Prevalence of daily flossing among adults by selected risk factors for periodontal disease— United States, 2009-2014

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BACKGROUND

Dental plaque is an etiological factor in the development of chronic periodontal disease, which can eventually lead to tooth loss, if untreated [1]. Plaque tends to accumulate on proximal surfaces, those locations between teeth. If unremoved, plaque leads to inflammation of the gingiva (i.e., gingivitis) and may progress to periodontitis [2]. Daily removal of dental plaque leads to reductions in both the prevalence and severity of gingival inflammation [3].

A toothbrush fails to completely remove plaque from proximal surfaces. Various interdental cleaning devices are commonly used, including dental floss, wood sticks, interdental brushes, single-tufted brushes, rubber tips stimulators, and irrigating devices [1]. Floss is the most widely used method of interdental cleaning, according to the American Dental Association [1]. Reports estimate that up to 80% of interdental plaque may be removed by this method, resulting in a significantly reduced incidence of caries and prevention of periodontal disease [3]. There is some debate about the importance of flossing, but it is a recommended part of daily dental hygiene [4–5]. The American Academy of Periodontology recommends daily flossing as part of a regular oral hygiene routine to reduce the prevalence and severity of gingival inflammation associated with periodontal disease [6].

Understanding the risk factors for periodontitis is important. Age, sex, race/ethnicity, income, education, tobacco use, and uncontrolled diabetes are risk factors for periodontal disease [7–12]. Periodontitis typically occurs with age. For women, hormonal changes can

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affect the gingiva and periodontium. Adults with low socioeconomic position and minority groups have higher rates of periodontitis compared to adults with higher socioeconomic status and White, non-Hispanic adults. Tobacco use is considered a modifiable risk factor, and diabetes is a systemic risk factor [11]. Tobacco use in the form of cigarette, cigar, or pipe smoking, as well as smokeless tobacco use, causes gum recession and bone lose. Diabetes impacts blood vessels and inflammatory processes that increase the risk for periodontal disease, especially when diabetes is not well-controlled [11].

Little is known about the flossing prevalence of adults with risk factors for periodontal disease. From a national public opinion poll, the 2014 Delta Dental Oral Health and Well-Being Survey reported that 41% of Americans floss at least once daily, and 20% never floss [13]. The purpose of this paper is to estimate daily flossing prevalence among adults 30 years and older in the United States, overall, and by demographic and health risk factors for periodontal disease including current tobacco use and diagnosed diabetes, using National Health and Nutrition Examination Survey (NHANES) data.

METHODS

Data from the NHANES 2011–2012 and 2013–2014 were used for these analyses. Administered by the National Center for Health Statistics (NCHS), NHANES is a cross-sectional survey designed to monitor the health and nutritional status of the civilian, noninstitutionalized U.S. population using a highly stratified, multistage probability design [14]. Since 1999, NHANES has been collected continuously with data released in two-year cycles. The NCHS Research Ethics Review Board approved the NHANES protocol, and all adult participants provided written informed consent. The survey consists of interviews conducted in participants' homes and standardized health examinations and biospecimen collection conducted in mobile examination centers (MECs). In 2011–2012 and 2013–2014, non-Hispanic black, non-Hispanic Asian, and Hispanic persons were oversampled, in addition to other groups, to obtain reliable estimates for these population subgroups. The 2011–2014 NHANES interview and examinations response rates for adults aged 30 years and older were respectively 65.7% and 63.3%.

The outcome variable for this study was obtained from the household interview question regarding the report of flossing in the last week, which is only asked in NHANES of respondents aged 30 years and older. Participants were asked: "Aside from brushing {your/his/her} teeth with a toothbrush, in the last seven days, how many days did {you/SP} use dental floss or any other device to clean between {your/his/her} teeth?" The respondent answered with a number of days from 0 to 7. Adults who flossed were categorized by the following flossing frequencies: not flossing (flossing 0 days), some flossing (flossing 1 to 6 days), and daily flossing (7 days). For this analysis, flossing refers to the use of dental floss or any other device to clean between the teeth.

