Effect of Tobacco Smoke on the Oral Health of US Women of Childbearing Age

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Abstract

Objectives: *To determine the oral health status of US women of childbearing age and to analyze the effect of tobacco smoke on their oral health.* ***Methods:*** *Data from the 1999-2004 National Health and Nutrition Examination Survey were evaluated for women 15-44 years of age. The association of exposure to tobacco smoke with untreated caries, mean DMFS, gingivitis, and periodontitis were examined in bivariate and regression analyses controlling for potential confounders.* ***Results:*** *The prevalence of untreated caries was 25%, for gingivitis 49%, and for periodontitis 6%. After adjusting for potential confounders, self-reported current smoking was a strong independent risk indicator for untreated caries, periodontitis, and to a lesser extent for greater DMFS count. Women with detectable cotinine levels below 15 ng/mL presented with an increased risk for gingivitis. Independent factors associated with increased risk for untreated caries were being Black, having less than a high school education, Medicaid or no health insurance, previous live births, and infrequent and episodic dental visits. Characteristics associated with gingivitis were being Mexican-American, obese, pregnant, and having infrequent dental visits. Older age, no insurance, and the last dental visit for treatment were independently associated with periodontitis.* ***Conclusions:*** *Dental caries and periodontitis were prevalent among certain subgroups of women of reproductive age. Smoking was found to be a significant risk indicator for various negative oral health outcomes. Barriers to accessing to dental care that were manifested by untreated caries among Black women, mothers, and Medicaid beneficiaries must be better understood.*

Key Words: smoking, oral health, women of childbearing age

Abbreviations: NHANES, National Health and Nutrition Examination Survey; NCHS, the National Center for Health Statistics; CDC, Centers for Disease Control and Prevention; MEC, Mobile Examination Center; ACASI, audio-computer-assisted self-interview; ETS, Environmental Tobacco Smoke; DS, decayed permanent tooth surfaces; DMFS, decayed, missing, and filled permanent tooth surfaces; FGM, free gingival margin; CEJ, cemento-enamel junction; LOA, loss of attachment; BMI, Body Mass Index; AOR, adjusted odds ratio; IDR, incidence density ratio; SE, standard error; CI, confidence interval; PRAMS, Pregnancy Risk Assessment Monitoring System.

Introduction

The surgeon general's report on women and smoking reported that nearly 14 million women of reproductive age were smokers, and the prevalence of smoking in this group was higher than in the overall population of women in 1998 (1). Cigarette smoking among women of childbearing age raises significant concerns, as the use of nicotine products is addictive and reportedly increases risks for conception delay, primary and secondary infertility and spontaneous abortion (1). Smoking during pregnancy is known to be associated with myriads of negative perinatal health outcomes in children including preterm delivery, low birth weight, sudden infant death syndrome, and the absence or early termination of breastfeeding (1,2). Maternal smoking during the perinatal period has also been linked to dental caries in offspring independent of socioeconomic factors (2,3). While understanding how prenatal and/or postnatal exposure to tobacco smoke influence children's susceptibility to dental caries is certainly a subject of future research, the scientific evidence regarding the influence of cigarette smoking on dental caries in smokers themselves also needs to be investigated. Furthermore, epidemiological data on oral health among women in the perinatal period are quite limited at present, even though the efforts of oral health promotion targeting women during pregnancy has increased in recent years (4). The aims of this study were twofold: a) to determine the oral health status of US women of childbearing age using the publicly released data set of the National Health and Nutrition Examination Survey (NHANES) 1999-2004; and b) to analyze the association between exposure to tobacco smoke and the oral health status of this population.

Methods

Study Population. We used data from the 1999-2004 NHANES, a cross-sectional health survey conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention,

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which represent the civilian, non-institutionalized population in the United States. The data of exposure to tobacco smoke, oral health, and other covariates were analyzed for 5,110 US women between 15 and 44 years of age. As the NHANES data are in the public domain, human subjects review was not required.

