might not be aware that dental caries, dry mouth, oral candidiasis, dental abscesses, oral peripheral neuropathy, and periodontal diseases are oral diseases considered to be oral complications of diabetes. Awareness about the two-way relationship between diabetes and periodontal disease is significant. Diabetes affects periodontal parameters leading to bone destruction and may ultimately result in tooth loss. Periodontal disease complicates diabetes by making control of blood glucose levels more difficult. Therefore, control of periodontal infections is critical for maintaining glycemic control of individuals with diabetes (Chee et al., 2013; Preshaw & Bissett, 2013; Teeuw, Gerdes, & Loose, 2010).

Lack of knowledge might influence the basic understanding of the importance of oral health. Insufficient knowledge about the link between diabetes and oral health may cause individuals to inadvertently ignore the importance of regular dental visits. However, knowledge of the relationship between diabetes and oral health might influence individuals with diabetes to perceive themselves as being more susceptible to periodontal
disease, which might increase the likelihood of dental visits as suggested by the Health Belief Model (HBM).

The HBM as a cognitive theory emphasizes the individual’s mental processes, such as thinking and reasoning. The individual’s behavior can be predicted from the individual’s valuation of an outcome as well as the expectation that a particular action will result from that outcome. The HBM hypothesizes that oral hygiene-preventive behaviors are a function of perceived risk of having the disease, perceived severity of the disease, and perception benefits and barriers to specific oral hygiene-preventive behaviors (Rosenstock, 1966).

Based on this, the HBM suggests that individuals with diabetes who feel susceptible to periodontal diseases, tooth loss, and who think periodontal diseases are a severe pathological condition affecting the supporting structures of the teeth, will be more likely to adhere to oral-preventive behavior, such as regular dental visits, brushing, and flossing. Modifying factors include knowledge and socio-demographics that might have an indirect effect on oral hygiene-preventive behaviors by influencing the perception of susceptibility, severity, benefits, and barriers.

Additionally, negative oral health attitudes and behaviors among individuals with diabetes as suggested by the studies Kanjirath et al., 2011; Syrjala et al., 1999; Syrjala et al., 2004 could be associated with lack of dental services utilization. Attitudes toward performing the behavior is related directly to individuals’ evaluations of the behavioral outcomes or individuals’ behavioral beliefs. A person who holds positive attitudes toward specific behavior will result in intention (motivation) to perform that behavior as suggested by the Theory of Planned Behavior (Ajzen, 1991). Thus, a person
with diabetes who holds weak beliefs about oral health will have a negative attitude toward oral health-related behaviors, which will contribute to lack of motivation to perform those behaviors.

Individuals with diabetes are considered at risk for major chronic complications, such as coronary heart diseases, blindness, nerve damage, foot damage, and kidney failure. Perhaps, this result might be due to the fact that the primary focus of individuals with diabetes is on medical care visits, i.e. diabetes care, foot care, and eye care which makes dental visits their lowest priority as suggested by the studies by Macek et al. (2008); Tomar & Lester (2000).

Health care professionals such as physicians and nurses, might not discuss the effect of diabetes on oral health with individuals with diabetes. They may refer individuals with diabetes to other health care professionals such as ophthalmologists, nephrologists, but not to dentists. Further research is needed to validate this point. Emphasizing the importance of oral health by health care professionals might increase the motivation of individuals with diabetes to engage in appropriate oral health behaviors.

Oral health education programs are needed to target both individuals with diabetes and non-dental health professionals who are involved in diabetic care to optimize the benefit. Non-dental health professionals, physicians and nurses, might see their clients (individuals with diabetes) more often than a dentist. So, non-dental health professionals should inform their diabetic individuals about the importance of maintaining good oral health. Emphasis should be placed on the importance of regular dental visits for oral preventive care as routine management for diabetic individuals. A strong educational foundation regarding the impact of diabetes on oral health is needed
among individuals with diabetes to increases their awareness, knowledge, and condition management. These educational programs could increase the knowledge of diabetes and help prevent oral complications associated with poor management, as well as motivate individuals with diabetes to adopt healthy practices and healthy lifestyles.