Periodontal disease risk factors were defined using questionnaire data. Key risk factors included current tobacco use and diagnosed diabetes [8, 12]. Current tobacco users were identified based on questions asked about tobacco use in the past five days. If respondents replied "yes" to using cigarettes, cigars, smokeless tobacco, chewing tobacco, or snuff in the

past five days, they were characterized as current tobacco users. If respondents replied "no", they were characterized as not being current tobacco users. E-cigarettes were only included in the questionnaire in the 2013–2014 survey cycle, so were not included in this analysis. There is no evidence about the link between e-cigarettes and gum disease, unlike tobacco. Participants were categorized as having diagnosed diabetes if they responded "yes" to the question, "have you ever been told by a doctor or health professional that you have diabetes?".

From the questionnaire and demographic data files, the following covariates were selected based on previous analyses and availability in NHANES [12, 16 17]: age, sex, race/Hispanic origin, poverty status and education. [12, 16]. Age was categorized as 30–44 years, 45–64 years, 65–74 years, and 75 years and older. Sex was categorized as male or female. Race/Hispanic origin was categorized as non-Hispanic white, non-Hispanic black, non-Hispanic Asian, and Hispanic. Hispanic included Mexican Americans and other Hispanic. Specific race and Hispanic origin estimates reflect individuals reporting only one race; non-Hispanic others and those reporting more than one race are included in the total but are not reported separately. Poverty status was categorized using the ratio of family income to the poverty guidelines (FIPR). Low income was categorized as less than 1.3 the ratio of family income to poverty which is the cut off for participation in the Supplemental Nutrition Assistance Program (SNAP) [18]. Middle income was categorized as between 1.3 and 3.5. High income was categorized as greater than or equal 3.5 the ratio of family income to poverty in order to have fairly equal sample sizes for each income group. Education was categorized as less than high school, high school or GED, some college, or associate's degree, and college degree or above and is labeled as <High School, High School, Some College, and College Degree or Above.

From 2011–2014, there were 9379 adults aged 30 years and older who participated in the NHANES study. Of these adults, 345 adults were missing oral health examination data, 669 did not have teeth (edentate), and 9 adults were missing questionnaire data on flossing (Figure 1). There were 8356 adults in the final analytic sample, defined in terms of participants aged 30 years and older who received an oral health examination, had teeth, and questionnaire data on flossing. There was no difference in the sociodemographic characteristics, current tobacco use, or diagnosed diabetes of the 1023 excluded adults compared to those in the analytic sample.

Statistical Methods

Estimates of flossing prevalence (none, some and daily) together with their standard errors are presented by tobacco use, diagnosis of diabetes, sex, age group, race Hispanic/origin, income, and education. For tobacco use, diagnosis of diabetes and all covariates except for age group, estimates of flossing prevalence were age-adjusted by the direct method to the year 2000 Census population using the age groups 30–44 years, 45–64 years, 65–74 years, and 75 years and older. Associations between the three categories of flossing and each covariate were tested using Satterthwaite-adjusted chi-square test was used with Rao-Scott correction at the $p < 0.05$ significance level. Multiple logistic regression analysis was used to evaluate the association between the periodontal disease risk factors and daily flossing,

comparing daily flossers to the other two groups combined (i.e., non-daily flossers). The multiple logistic regression model included all covariates, current tobacco use, and diagnosed diabetes. There were no significant interactions between sex and any of the other covariates or between current tobacco use and diagnosed diabetes so no interactions were included in the model. Odds ratios and 95% confidence intervals are presented.

Given that there were differences in characteristics among the three flossing groups, and that those reporting some flossing group were more similar to those reporting daily flossing, compared to those reporting no flossing, a sensitivity analysis was conducted with a model using any reported flossing versus no flossing to assess whether odds ratios were influenced by the inclusion of those reporting some flossing in the original analysis. To account for the differential probabilities of selection, nonresponse, and noncoverage, NHANES interview sample weights were incorporated into the estimation process. In estimating standard errors the complex sample design which included weighting was incorporated by using Taylor series linearization [19]. Adjustments were not made for multiple comparisons.

Statistical analyses were conducted using SAS System for Windows, release 9.3 (SAS Institute Inc., Cary, N.C.) and SUDAAN, release 11.1 (RTI International, Research Triangle Park, N.C.).

