The dental office visit as a potential opportunity for diabetes screening: an analysis using NHANES 2003-2004 data

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Abstract

Objectives: The bidirectional relationship between periodontitis and diabetes suggests that the dental visit may offer a largely untapped opportunity to screen for undiagnosed diabetes. To better examine this potential opportunity, data from the National Health and Nutrition Examination Survey (NHANES) 2003-2004 were used to determine if a larger proportion of patients with periodontal disease as compared with those without periodontitis would be recommended for screening according to American Diabetes Association (ADA) guidelines. The data were also used to determine whether at-risk individuals with periodontitis visited a dental professional recently, so that they could avail themselves of this opportunity for screening, if offered.

Methods: Data to perform these analyses were collected from 2,923 subjects aged 20 and older who reported that they were never told that they had diabetes, had a periodontal examination, and had sufficient data to compute body mass index. Descriptive statistics, *t*-tests, and chi-square analyses that compared those with and without periodontitis were extrapolated to the US population.

Results: A total of 62.9 percent of those without periodontitis and 93.4 percent of those with periodontal disease met ADA guidelines for diabetes screening. Of those at-risk with periodontal disease, 33.9 percent had seen a dentist in the past 6 months, 50 percent in the past year, and 60.4 percent in the past 2 years.

Conclusions: As almost all individuals with periodontitis would have been recommended for diabetes screening, and many at-risk persons with periodontal disease recently visited a dentist, our data suggest that the dental visit provides an important potential venue for this screening.

Introduction

In 2007, it was estimated that 17.9 million people in the United States had been diagnosed with diabetes (1), a disease that is associated with a wide range of medical and dental complications (2,3), and with attendant costs of $174 billion in 2007 alone (4). An additional 5.7 million people with diabetes in the United States were thought to have remained undiagnosed that year (1), a number that is expected to rise dramatically over time (5). Because of the frequently mild or asymptomatic nature of diabetes in its early stages, many individuals with undiagnosed diabetes are likely to have had the disease for at least several years before they are diagnosed (6). Unfortunately, by the time diabetes is diagnosed, beta cell function may have declined substantially (7), and significant damage may have already been done to the body. Early diagnosis, treatment, and accompanying lifestyle changes in diet and physical activity may help to prevent or delay the

long-term complications of diabetes that are responsible for reduced quality of life and high levels of morbidity and mortality (8).

To guide an effective approach for the early detection of diabetes, the American Diabetes Association (ADA) provides guidelines for diabetes screening in high risk, asymptomatic individuals (9). These individuals include those who are 45 years of age or older, particularly if they have a body mass index (BMI) of at least 25 kg/m^2. The ADA also suggests that screening be considered for younger individuals with a BMI of at least 25 kg/m^2 if they have another risk factor for diabetes (e.g., have a first degree relative with diabetes). In order to reach the greatest number of these high-risk individuals, diabetes screening has generally been conducted both in primary care settings and elsewhere, such as in the emergency room (10).

In view of the bidirectional relationship between periodontitis and diabetes (11,12), and the fact that moderate or more severe periodontitis affects about one-eighth of the US population at least 30 years of age (13), the dental office visit may offer a largely untapped opportunity for diabetes screening (14,15). In particular, it has been well-established that persons with diabetes are more likely to have periodontal disease than those without diabetes (11), and there is evidence that periodontal disease may predispose individuals to incident diabetes (16). In addition, using National Health and Nutrition Examination Survey (NHANES) III data, Borrell and colleagues determined that, among individuals with a self-reported family history of diabetes, hypertension, and high cholesterol levels, having clinical evidence of periodontitis added significant predictive ability to identify individuals with undiagnosed diabetes (17).

In this paper, we further explore Borrell and colleagues' findings regarding the opportunity to identify patients at risk for undiagnosed diabetes at the time of the dental visit. The present investigation involves a comparison of two groups of individuals who indicate that they have never been told by a health provider that they have diabetes: patients with and without periodontitis. Using a large nationally representative sample from the US population, we compare the proportion of patients in these two groups who are at high risk for diabetes and would be recommended for screening according to ADA guidelines. Findings will support the use of the dental visit as an important diabetes screening opportunity if there is a significantly larger proportion of people with periodontitis at high risk for diabetes as compared with the proportion at high risk without periodontitis.

Methods

To perform the analyses, we used data from NHANES 2003-2004. NHANES, conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, is intended to assess the health status of a nationally representative sample of civilian, non-institutionalized adults and children in the United States through interviews and direct physical examinations. NHANES participants are selected through a stratified, multistage, probability sampling design. A full description of this design in NHANES 2003-2004 is available on the NHANES website: http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/general_data_release_doc_03-04.pdf.