Data on Exposure to Tobacco Smoke. To evaluate the status of women's exposure to tobacco smoke, we used both self-reported data on cigarette smoking and the levels of serum cotinine from laboratory tests.

Self-reported cigarette-smoking data. Information on smoking and tobacco use were obtained from Mobile Examination Center (MEC) interviews and household sample person interviews. Youths 12-19 years of age were asked questions on recent smoking and tobacco use (during the past 5-day period) utilizing the MEC audio-computer-assisted self-interview (ACASI) method (5). The samples were classified as either current smokers (had smoked ≥100 cigarettes in their lifetime and smoked during the past 5 days), previous smokers (had smoked ≥100 cigarettes in their lifetime and did not smoke during the past 5 days), or never smokers (had not smoked ≥100 cigarettes in their lifetime and did not smoke during the past 5 days). These definitions of smokers were slightly modified from the definitions used previously (6,7) for reasons related to the inclusion of adolescents in the present study. As the information of "ever smoked ≥100 cigarettes in lifetime" from household interview was not available for the samples <20 years of age, we used the information of "ever tried cigarette smoking" obtained from ACASI to identify the history of smoking among 15- to 19-year-olds in this study.

Serum cotinine data. Cotinine is a major metabolite of nicotine and often used to measure the extent of tobacco use and the exposure to the Environmental Tobacco Smoke (ETS) (8). As the 1999-2000 NHANES detection limit was 0.05 ng/mL in serum (8), this cotinine level was used to distinguish between the status of exposure and non-exposure to tobacco smoke. It has been reported that cotinine levels <10-13 ng/mL are consistent with no active smoking (9). Our cursory analysis indicated that 90% of current smokers had cotinine values ≥15 ng/mL. Therefore, we dichotomized women with cotinine at the levels of 15 ng/mL to examine the effect of the intensity of tobacco exposure including second-hand smoke.

Data on Oral Health. Four measures of oral health outcomes used for this study were: a) prevalence of untreated caries, defined as one or more decayed permanent tooth surfaces; b) mean decayed, missing (due to disease), and filled permanent tooth surfaces (DMFS); c) the prevalence of gingivitis, defined as bleeding from one or more mesial and buccal/midfacial sites per probing; and d) prevalence of destructive periodontitis, defined as the presence of one or more mesial and buccal/midfacial sites with ≥4 mm loss of tooth attachment compared to surrounding periodontal tissues.

Trained dental examiners assessed the coronal conditions of all teeth and tooth surfaces, except third molars using a surface reflecting mirror and No. 23 explorer. Radiographs were not taken. The prevalence of bleeding from probing and measurement to ascertain periodontal attachment loss was assessed in the same randomly selected quadrants: one maxillary and one mandibular. Only fully erupted permanent teeth were scored. Examiners measured the distance in millimeters (mm) from the free gingival margin (FGM) to the cemento-enamel junction [*X*] and the distance from the FGM to the bottom of the gingival sulcus [*Y*] using a surface reflecting mirror and a periodontal probe. Loss of attachment ($LOA = Y - X$) was calculated by the computer program.

All study participants who met the inclusion criteria were examined in the MEC. Details of the dental examination procedures are described in the NHANES procedure manual (10).