RESULTS

Figure 2 shows flossing prevalence among adults aged 30 years and older by the number of days of flossing. Flossing prevalence ranged from 1.5% (SE=0.3) for six days to 31.9% (SE=0.9) for no days. The overall daily flossing prevalence was 31.6% (SE=0.8). Table 1 presents flossing prevalence using the three categories defined in the methods (none, 1–6 days (some) and daily) among adults aged 30 years and older by the selected demographic characteristics and risk factors for periodontal disease. Although 31.6% (SE=0.8) of adults reported flossing daily, 36.6% (SE=0.9) adults reported they floss between 1 and 6 days each week and 31.9% (SE=0.9) of adults reported not flossing. There were significant differences in age, sex, race-Hispanic origin, poverty status, education, current tobacco use, and diagnosed with diabetes among the categories of flossing.

Table 2 shows the odds of daily flossing among adults from the multiple logistic regression model that included all covariates, current tobacco use, and diagnosed with diabetes. Compared to the youngest age group 30–44 years, adults 45–64 years (OR 1.24; 95% CI, 1.01–1.52) and 65–74 years (OR 1.67; 95% CI, 1.18–2.35) had significantly higher odds of daily flossing. Women (OR 1.78; 95% CI, 1.46–2.16) had higher odds of daily flossing than men and non-Hispanic Asian (OR 1.63; 95% CI, 1.22–2.18) and Hispanic (OR 1.54; 95% CI, 1.19–2.00) adults had higher odds of daily flossing than non-Hispanic white adults. Adults in the highest income group had higher odds of daily flossing (OR 1.68; 95% CI, 1.30–2.18) compared to the lowest income group and there were no significant differences by education. Current tobacco users had lower odds of daily flossing (OR 0.82; 95% CI, 0.68, 0.99) compared to non-users but there was no difference between adults diagnosed and non-diagnosed with diabetes (OR 0.75; 95% CI, 0.52, 1.08).

Model results from the sensitivity analysis comparing any flossing to no flossing showed a different pattern by age, no differences by race/Hispanic origin and significant differences by education, unlike the main analysis on daily flossing. Sensitivity results related to diagnosed diabetes were similar but stronger in terms of current tobacco use (data not shown).

DISCUSSION

Based on NHANES 2011–2014, approximately 32% of adults aged 30 years and older, 26% of men, and 37% of women floss daily. This is inconsistent with the American Academy of Periodontology recommendation for daily flossing among all persons. However, the majority of adults, about 68%, reported flossing at least once weekly. While the Delta Dental national public opinion poll of 1,003 adults found that 20% of Americans never floss [13], this study found that 32% of adults reported no flossing in the past week. Estimates could differ due to different sampling approaches or measurement techniques Estimates could differ due to different sampling approaches or measurement techniques Moreover, similar to the Delta Public Opinion Poll, we found that the odds of daily flossing was higher in women than men. There are no other national studies on flossing prevalence.

The results from this study may help to better understand racial and ethnic dispari ties in oral health and is the first to report flossing prevalence for non-Hispanic Asian adults. We found that the odds of daily flossing among non-Hispanic Asian and Hispanic adults were higher than in non-Hispanic white adults. Prior knowledge on racial and ethnic disparities has focused on periodontal disease, this study adds to this body of knowledge information about behaviors to support periodontal health, specifically adding knowledge about reported flossing. In 2011–2012, the prevalence of periodontitis was 50.0% among non-Hispanic Asian adults, 63.1% among Hispanic adults, and 59.1% among non-Hispanic black adults, all higher than among non-Hispanic white adults (40.8%) [7]. The patterns in flossing are not consistent with periodontitis which was lower among non-Hispanic whites but the odds if flossing were higher for non-Hispanic Asians and Hispanics [7].

NHANES examination data have previously been used to assess periodontal health by risk factors for periodontal disease [17]. But the current study is the first to report national flossing prevalence by risk factors for periodontal disease. While Eke et al, found that current smokers had a higher likelihood of total periodontitis compared to non-smokers, the current study shows that current tobacco users had a lower prevalence of daily flossing. Additional studies may be useful to better understand flossing behavior among adults with risk factors for periodontal disease.

There are growing debates in media about the efficacy of flossing and the role that flossing may play in preventing periodontal diseases [4, 5]. In a review of twelve trials to assess the effectiveness of flossing in addition to toothbrushing to prevent gum disease and dental caries in adults, Sambunjak et al. found in a 2012 Cochran Systematic Review "there is no evidence to support or refute that flossing reduces plaque." [1]. Furthermore, while there were small reductions in plaque at one and three months, they conclude that "flossing is an effective adjunct to toothbrushing, as the important benefits outweigh any potential harms."