The NHANES 2003-2004 dataset comprised a total sample of 10,122 individuals, including 9,001 who completed the NHANES questionnaire and responded negatively to the question, "[Other than during pregnancy], have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Of these 9,001 individuals, 4,425 were at least 20 years of age, and 4,088 of these 4,425 individuals also had sufficient information to compute BMI. A total of 72 percent (2,923) of these 4,088 individuals also had a complete periodontal examination. These 2,923 individuals comprise the study sample. We note that individuals 20 years of age or older were not given a periodontal examination if they were ever told by a doctor or dentist that they must always take antibiotics before they get a dental check up or receive care; have congenital heart murmurs, heart valve problems, congenital heart disease, or bacterial endocarditis; have rheumatic fever; have kidney disease requiring renal dialysis; have hemophilia; or have a pacemaker or automatic defibrillator or artificial material in their heart veins or arteries.

The periodontal examination was performed using a standardized procedure by dentists carefully trained in the NHANES protocol. The examination gathered data on three sites per tooth (mid-facial, distal-facial, and mesial-facial) in two randomly chosen quadrants, one maxillary and one mandibular. Third molars were excluded because of their frequent extraction in young adulthood, thus yielding a maximum of 14 teeth and 28 interproximal sites per individual for examination. Examinations included determinations of loss of attachment and pocket depth at each site.

For the current analyses, we defined periodontitis using the collaborative Centers for Disease Control and Prevention and the American Academy of Periodontology definition for moderate periodontal disease. This definition specifies that individuals with moderate periodontal disease include those having at least two teeth with interproximal attachment loss of 4 mm or more, or those with at least two teeth with interproximal pocket depths of 5 mm or greater. This definition is described in a National Institute of Dental and Craniofacial Research report, and is available at http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/GumDisease/PeriodontaldiseaseSeniors65over. For consistency with this definition, the mid-facial readings assessed in the NHANES periodontal examination were not used in this study.

We also included in the current analyses four specific risk factors for diabetes in addition to participants' age and BMI, as determined by participants' responses to four questions that elicited such risk. First, to assess whether the participant had a first degree relative with diabetes, participants were asked, "Including living and deceased, were any of your biological, that is blood relatives including grandparents, parents, brothers, sisters ever told by a health professional that they had diabetes?" Participants were recorded as having a first degree relative with diabetes if they responded "yes" to this question, and subsequently identified either a parent or sibling who had been told that she/he had diabetes. Second, race/ethnicity in the public use data file was recorded according to whether participants were non-Hispanic White, non-Hispanic Black, Mexican–American, Other Hispanic, or Other. For the current analyses, a participant was considered to have an "at-risk" race/ethnicity if she/he was non-Hispanic Black, Mexican–American, or Other Hispanic, as these are the only categories of race/ethnicity that could specifically be identified according to ADA guidelines as being high risk racial/ethnic groups (9). Third, we considered that a person had hypertension if she/he answered "yes" to the question, "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" Finally, we considered that a person had hypercholesterolemia if she/he answered "yes" to the question, "Have you ever been told by a doctor or other health professional that your blood cholesterol level was high?"

Participants were also asked, "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." For those individuals with periodontitis who would be recommended for diabetes screening according to ADA guidelines, we examined the length of time since their last dental visit, as it provides some indication of the extent to which the dental visit can be used as an actual site of opportunity for diabetes screening for high risk individuals with periodontitis.

The primary purpose of this investigation was to compare the proportion of people with and without periodontitis who should be screened for diabetes according to ADA guidelines. First, descriptive statistics were calculated for selected characteristics in the total population and according to group based on periodontal disease status. Chi-square statistics (for categorical variables) and *t*-tests (for continuous variables) were used to determine statistically significant differences between the two periodontal disease status groups. In the analyses, we followed the analytic guidelines provided by NHANES, available at http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/nhanes_analytic_guidelines_dec_2005.pdf, used the examination weights provided, and used STATA software to enable analyses involving surveys with complex sampling designs.

Results

We determined that, when extrapolating data on the study sample of 2,923 participants to the US population as a whole, almost three quarters (71.9 percent) were non-Hispanic White, about one-tenth (10.7 percent) were non-Hispanic Black, and almost another one-tenth (8.5 percent) were Mexican–American, and that overall, 6.6 percent had periodontitis. As can be seen in Table 1, almost two-thirds of those with and without periodontitis (64.3 percent) had a BMI of 25 kg/m^2 or more. We found no differences in BMI or race/ethnicity distribution according to whether or not periodontitis was present. However, persons with periodontitis were significantly older (56.5 years versus 41.0 years; $P \leq 0.001$) and were significantly less likely to be female (36.4 percent versus 51.1 percent; $P \leq 0.01$) compared with those without periodontitis.