Covariates Investigated. Demographic variables including age, race, country of birth, poverty level, educational attainment, and marital and pregnancy status were analyzed for their potential association with oral health outcomes. Poverty status was based on family income and family size compared to the federal poverty level (FPL) for that year and defined by three categories: family income <100% of the FPL, ≥100% but <200% of the FPL, and ≥200% of the FPL. Covariates from the household interviews included health insurance status, live birth status (having ≥1 live births versus never pregnant or no live births), alcohol use (≥20 years old only), and the time and reason for the last dental visit. Current alcohol drinking status was defined using previously reported criteria (had at least 12 drinks in any year or in their entire life and had consumed alcohol on at least 1 day in the last year) (11). Data on Body Mass Index (kg/m^2) were obtained as part of the MEC examinations. The dietary interview dataset in the NHANES contains detailed 24-hour recall information on the individual foods and types of meals reported by respondents. Data on carbohydrate intake in grams consumed as snack/beverage were extracted, and the total intake (gm) and frequency were calculated. The 2003-2004 NHANES released 2 days of dietary intake data (the first day was collected in the MEC and the second day was collected by telephone 3-10 days later) for each participant (12). We used the first-day carbohydrate intake data for analyses, as the NHANES in the previous years did not collect second-day data. These variables were selected because they were previously found to be associated with oral health and socioculturally believed to be important to be investigated among the women of this age group.

Statistical Analyses. Bivariate (unadjusted) analyses were conducted to estimate the prevalence of dental and periodontal diseases and

assess their association with exposure to tobacco smoke and selected covariates. Variables found to be statistically significant based on a *t*-test of pairwise comparisons ($P \leq 0.10$) were included in multivariable regression analyses to determine independent associations with oral health outcomes. Logistic regression analyses were performed in the separated models using either cotinine or self reported smoking (referred as cotinine model and smoker model as follows) with the outcomes of untreated caries, gingivitis, and periodontitis controlling for the potential confounders found in bivariate analyses. Similarly, Poisson regression analyses were performed with mean DMFS count. Multiregression analyses for samples aged 20-44 years were separately performed including variables of alcohol use and educational attainment. Adjusted odds ratios (AOR), incidence density ratios, and statistical significance from χ^2 test, *t*-test, and Wald *f*-test were calculated for each, respectively. As the NHANES uses a complex, multistage sampling design, SUDAAN version 9.0.1 (Research Triangle Institute, Research Triangle Park, NC) was used to estimate appropriate variances for all of the analyses, including the bivariate analyses and multivariable logistic and Poisson regressions (13). Results were weighted to be representative of US women between 15 and 44 years of age according to the sampling weights that were provided by the NHANES.

Results

In 1999-2004, an estimated 20% [standard error (SE), 1.2] of the US women between 15 and 44 years of age were current smokers, and 26% of the sample had cotinine levels at or higher than 15 ng/mL (data on demographic characteristics of smoking and cotinine are not shown in the tables). Overall, 34% of the sample women were estimated to have detectable cotinine levels below 15 ng/mL, suggesting either low levels of tobacco use or exposure to ETS. Prevalence of smoking was higher among 20- to 44-year-old women compared with <20-year-olds (21% versus 16%). The prevalence of detectable cotinine levels below 15 ng/mL was, however, higher among the younger age group, while non-detectable cotinine levels were more common among older women. Mexican-Americans and women born in Mexico were statistically less likely to smoke compared to White and US-born women (10% and 8% versus 23% and 22%, respectively). Smoking was more common among women living in <200% FPL, having ≤high school education, having Medicaid insurance, those without health insurance, and those with live births. Smoking was also more common among women who were underweight, current drinkers, infrequent dental visitors (>1 year), and those who had their last dental visit for reasons other than checkups compared with each reference group ($P < 0.01$).

The characteristics of the sample and the results of bivariate analyses for untreated caries and mean DMFS are shown in Table 1. Overall, approximately 25% of women between 15 and 44 years of age were estimated to have one or more untreated carious tooth surface. Mean DMFS was estimated to be 19. Approximately 61% of women between 15-44 years of age reportedly had the last dental visit within a year, and 65% had a checkup at their last dental visit. Untreated caries was more common among current smokers and women with detectable serum cotinine than nonsmokers or women with undetectable serum cotinine. Mean DMFS was greater among current smokers, while it was not statistically significant between non-smokers and previous smokers.