The results from the systematic review suggest that additional studies may be helpful to explore assess the efficacy of daily flossing.

Limitations

This study has limitations. The results are limited by the inherent bias associated with self-reported questionnaire data, including social desirability bias.. There is an additional limitation in using a question focused on flossing in the past week which may not reflect long term patterns. Additional information is needed to better understand daily flossing over longer periods of time as well as to assess other contributing risk factors to periodontal disease, such as diet and genetics.

Strengths

A strength of the analysis is the use of national-level, representative data to assess flossing prevalence. This analysis also describes flossing prevalence for non-Hispanic Asians expanding on previous work describing the oral health of non-Hispanic Asians [7]. An additional strength of the analysis is the broad definition of tobacco use that is used. Most studies of oral health focus on cigarette smoking [9]. By including all forms of tobacco use except e-cigarettes (cigarettes, cigars, smokeless tobacco, chewing tobacco, and snuff), this analysis has a more inclusive account of tobacco use and included more adults with a risk for periodontal disease.
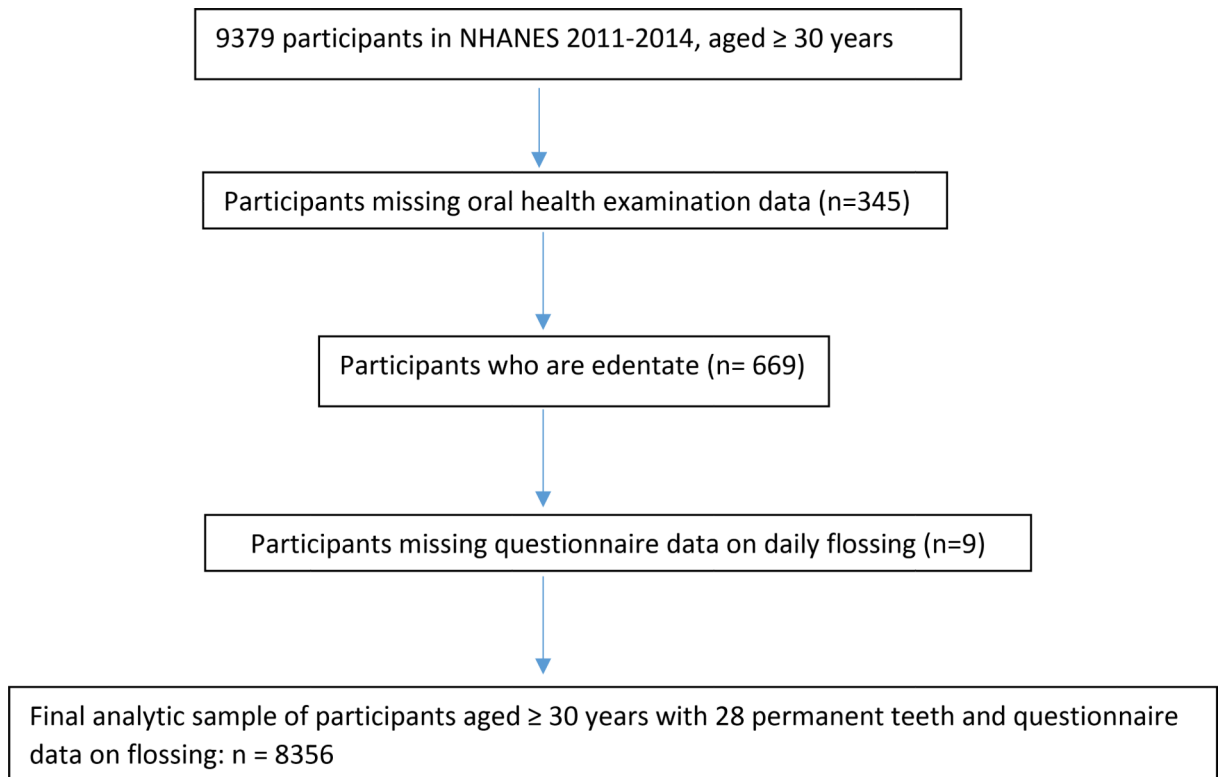
Public Health Implications

In conclusion, approximately 32% of adults aged 30 years and older floss daily. Current tobacco users have lower odds of daily flossing. Our study adds to the literature on oral health, specifically periodontal health behaviors, and identifies risk factors for periodontal disease that are associated with not flossing daily.