A dental hygienist is a licensed professional member of the health care team. Dental hygienists have different roles and functions which include clinician, oral health educator, manager, consumer advocate, and researcher. The role of dental hygienist as oral health educator is very important in providing detailed information to clients in order to promote oral health and prevent oral disease. The primary role of dental hygienists according to the American Dental Hygienists Association (ADHA) Code of Ethics is “promoting the well being of individuals and the public by engaging in health promotion/disease prevention activities” (ADHA, 1995), which could be achieved by placement of dental hygienists in primary care offices if not for clinical care, then for education.

**Research question two.**

What is the contribution of diabetes status relative to predisposing, enabling, and illness level variables that predict dental services utilization?

**Predisposing variables:** Results predicting the likelihood of using preventive or emergency services in the past 12 months indicate that among predisposing characteristics: age, marital status, and education were significant predictors of preventive and emergency services use. Gender was a significant predictor of using preventive services only.

Females and individuals with higher education are more likely to obtain preventive dental services. This finding might call into question whether females are
more likely to be concerned about their dental appearance than males. This might be answered by Grath & Bedi (2000), who found that the social and psychological impact of oral health among females was higher than males. Also, the study found that the perception of the influence of oral health on quality of life was higher among females. Examples of social and psychological impacts of oral health as perceived by females compared to males were: pain, embarrassment, and appearance. These were major factors in financial decision making, and efforts to improve overall well-being, which might explain the results regarding their increased likelihood of preventive dental services compared to males (Grath & Bedi, 2000). This result might be due to the fact that the teeth and mouth are major parts of one’s physical appearance and greatly affect smile and speech, thereby increasing a woman’s desire to care for her teeth (Kassak, Dagher, & Doughan, 2001). Females may have a better oral health knowledge, attitudes, and behaviors, compared to males, as suggested by Al-Omiri et al. (2012). Females were found to be more likely to adhere to oral-preventive behaviors such as dental visits, brushing, and flossing compared to males, which might explain the increased likelihood of dental visits among females, as compared to males (Al-Omiri et al. 2012; Azodo & Unamatokpa; 2012; kateeb, 2010; Mak & Day, 2011). Another explanation is that females are more likely to adhere to oral health professional’s recommended regimens as supported by Azodo et al. (2012). These findings regarding the increased likelihood to follow oral hygiene recommendations among females compared to males are similar to those determined in the study by Al-Omari & Hamasha, (2005).

The higher one’s education, the more likely the person is possesses knowledge and understanding of the importance of oral health. Exposure to education and mass
media can lead to both preventive and emergency services use to maintain good oral health and prevent complications. Meyerhoefer et al. (2012) reported that education is a key factor in, and strong predictor of using preventive service. This finding correlates with literature that suggests that the use of dental services increases with education (Blackwell et al., 2014; Christian et al., 2013; Dye et al., 2007; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; Manski et al., 2014; Roberts-Thomson et al., 2011).

A lower likelihood of preventive and emergency services use was found among younger respondents and those who were not married (all others category). This result might be due to the fact that younger people are more likely to use preventive oral hygiene behaviors such brushing and flossing; therefore, they are less likely to need non-routine dental visits. These findings correlate with literature that suggests that the use of dental services increases with age (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Roberts-Thomson, 2011). Using preventive behaviors among young people reduces the need for emergency visits. Another explanation for preventive or emergency service visits could be the negative emotions and beliefs associated with dental visits, such as pain, fear, anxiety, and sensitivity as suggested by Essex-Lancaster, 2003; Tripp, Neish, & Sullivan, 1998.