Participants with periodontitis were also significantly more likely to self-report that they had hypertension (39.2 percent versus 20.9 percent, $P < 0.001$), had a parent or sibling with diabetes (37.5 percent versus 25.2 percent; $P \leq 0.01$), and tended to report having high cholesterol (31.2 percent versus 23.2 percent; $P = 0.10$), as compared with those without periodontitis.

As can be seen in Figure 1, 26.1 percent of those without periodontitis were at least 45 years old and had a BMI of at least 25 kg/m^2 (Category A), and 11.3 percent were 45 years of age or older and had a BMI less than 25 kg/m^2 (Category B). All of these individuals would be recommended for diabetes screening according to the ADA guidelines. An additional 25.5 percent of those without periodontitis would also have been recommended for diabetes screening by these guidelines (Category C). They were less than 45 years of age, had a BMI of at least 25 kg/m^2, and had at least one of the additional four risk factors we considered in the current work: having a first degree relative with diabetes; being a member of a high risk racial/ethnic population; being hypertensive; and having high cholesterol. Thus, of those without periodontitis, 37.1 percent (Category D) would not have been recommended for diabetes screening according to the ADA guidelines.

In contrast, among those with periodontitis, 51.9 percent of individuals 45 years of age or more had a BMI of 25 kg/m^2 or greater (Category A), and 27.8 percent of those with periodontitis who were at least 45 years of age had a BMI of less than 25 kg/m^2 (Category B – Figure 1). Together, these two groups of individuals constitute 79.7 percent of those with periodontitis, and all of the individuals in these two groups would be recommended for diabetes screening according to ADA guidelines. An additional 13.7 percent of those with periodontitis were less than 45 years old, had a BMI of at least 25 kg/m^2, and had at least one additional risk factor (Category C). This latter group of individuals would also have been recommended for diabetes screening according to these

Table 1 Characteristics of US Adults in NHANES 2003-2004 Aged ≥20 years Who had Never Been Told that They had Diabetes According to Periodontal Disease Status*

	No periodontal disease (n = 2,648)	Periodontal disease (n = 275)	Total sample (n = 2,923)
Female (%, standard error)¶	51.1 (0.9)	36.4 (4.0)	50.1 (0.9)
Age (mean, standard error)§	41.0 (0.5)	56.5 (1.0)	42.0 (0.5)
BMI ≥25 kg/m^2 (%, standard error)	64.0 (1.3)	68.6 (4.5)	64.3 (1.2)
Race (%, standard error)			
Mexican–American	8.6 (1.9)	7.1 (3.8)	8.5 (2.0)
Other Hispanic	3.6 (0.7)	6.1 (2.4)	3.8 (0.7)
Non-Hispanic White	72.3 (3.1)	66.0 (5.8)	71.9 (3.2)
Non-Hispanic Black	10.4 (1.6)	15.4 (2.6)	10.7 (1.7)
Other†	5.1 (0.7)	5.3 (1.6)	5.1 (0.7)
Self-reported a first degree relative (parent or sibling) with diabetes (%, standard error)¶	25.2 (1.0)	37.5 (3.8)	26.0 (1.0)
Self-reported high blood pressure (hypertensive) (%, standard error)§	20.9 (1.3)	39.2 (3.6)	22.1 (1.3)
Self-reported high cholesterol (hypercholesterolemic) (%, standard error)‡	23.2 (1.3)	31.2 (5.0)	23.7 (1.3)

* Periodontal disease is defined as having at least two teeth with interproximal attachment loss of 4 mm or more OR at least two teeth with 5 mm or more of pocket depth at interproximal sites. This is the Centers for Disease Control and Prevention and the American Academy of Periodontology definition of moderate periodontal disease. In the analyses, we followed the analytic guidelines provided by the National Health and Nutrition Examination Survey (NHANES) (http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/nhanes_analytic_guidelines_dec_2005.pdf), used the appropriate examination weights provided by NHANES when analyzing subsets of the whole NHANES data set, and used STATA software to enable analyses involving surveys with complex sampling designs in order to extrapolate findings to the entire US population at least 20 years of age who had never been told they had diabetes.

† Including multi-racial.