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9379 participants in NHANES 2011-2014, aged ≥ 30 years

↓

Participants missing oral health examination data (n=345)

↓

Participants who are edentate (n= 669)

↓

Participants missing questionnaire data on daily flossing (n=9)

↓

Final analytic sample of participants aged ≥ 30 years with 28 permanent teeth and questionnaire data on flossing: n = 8356
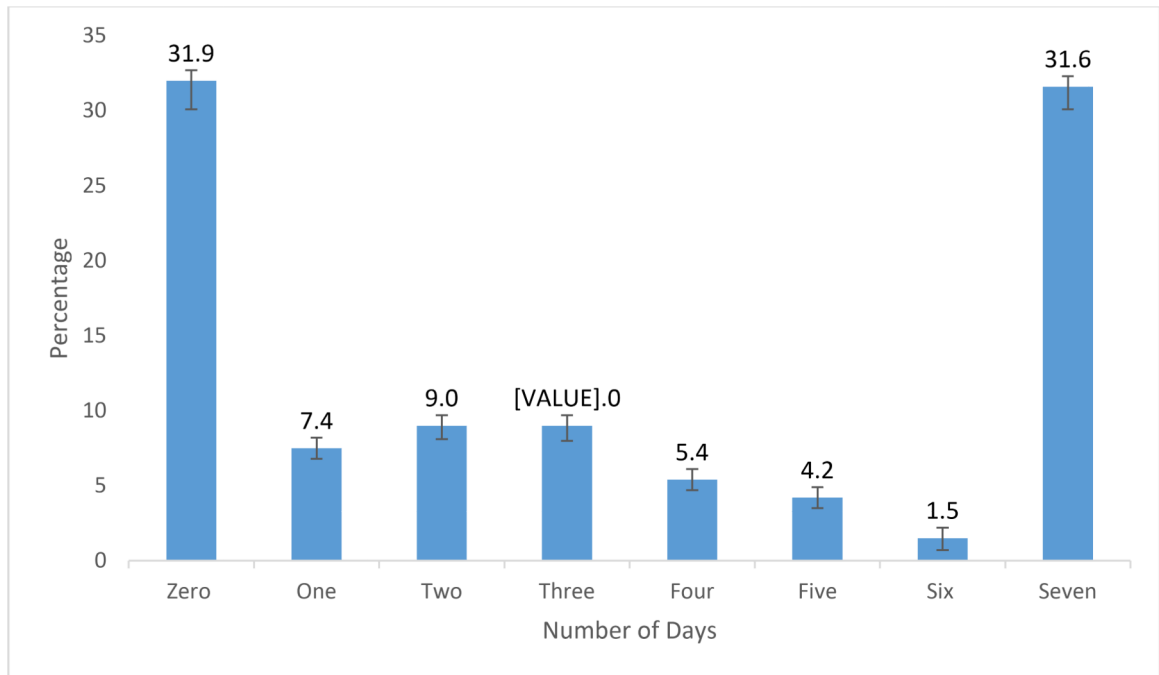
Figure 1.
National Health and Nutrition Examination Survey* 2011–2014 Analytic Sample Flow Diagram
* Data Source: National Health and Nutrition Examination Survey, 2011–2014 [16].

Figure 2.
Prevalence* of days of flossing in past week among adults aged 30 years, United States,
National Health and Nutrition Examination Survey†, 2011–2014
* With 95% confidence intervals indicated with error bars.
† Data Source: National Health and Nutrition Examination Survey, 2011–2014 [16].

Table 1.