The fact that unmarried individuals have a lower likelihood of preventive and emergency services use, as reported by Manski et al. (2014); & Pleis et al. (2009), might be due to the lack of social support that can be needed for dental services. Marital status as a measure of social support plays an important role in dental service utilization as documented by Campo & Yon (2014). Married individuals possess higher levels of
social support compared to individuals who are not married (Campo & Yon, 2014). Social support provides help in task performance, guidance, and material support to facilitate the decision making process (Husaini & Neff, 1982). Individuals who are not married may not have dental insurance, transportation, or income, which might affect their decision to visit a dentist.

**Enabling variables:** According to Andersen, for use to take place, oral health professionals and facilities must be available first. Additionally, availability of the means and knowledge of how to get to those services and make use of them is needed (Andersen, 1995). Individuals with higher income might have the resources for a preventive dental visit. Limited resources among those with lower income can impede one’s ability to take advantage of preventive visits (Christian et al., 2013; Gilbert et al., 1998; Koletsi-Kounari et al., 2011; Manski et al., 2002; & Roberts-Thomson et al, 2011). Communication between those with lower income and dental health professionals regarding the importance of oral health is less likely to occur. The presence of a regular dentist and dental insurance were significant predictors for both preventive and emergency services use. These results are similar to the findings in the studies by Blackwell et al. (2014); Christian et al, (2013); Gilbert et al. (1998); Koletsi-Kounari et al. (2011); Manski et al. (2002); Mueller & Monheit (1988); & Roberts-Thomson et al. (2011); Shi & Stevens (2005). The presence of a regular dentist and of dental insurance make health services resources accessible to the individual and serve as conditions for obtaining dental care. Of the other predictors, the strongest was the enabling variables, presence of a regular dentist.
With regard to dental insurance, the study findings reveal a higher likelihood of dental service use in the past 12 months among individuals with dental insurance. This result is similar to findings made by Blackwell et al. (2014); Christian et al. (2013); Gilbert et al. (1998); Koletsi-Kounari et al. (2011); Manski et al. (2002); Mueller & Monheit (1988); and Roberts-Thomson et al. (2011). With regard to presence of regular source of dental care, the analyses indicate a higher likelihood of dental service use in the past 12 months among individuals reporting the presence of a regular dentist. This result is similar to that found in study by Shi & Stevens (2005).

Lack of, or inadequate, dental insurance and high out-of-pocket costs are the most common barriers to adequate dental service use, reported by Lee et al. (2012); Manski & Cooper (2007); Mueller & Monheit (1988); and Shi & Stevens (2005). Individuals without dental insurance, the underinsured, and those with low income levels may have limited access to regular dental care resulting in a decrease in dental services utilization (Yu, Bellamy, Schwalberg, & Drum, 2001).

**Illness level variables:** Individuals with self-reported tooth pain had a decreased likelihood of seeking preventive service and an increased likelihood of emergency service use. This result might be due to negative feelings associated with dental visits, such as fears, memory of pain, depression, and sensitivity. Without dental treatment of oral problems emergency service is often sought for acute pain. Recommended care based upon findings from the oral exam was significantly associated with lower likelihood of preventive and emergency services use among individuals with oral concern. This result might be due to the individual’s lack of knowledge about treating conditions before they become serious and cause pain. Those individuals might have no
symptoms of inflammation or may be unaware of symptoms that cause the need for
dental service use. Many individuals believe bleeding gums are normal. Perhaps, they
think their oral condition is not serious and so there is no perceived need for such
services. Individuals might be more likely to utilize dental services if they feel
susceptible to pathological conditions. They may have their own remedies, such as use of
herbs and or rinsing their mouth with salt and water or hydrogen peroxide, which reduces
the signs and symptoms of inflammation. The reduction of inflammation might be
interpreted as the only necessary solution.