Table 2 shows the results of bivariate analyses for gingivitis and periodontitis. An estimated 49% and 6% of US women of childbearing age had gingivitis and periodontitis, respectively. Unlike other oral health outcomes investigated, age was not associated with the rate of gingivitis, while age increment showed significant effect on the prevalence of periodontitis. Approximately 13% of women 37-44 years of age had periodontitis, whereas periodontitis was barely present among <20-year-olds (0.2%). Smoking history did not statistically influence the prevalence of gingivitis, but cotinine levels did. Women who had detectable cotinine levels were more likely to have gingivitis than women with undetectable cotinine. Current smokers were more likely to have periodontitis than never-smokers or previous smokers.

The results of multivariable regression analyses are shown in Tables 3-6. Current smoking remained strong as an independent risk factor for untreated caries, periodontitis, and to a lesser extent, greater DMFS count after controlling for potential confounders. The odds of having poor oral health among previous smokers were not significantly different from never smokers, except for the prevalence of mean DMFS. Previous smokers presented slightly higher prevalence of greater DMFS than never-smokers statistically. Cotinine models did not differ greatly from smoker models and showed that cotinine levels ≥15 ng/mL were associated with dental caries and periodontitis. Detectable cotinine levels below15 ng/mL remained statistically significant as a risk factor for gingivitis.

Covariates that showed independent association with untreated caries after controlling for potential confounders were as follows (Table 3): Black race, educational attainment equal to or less than high school, Medicaid or no insurance status, and having live births presented increased risk for untreated caries. Current alcohol consumption, however, decreased the odds of having untreated caries by 40% compared to non-drinkers. Women with infrequent dental visits (>1 year) were at about 50% increased risk for untreated caries, while women who had problem-based last dental visit presented more than three times higher risk for untreated caries than the reference group.

Table 1
Distribution of US Women Aged 15-44 Years* by Study Variables for DS and Mean DMFS