‡ $P \leq 0.1$; ¶ $P \leq 0.01$; § $P \leq 0.001$.

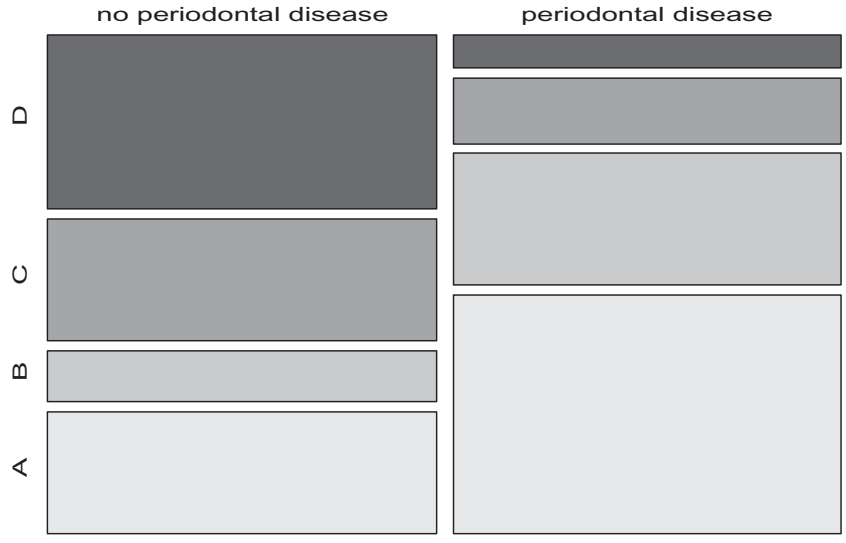

Figure 1 Proportion of US adults aged ≥20 years recommended for diabetes screening according to periodontal disease status. A: age ≥45 years; body mass index (BMI) ≥25 kg/m^2. B: Age ≥45 years; BMI <25 kg/m^2. C: Age <45 years; BMI ≥25 kg/m^2; additional risk factor. D: Not recommended for diabetes screening. Periodontal disease is defined as having at least two teeth with interproximal attachment loss of 4 mm or more OR at least two teeth with 5 mm or more of pocket depth at interproximal sites. This is the Centers for Disease Control and Prevention and the American Academy of Periodontology definition of moderate periodontal disease.

guidelines. Thus, in all, 93.4 percent of the individuals with periodontitis would have been recommended for diabetes screening.

Among those individuals with periodontitis who would have received this recommendation to screen for diabetes, 33.9 percent saw a dentist in the past 6 months, 50.0 percent saw a dentist in the past year, and 60.4 percent saw a dentist in the past 2 years. Thus, a large number of persons with periodontal disease at risk for diabetes have had recent contact with a dental professional.

Discussion

Using data from individuals who participated in NHANES 2003-2004 who indicated that they had never been told by a medical professional that they had diabetes, we determined that 93.4 percent of those with periodontitis, as compared with 62.9 percent of those without periodontitis, would have been recommended for diabetes screening according to ADA guidelines. What's more, among those with periodontitis who would have been recommended for screening, about one-third saw a dentist in the past 6 months, and three in five had a dental visit in the past 2 years. Given the large number of patients with periodontitis who are at risk for diabetes, and their frequent contact with a dentist, the dental visit may be a useful opportunity for diabetes screening.

Little is currently known, however, about the extent to which such screening for diabetes in the dental office visit is feasible and acceptable to both dental patients and dental practitioners. One of the few studies to examine dentists' roles involving both diabetes screening and addressing the needs of patients with diabetes reported on a survey administered to dentists in the northeastern United States (18). Survey results indicate that only 10 percent of respondent dentists felt "very confident" in their ability to screen patients for diabetes. In addition, only 3 percent strongly agreed that their colleagues expected them to take a more active role in controlling diabetes, and an identical proportion strongly agreed that their patients expected them to take such an active role. Thus, the use of the dental visit as an opportunity to screen for diabetes would require a change in the confidence and mind-set of dental providers regarding their role in the screening and control of diabetes.