Prevalence of flossing among adults aged 30 years by demographic factors and risk factors for periodontal diseases, United States, 2011–2014[*]

Characteristic	n[†]	NO FLOSSING (0 days) % (SE)	SOME FLOSSING (1–6 days) % (SE)	DAILY FLOSSING (7 days) % (SE)	p value[‡]
Overall	8365	31.9 (0.9)	36.6 (0.9)	31.6 (0.8)	
Age (years)					
30–44	2671	30.9 (1.4)	41.9 (1.4)	27.2 (0.8)	
45–64	3433	29.5 (1.2)	37.9 (1.3)	32.7 (1.2)	p<0.001
65–74	1268	34.1 (1.7)	28.8 (1.7)	37.1 (1.9)	
75 and older	984	44.2 (1.9)	21.4 (1.4)	34.4 (2.0)	
Sex[§]					
Male	4069	38.0 (1.2)	36.0 (1.1)	26.0 (1.1)	p<0.001
Female	4287	26.2 (0.9)	37.1 (0.9)	36.8 (0.8)	
Race, Hispanic origin[§]					
White, non-Hispanic	3500	30.1 (1.2)	38.7 (1.1)	31.2 (1.1)	
Black, non-Hispanic	1926	37.7 (1.9)	33.7 (1.4)	28.7 (1.5)	p<0.001
Asian, non-Hispanic	1004	29.7 (1.9)	32.0 (1.6)	38.4 (1.3)	
Hispanic	1713	36.4 (1.7)	29.2 (1.5)	34.5 (1.3)	
Poverty Status[§]					
<130% FIPR	2544	47.9 (1.7)	26.8 (1.5)	25.3 (1.4)	
130–350% FIPR	2626	34.0 (1.3)	35.6 (1.0)	30.4 (1.3)	p<0.001
350% FIPR	2513	21.4 (1.1)	43.1 (1.2)	35.5 (1.2)	
Education[§]					
< High school	1962	54.3 (1.8)	21.2 (1.4)	24.5 (1.5)	
High school	1820	38.3 (1.6)	30.4 (1.4)	31.3 (1.3)	p<0.001
Some college	2356	27.3 (1.1)	41.2 (1.3)	31.5 (1.3)	
College degree and above	2212	20.9 (1.1)	43.8 (1.5)	35.3 (1.4)	
Current Tobacco use[§]					
Yes	1751	44.2 (1.8)	32.3 (1.3)	23.6 (1.5)	p<0.001
No	5925	29.8 (1.2)	37.1 (1.1)	33.1 (1.0)	
Diagnosed with diabetes[4]					
Yes	1244	39.8 (2.4)	30.8 (2.3)	29.5 (2.6)	p=0.002
No	7107	30.8 (1.0)	37.3 (0.9)	31.9 (0.7)	

[*] Data Source: National Health and Nutrition Examination Survey, 2011–2014 [16].

[†] There were 8356 adults aged 30 years with 28 permanent teeth and questionnaire data on flossing. Due to missing numbers, the values for the covariates do not sum to the total. Other, non-Hispanic category was included in the total sample but not shown.

[‡]Satterthwaite-adjusted chi-square test was used with Rao-Scott correction.

[§]Age-adjusted prevalence by the direct method to the year 2000 Census population, using the age groups: 30–44 years, 45–64 years, 65–74 years, and 75 years and older.

Table 2.

Odds ratios and 95% confidence intervals of daily flossing among adults aged 30 years by demographic factors and risk factors for periodontal diseases, United States, 2011–2014 [*],[†]

Characteristic	Odds Ratio	95% Confidence Interval	p-value
Age (years)			
30–44	Reference		p=0.024
45–64	1.24	1.01, 1.52	
65–74	1.67	1.18, 2.35	
75 and older	1.29	0.88, 1.91	
Sex			p<0.001
Male	Reference		
Female	1.78	1.46, 2.16	
Race, Hispanic origin			p=0.021
White, non-Hispanic	Reference		
Black, non-Hispanic	1.10	0.83, 1.46	
Asian, non-Hispanic	1.63	1.22, 2.18	
Hispanic	1.54	1.19, 2.00	
Poverty Status			p=0.011
<130% FIPR	Reference		
130–350% FIPR	1.30	0.93, 1.83	
350% FIPR	1.68	1.30, 2.18	
Education			
< High school	Reference		p=0.272
High school	1.41	0.96, 2.08	
Some college	1.21	0.77, 1.89	
College degree and above	1.38	0.85, 2.25	
Current Tobacco use			p=0.043
Yes	0.82	0.68, 0.99	
No	Reference		
Diagnosed with diabetes			p=0.117
Yes	0.75	0.52, 1.08	
No	Reference		

[*] Data Source: National Health and Nutrition Examination Survey, 2011–2014 [16].

[†] Odds ratios were adjusted for sex, age, race/Hispanic origin, poverty and education.