Variables	Sample size	DS (SE)	Mean DMFS (SE)
Overall	5110	24.6 (1.1)	19.1 (0.5)
Tobacco smoking history	4357	†	†
Current	641	34.6 (2.5)	25.5 (1.6)
Previous	1179	18.3 (1.6)	16.5 (0.7)
Never	2537	20.3 (1.2)	16.1 (0.5)
Serum cotinine (ng/mL)	4742	†	†
≥15	894	38.7 (2.3)	27.7 (1.3)
<15, ≥0.05	1855	25.3 (1.7)	15.6 (0.7)
<0.05	1993	14.6 (1.1)	17.0 (0.6)
Age (years)	5110	†	†
15-19	1945	20.3 (1.8)	5.9 (0.2)
20-27	1137	27.5 (1.7)	11.5 (0.7)
28-36	1138	24.3 (1.6)	18.4 (0.7)
37-44	890	24.8 (1.8)	34.2 (1.2)
Race/Ethnicity	5110	†	†
White-NH	1956	18.9 (1.4)	19.6 (0.6)
Black-NH	1195	39.8 (1.9)	19.0 (0.8)
Mexican	1493	34.9 (2.3)	15.2 (0.7)
Other	466	30.4 (2.8)	19.4 (1.5)
Country of birth	5101	†	†
United States	4009	23.3 (1.1)	18.5 (0.6)
Mexico	704	38.7 (2.2)	16.8 (1.0)
Other	388	28.1 (2.9)	25.5 (2.0)
Poverty	5110	†	†
<100% FPL	1727	2.5 (2.3)	21.3 (1.2)
100 < 200% FPL	1180	1.9 (1.9)	20.1 (1.1)
≥200% FPL	2203	0.6 (1.0)	17.6 (0.5)
Education	5106	†	†
<High school	2296	36.0 (2.1)	16.7 (0.9)
= High school	979	33.3 (1.9)	23.5 (1.3)
>High school	1831	15.1 (1.0)	18.5 (0.6)
Marital status	4979	†	†
Never	2568	22.5 (1.6)	10.6 (0.5)
Married	1698	21.8 (1.4)	22.9 (0.8)
Cohabitating	336	29.0 (3.5)	20.1 (2.1)
Widow/Divorced/Separated	377	37.9 (3.2)	30.8 (1.7)
Health insurance	5060	†	†
Private insurance	2811	16.3 (1.0)	17.7 (0.6)
Medicaid	994	42.5 (2.8)	21.3 (1.1)
No insurance	1255	39.4 (2.0)	22.4 (1.5)
Pregnancy status	4560		†
Pregnant	847	28.3 (3.1)	15.1 (0.9)
Non-pregnant/Not known	3713	24.2 (1.2)	19.9 (0.5)
Live births	4548	†	†
Any	2273	30.2 (1.3)	25.2 (0.7)
None	2275	15.6 (1.2)	10.5 (0.5)
BMI (kg/m^2)	5110	†	†
Normal	2112	19.0 (1.6)	16.6 (0.6)
Overweight	1276	26.1 (1.4)	20.0 (0.9)
Obesity	1426	32.3 (2.1)	22.1 (0.9)
Underweight	296	21.9 (3.4)	19.2 (2.4)
Carbohydrate intake as snack/beverage	5110		
>Mean (77 g)	1790	23.6 (1.5)	18.5 (0.9)
≤Mean	3320	25.0 (1.2)	19.4 (0.6)
Frequency of carbohydrate intake as snack/beverage	5110		
>Mean (4x/day)	1376	22.3 (1.7)	20.4 (1.0)
≤Mean	3734	25.4 (1.2)	18.6 (0.6)
Alcohol use (≥20 y/o only)	2904	†	†
Current user	1608	20.4 (1.5)	20.6 (0.7)
Non-current user	1296	32.6 (2.1)	23.3 (1.1)
Time of the last dental visit	5102	†	
≤1 year	3101	18.4 (1.3)	18.8 (0.5)
>1 year	2001	36.1 (1.4)	19.6 (0.9)
Reason for the last dental visit	4753	†	†
Checkups	3079	15.0 (1.1)	15.1 (0.5)
Recommended treatment	315	23.3 (2.8)	25.3 (2.6)
Problems	1359	46.3 (1.9)	25.6 (1.0)

* Source: The National Health and Nutrition Examination Survey, 1999-2004.
† $P \leq 0.10$.
DS, decayed permanent tooth surfaces; DMFS, decayed, missing, and filled permanent tooth surfaces; FPL, federal poverty level; BMI, body mass index; SE, standard error.

Table 2
Distribution of US Women Aged 15-44 Years* by Study Variables for Gingivitis† and Periodontitis‡