**Diabetes Status:** With regard to diabetes status, a significantly decreased
likelihood of preventive service use among those with diabetes was found. Although not
statistically significant, there was a decrease in likelihood of emergency service use
among those with diabetes. These results are similar to those of Chaudhari et al. (2012)
and are possibly due to a lack of knowledge and awareness of the relationship between
diabetes and oral health among individuals with diabetes. Regardless of the higher risk
of oral complications, individuals with diabetes do not seek dental services on a regular
basis as recommended. Regular preventive dental services are important in maintaining
optimal oral health, reducing periodontal diseases, and reducing future tooth loss. This
result might be due to the misperception that individuals with diabetes will lose their
teeth and become edentulous, and, therefore, there is no value in preventive visits. The
results of this study indicate that diabetes status is a significant predictor of not having a
preventive dental visit among individuals with diabetes, even after controlling or
adjusting for age, gender, marital status, income, race/ethnicity, and education. Although
there is a clear association between diabetes and periodontal disease (Matthews, 2002;
Taylor & Borgnakke, 2008; Ruiz, Romito, & Dib, 2011), diabetic individuals do not look for preventive dental services on a regular basis as recommended. Fortunately, most oral diseases can be prevented. Unfortunately, once they occur, the physical intervention of an oral health professional is needed. Dental treatment success is highly related to patients’ willingness to maintain good oral hygiene and regular dental visits (Renz & Newton, 2009). Maintaining routine dental visits can be impacted negatively by lack of knowledge and awareness of the link between diabetes and oral health. The lack of knowledge may cause individuals with diabetes to avoid preventive dental visits, thus jeopardizing their health. As a result, dental diseases, loss of teeth, and systemic health problems occur. To reduce the incidence of periodontal diseases, increase the amount of tooth retention, and improve health outcomes a strong educational foundation is needed to increase awareness and knowledge among diabetic individuals about the importance of oral health.

Recognizing that the use of dental service uses includes complex relationships between diabetic status, oral health status, and different socio-demographic and related variables, the Andersen and Newman Framework of Health Services Utilization (Andersen & Newman, 1973) successfully highlighted the contributions of predisposing, enabling, and illness variables with regard to use of preventive and emergency dental service.

**Research question three.**

Is the relationship between diabetes and dental service utilization direct (having diabetes directly influences service use/nonuse) or indirect (oral health illness variables mediate the relationship between diabetes status and the use of dental service)?
After statistical controls for illness level variables, diabetes absolute change in estimated odds ratio is less than 10% between models, indicating that the association between diabetes and dental service use is direct, rather than mediated by illness level variables, tooth pain and recommended care based upon oral exam findings. This result might be due to negative beliefs and attitudes toward oral health, which mediate the relationship between diabetes and dental service utilization. As reported by Kanjirath et al., 2011; Syrjala et al., 1999; Syrjala et al., 2004 individuals with diabetes had poor oral health-related behaviors, such as brushing and flossing compared with individuals without diabetes suggesting bad attitudes and beliefs toward oral health. Unfortunately, the present dataset does not contain the needed measures of oral health-related behaviors (variables) to evaluate/test this explanation.

Alternatively, this result might be due to the fact that the association between diabetes and dental service use is influenced by interaction effects of illness level variables (moderating effects). The interaction effect can affect the direction and/or strength of the relationship between diabetes and dental service use. These illness level variables might be hypothesized to influence the relationship between diabetes status and the decrease/increase use of dental service. Perhaps, the relationship between diabetes status and the use of dental service is due to the interaction effect of illness level variables and diabetes. So, three effects can exist: main effect of diabetes, main effect of illness level variables, and interaction (moderating) effect of diabetes and illness level variables. The illness level variables, in that relation between diabetes and dental service utilization could be stronger for individuals with more illness level variables and weaker or non-
existent for individuals with no or reduced presence of illness level variables. Further research is needed to validate this concept.
CHAPTER V

CONCLUSIONS

The literature has shown that individuals with diabetes are at a higher risk for oral diseases compared to individuals without diabetes (Matthews, 2002; Ruiz et al., 2011; Taylor & Borgnakke, 2008). However, little is known about the pattern of dental services utilization among this population. The aim of this study was to clarify the relationship between diabetes status and the utilization of emergency and preventive dental services. The question was whether individuals with diabetes are more or less likely to utilize dental services, measured by the use of preventive and emergency services during the past year. A national representative dataset from the NHANES 2001-2002 was obtained to clarify whether the probability that individuals with diabetes may be differentially related to the use of preventive and emergency dental visits.