Dental providers can perform diabetes screening using risk factor information provided by patients [as demonstrated by Borrell and colleagues (17)] or by measuring glucose from a finger stick blood sample. This latter approach is currently being implemented in some Minnesota dental practices as part of a demonstration project spearheaded by Delta Dental of Minnesota, a dental insurance provider (and described at http://www.deltadentalmn.org/content/files/Press_Releases/diabetes_press_rlse_122007.pdf). Alternately, because bleeding on probing in those with periodontitis produces ample amounts of blood for glucometric analysis during diagnostic examination, researchers have used gingival crevicular blood from persons with periodontal disease to obtain a rapid glucose reading. The readings are obtained using readily available and inexpensive glucometers, such as those used for daily glucose monitoring by patients with diabetes. The accuracy of the oral readings from individual patients was verified by correlating glucose readings obtained using the patient's gingival crevicular blood with those obtained through a traditional finger stick sample from the patient. While some investigators have found correlations of these two readings to be as high as 0.98 (14,15), others have failed to show such high correlations (19). Our research has shown that correlations of these two readings are high for patients who have blood collected from sites with adequate bleeding on probing to obtain a blood sample without touching the tooth or gingival margin (20).

We acknowledge a number of limitations to the present analyses. First, our definition of periodontitis is only one of many possible definitions, and our results may have differed somewhat if we had used an alternate definition for periodontitis. For example, we did not find a statistically significant difference between those individuals with and without periodontitis who had a BMI of 25 kg/m^2 or more. Al-Zahrani and colleagues (21), however, defining periodontitis as having one or more sites with attachment loss $\geq$3 mm and probing depth $\geq$4 mm, found that for individuals 18 to 34 years of age, a BMI $\geq$30 kg/m^2 was significantly associated with periodontal disease. In a sample of 706 Brazilian subjects 30 to 65 years old, Dalla Vecchia and colleagues (22), defining periodontal disease as having $\geq$30 percent of teeth with attachment loss $\geq$5 mm, found that females with a BMI $\geq$30 kg/m^2 had a significantly higher prevalence of periodontitis than females with a BMI $\leq$25 kg/m^2. We also did not find a statistically significant difference between those individuals with and without periodontitis according to race/ethnicity. Defining periodontitis as having at least two sites with clinical attachment loss $\geq$4 mm and at least one site with pocket depth $\geq$4 mm, and limiting their analyses to individuals who were non-Hispanic Black, non-Hispanic White or Mexican–American in the NHANES data sets from 1999-2004, Borrell and Crawford (23) found that non-Hispanic Blacks and Mexican–Americans were significantly more likely to have periodontal disease than non-Hispanic Whites. However, using the NHANES 1999-2000 data set, Borrell and colleagues (24) found that when periodontitis was defined to be at least 3 sites with clinical attachment loss >4 mm and at least 2 sites with pocket depth >3 mm, non-Hispanic Blacks were more likely to have periodontitis than either Mexican–Americans of non-Hispanic Whites. Differences in our definition of periodontitis, combined with the inclusion of individuals 20 to 29 years of age, are also likely to account for a lower adult population

periodontitis prevalence as compared with those of others whose study sample excluded individuals under age 30 (13). Periodontitis prevalence may also be underestimated in the current work because the NHANES 2003-2004 participants included in our analyses only had facial sites assessed for loss of attachment and pocket depth.

Another study limitation involves the use of self-report data, especially regarding patients' medical history. However, self-reported medical data have often been found to be highly correlated with physician's records (25,26). Other limitations especially involve those inherent in the use of survey data: namely, the fact that questions and answer options (e.g., categories of race/ethnicity) are limited by the specific manner in which they were asked and recorded in the survey. Finally, we may also have underestimated the proportion of individuals under the age of 45 with a BMI of at least 25 kg/m^2 who would have been recommended for diabetes screening. According to ADA guidelines, these individuals are at risk if they have at least one of a number of specific ADA identified risk factors, only four of which were included in the current analyses.

In spite of its limitations, our study suggests the important and often overlooked opportunity to use the dental visit as an alternate site to identify those with undiagnosed diabetes, especially for those who might not be screened elsewhere because they do not visit office-based health providers. In fact, using data from the 2006 Medical Expenditure Panel Survey (accessed at http://www.meps.ahrq.gov/mepsweb/data_stats/MEPSnetHC.jsp), we determined that of those individuals in the United States who did not have an office-based provider visit during 2006, 27 percent had at least one dental visit during this time. Of this latter group of individuals, some were among those at greatest risk for diabetes, including 27 percent who were African–American or Hispanic, 22 percent who were at least 45 years of age, 25 percent who were of lower income, and 26 percent who did not have private insurance. Whether the approach to screening for diabetes is through assessment of risk factors, or through finger stick or oral blood sample testing, the extraordinarily large proportion of patients with periodontitis who would be recommended for screening according to ADA guidelines suggests the value and importance of the dental visit as a critical diabetes screening site. In view of the continuing and growing diabetes epidemic, such an opportunity for screening should be given serious consideration and necessary support.

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