Variables	Sample size	Gingivitis (SE)	Sample size	Periodontitis (SE)
Overall	3270	49.4 (2.8)	4375	5.8 (0.5)
Tobacco-smoking history	2958		3759	¶
Current	589	50.7 (4.0)	586	11.3 (1.6)
Previous	743	50.6 (4.0)	960	3.4 (1.0)
Never	1626	48.4 (3.2)	2213	3.9 (0.5)
Serum cotinine (ng/mL)	3052	¶	4078	¶
≥15	573	51.1 (4.0)	768	11.9 (1.4)
<15, ≥0.05	1148	55.2 (3.2)	1572	4.3 (0.6)
<0.05	1331	43.6 (3.7)	1738	3.3 (0.7)
Age (years)	3270		4375	¶
15-19	1276	49.7 (3.8)	1510	0.2 (0.1)
20-27	727	51.8 (3.7)	1056	2.3 (0.7)
28-36	727	48.8 (3.7)	1042	5.0 (0.9)
37-44	540	47.7 (4.3)	767	13.1 (1.5)
Race/Ethnicity	3270	¶	4375	¶
White-NH	1324	44.2 (3.1)	1710	5.2 (0.6)
Black-NH	796	59.2 (4.3)	1003	8.0 (1.1)
Mexican	884	64.2 (5.2)	1271	5.3 (0.9)
Other	266	56.4 (4.7)	391	7.6 (1.7)
Country of birth	3269	¶	4369	¶
United States	2605	47.9 (2.9)	3396	5.4 (0.5)
Mexico	428	67.1 (7.3)	631	6.5 (1.1)
Other	236	53.0 (5.9)	342	8.9 (1.7)
Poverty	3270	¶	4375	¶
<100% FPL	1012	55.3 (3.1)	1429	8.4 (1.0)
100 < 200% FPL	795	56.8 (3.7)	1025	8.6 (1.3)
≥200% FPL	1463	44.0 (3.3)	1921	3.5 (0.6)
Education	3269	¶	4372	¶
<High school	1470	54.8 (3.7)	1816	8.1 (1.1)
= High school	609	53.1 (3.8)	891	8.2 (1.3)
>High school	1190	45.2 (2.9)	1665	3.8 (0.7)
Marital status	3270		4259	¶
Never	1701	48.5 (3.4)	2100	3.2 (0.7)
Married	1128	48.9 (3.1)	1529	5.9 (0.7)
Cohabitating	232	54.4 (4.4)	302	9.4 (2.5)
Widow/Divorced/Separated	209	52.0 (4.5)	328	12.4 (2.1)
Health insurance	3238	¶	4329	¶
Private insurance	1795	44.6 (2.8)	2420	3.8 (0.6)
Medicaid	656	59.9 (4.0)	797	5.4 (1.5)
No insurance	787	57.2 (4.2)	1112	12.0 (1.4)
Pregnancy status	3171	¶	4234	
Pregnant	546	61.5 (4.1)	772	4.3 (1.5)
Non-pregnant/Not known	2625	48.9 (3.0)	3462	5.8 (0.6)
Live births	2892	¶	3885	¶
Any	1402	52.2 (3.3)	2035	8.8 (0.7)
None	1490	46.0 (3.5)	1850	2.1 (0.6)
BMI (kg/m^2)	3270	¶	4375	¶
Normal	1353	44.5 (3.3)	1761	3.9 (0.7)
Overweight	811	50.1 (3.4)	1131	7.2 (1.0)
Obesity	891	59.2 (3.3)	1238	7.1 (1.1)
Underweight	215	37.9 (4.4)	245	7.9 (2.6)
Carbohydrate intake as snack/beverage	3270		4375	¶
>Mean (77 g)	1162	49.0 (3.5)	1507	4.3 (0.8)
≤Mean	2108	49.7 (3.0)	2868	6.5 (0.6)
Frequency of carbohydrate intake as snack/beverage	3270		4375	
>Mean (4x/day)	895	48.0 (3.4)	1177	6.7 (0.9)
≤Mean	2375	50.0 (2.9)	3198	5.5 (0.5)
Alcohol use (≥20 y/o only)	1814		2623	¶
Current user	1012	47.8 (3.4)	1446	5.8 (0.7)
Non-current user	802	51.8 (3.6)	1177	9.0 (1.2)
Time of the last dental visit	3266	¶	4369	¶
≤1 year	1988	44.2 (2.8)	2643	4.4 (0.5)
>1 year	1278	58.6 (3.5)	1726	8.4 (0.9)
Reason for the last dental visit	3037	¶	4086	¶
Checkups	1992	46.6 (3.0)	2630	3.7 (0.5)
Recommended treatment	222	43.9 (4.9)	269	8.6 (2.5)
Problems	823	55.2 (3.4)	1187	9.9 (1.1)

* Source: The National Health and Nutrition Examination Survey, 1999-2004.
† The presence of bleeding from one or more mesial and buccal/midfacial sites per probing.
‡ The presence of one or more mesial and buccal/midfacial sites with ≥4 mm loss of tooth attachment.
¶ $P \leq 0.10$.
FPL, federal poverty level; BMI, body mass index; SE, standard error.