The results of this study confirmed the ability of the Andersen and Newman Framework of Health Services Utilization dimensions-predisposing, enabling, and illness variables-to predict preventive and emergency dental services utilization by individuals with diabetes during the past 12 months. Findings suggest that individuals with diabetes are less likely to report a visit to the dentist in the past 12 months compared to individuals without diabetes. The results indicate that being a diabetic is a significant predictor for not obtaining preventive dental services after adjusting for age, gender, marital status, income, race/ethnicity, and education. This outcome raises greater concern for the oral health of diabetics given the effect of periodontitis on glycemic control (Matthews, 2002; Rodrigues et al., 2003; Ruiz et al., 2011; Taylor & Borgnakke, 2008; Teeuw et al., 2010). Regular preventive dental visits by individuals with diabetes are critical in maintaining
glucose levels. Understanding the relationship between diabetes and periodontal diseases is important for individuals with diabetes to reduce oral complications, improve quality of life, and improve health outcomes.

Including a dental hygienist on the diabetic care team can affect changes for improved health outcomes for individuals with diabetes. A dental hygienist can provide oral health assessment, oral cancer screening, and head and neck examinations. Furthermore, a dental hygienist can provide individuals with diabetes the appropriate self-help measures, such as tooth brushing, interdental cleaning, nutritional counseling, and referrals, if needed. Integrating diabetes examination in the dental setting by screening and monitoring blood glucose levels for pre-diabetes or people at risk of developing diabetes is important in detecting diabetes among this population. Including regular oral screenings of all clients by trained non-dental health professionals who are involved in diabetic care is important in monitoring oral health. The non-dental health professional can evaluate oral health and provide a referral to oral health professionals for dental examination and treatment, as needed. This approach may increase the knowledge of individuals with diabetes about the relationship between diabetes and oral health, therefore reducing oral complications.

Interestingly, the results of this study reveal that the presence of a regular source of care (dentist) has the highest contribution to determining utilization of preventive and emergency dental services. Feeling pain or needing dental care based on professional judgment were expected to have the highest influence in determining utilization of preventive and emergency dental services as it is the most immediate cause of health service utilization according to Anderson and Newman (1973). This outcome may
indicate that having a regular dentist may build a positive dental knowledge and attitudes toward oral health, which emphasize the importance of dental visits. Furthermore, having a regular dentist may increase the use of preventive and treatment dental services and ultimately increase dental visits.

The study results imply that access to care is limited to individuals who have accessible resources and conditions of obtaining dental care regardless of their need for care. Inequitable access to dental care is suggested by the high influence of enabling variables in determining utilization of preventive and emergency dental services.

**Policy Implications**

Policy is needed to improve oral health among individuals with diabetes by increasing access to dental services among this population to reduce the incidence of oral diseases and to increase tooth retention. Identifying factors associated with dental service use for individuals with diabetes can contribute to policy development by recognizing areas that will help to reduce barriers to dental service utilization and increase the likelihood of using preventive care among individuals with diabetes. Furthermore, identifying these factors for individuals with diabetes may identify areas where education is needed to emphasize the importance of regular dental visits as well as guide where resources are needed to enhance access to dental services.

This study confirmed that individuals with resources, such as dental insurance and a regular source of dental care, are more likely to use dental services compared to individuals without such resources. Health care policy can play an important role in changing these characteristics to improve access to care. Policy is needed to address dental services access inequalities. Providing uninsured individuals with diabetes with
dental coverage may increase the likelihood of this population’s regular use of dental services. Including an oral health professional, such as a dental hygienist in the primary care physician’s team may enhance health outcomes for individuals with diabetes and increase access to dental care. In addition, adding access to a dental therapist to underserved populations may address unmet needs and increase access to dental care.

This study could serve as a foundation for public health program planning and interventions. Public health programs need to implement oral health education programs by providing educational workshops and promotional materials. These programs inform the community about the impact of diabetes on oral health, educate people about how to prevent and manage diabetes and its oral complications, and motivate people to adopt healthy practices. In addition, increasing the awareness and knowledge among non-dental health professionals who are involved in diabetic care by providing continuing education courses (CE) is important. Furthermore, oral disease prevention and oral health promotion can be implemented as an important part of diabetes management by the non-dental health professionals in public health settings.

Health care policy makers and public health leaders may use these findings to aid effective planning of an intervention program to address knowledge and awareness of the relationship between diabetes and periodontal disease. This program would build a strong educational foundation for individuals with diabetes by providing interventions and materials that inform this population about the effect of diabetes on oral health and vice versa, as well as to increase the awareness among non-dental health professionals involved in diabetic care.
Limitations

A number of limitations exist for this study.

- This dataset is not the most recently released NHANES dataset. While NHANES released a more recent dataset, it did not include comparable enabling and need variables that are essential in answering the specific research questions as defined by the theoretical framework.

- The diabetes measure does not distinguish between type 1 and type 2 and it was based on the participant’s response, not on the lab test. Self-reported diabetes status might be subject to recall bias since it was not validated with the participant’s medical record or lab test.

- The NHANES dataset did not include important variables that reflect health care attitudes and beliefs that could likely impact the utilization of dental care.

- This study is based on cross-sectional data, which makes it difficult to establish causation in this design.

- Self-reported dental service use was the dependent variable, and could be subject to recall bias since it was not validated with the participant’s dental record.

- Self report of participants’ dental service use might be subject to social desirability during the interview.

Future Research

Based on the results of this study, the following are recommendations for future research:
• Use the complete predisposing dimensions of the Andersen and Newman Framework of Health Services Utilization, especially the belief variables, such as values concerning health, attitudes toward health services, and knowledge about disease to identify their contributions in predicting preventive and emergency dental services utilization.

• Use the full model of the Andersen and Newman Framework of Health Services Utilization at both individual (predisposing, enabling, and illness) and the societal levels (technology and norms) to identify the determinants of dental service utilization.

• Explore the awareness and knowledge of individuals with diabetes about the link between diabetes and oral health using mixed method design.

• Explain the barriers for underutilization of dental services among individuals with diabetes using qualitative research.

• Evaluate the effectiveness of oral health education programs that increase public awareness about the effect of diabetes on the mouth, the most common oral problems from diabetes, and the steps to maintain oral health.

• In addition, considering the results and limitations of this study, future studies should focus on answering the following research questions:
  1. Are individuals with diabetes type 1 more or less likely to utilize dental health services in the past year compared to individuals without diabetes?
2. Are individuals with diabetes type 2 more or less likely to utilize dental health services in the past year compared to individuals without diabetes?

3. What is the knowledge level of individuals with diabetes about the relationship between diabetes and oral disease?

4. What is the knowledge level of non-dental health professionals about the relationship between diabetes and oral disease?

5. What is the attitude of individuals with diabetes toward oral health?

6. Is the relationship between diabetes and dental service utilization direct (having diabetes directly influences service use/nonuse) or indirect (beliefs and attitudes toward oral health variables mediate the relationship between diabetes status and the use of dental service)?

7. Is the relationship between diabetes and dental service utilization direct (being diabetic directly influences service use/nonuse) or indirect (oral health illness variables moderate the relationship between diabetes status and the use of dental service)?
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