Table 3
Multivariable Logistic Regression, Smoker Model, for Untreated Caries (DS): US Women Aged 20-44 Years* (*n* = 2246)

Independent variables	AOR	95% CI
Tobacco-smoking history		
Current	1.82	1.23-2.70†
Past	0.99	0.65-1.52
Never	1.00	
Age (years)		
20-27	1.00	
28-36	0.82	0.58-1.15
37-44	0.71	0.48-1.06
Race/Ethnicity		
White-NH	1.00	
Black-NH	1.99	1.32-3.00†
Mexican	1.57	0.81-3.03
Other	1.53	0.96-2.44
Country of birth		
United States	1.00	
Mexico	0.67	0.34-1.33
Other	0.82	0.50-1.35
Poverty		
<100% FPL	1.49	0.96-2.31
100 < 200% FPL	1.44	0.99-2.09
≥200% FPL	1.00	
Education		
<High school	1.97	1.33-2.92†
= High school	1.63	1.16-2.31†
>High school	1.00	
Health insurance status		
Private insurance	1.00	
Medicaid	1.55	1.02-2.36†
No insurance	1.42	1.00-2.00†
Marital status		
Never	1.40	0.86-2.29
Married	1.00	
Cohabitating	1.13	0.61-2.06
Widow/Divorced/Separated	1.14	0.73-1.80
Live births		
Any	1.84	1.23-2.76†
None	1.00	
BMI (kg/m^2)		
Normal	1.00	
Overweight	1.15	0.79-1.68
Obesity	1.37	0.96-1.98
Underweight	0.70	0.33-1.49
Alcohol use		
Current drinker	0.60	0.45-0.81†
Non-drinker	1.00	
Time of the last dental visit		
≤1 year	1.00	
>1 year	1.47	1.12-1.93†
Reason for the last dental visit		
Checkups	1.00	
Recommended treatment	1.51	0.91-2.52
Problems	3.02	2.18-4.18‡

* Source: The National Health and Nutrition Examination Survey, 1999-2004.
† $P \leq 0.05$.
‡ $P < 0.001$.
DS, decayed permanent tooth surfaces; AOR, adjusted odds ratio; CI, confidence interval; FPL, federal poverty level; BMI, body mass index.

Age remained a significant risk factor for greater DMFS count presenting dose dependent association (Table 4). The following sample characteristics presented weak but statistically significant associations with greater DMFS count: being born in countries other than the United States or Mexico, educated at high school level, and having live births. Mexican-Americans and current drinkers were found to be protected for greater DMFS, although the associations were weak. The odds of having greater DMFS count were higher among women who had recommended treatments or problems at the last dental visit than women who had checkups.

The odds of periodontitis significantly increased with older age (Table 5). Women who had no health insurance and who had a recommended treatment at the last dental appointment presented significantly increased risk for periodontitis.

In the multivariable logistic regression analyses performed for gingivitis (Table 6), Mexican-American, obesity, and pregnancy status remained significant after controlling for the potential confounders. The odds of having gingivitis were also significantly higher among individuals who visited a dentist infrequently.

Discussion

In the present study of US women of childbearing age, cigarette smoking was a strong risk indicator not only for periodontitis but also for dental caries independent of socioeconomic and lifestyle variables investigated. This result is consistent with the previous studies that reported increased risk for dental caries among adolescent and/or adult smokers in the United States (14) and other countries (15-18). While untreated caries is usually considered an indicator of an individual's lack of preventive and regular dental care, it also indicates an active disease state. The association between untreated caries and smoking found in this study, as well as the previously reported link between maternal smoking and

Table 4
Multivariable Poisson Regression, Smoker Model, for Mean DMFS: US Women Aged 20-44 Years* (*n* = 2196)

Independent variables	IDR	95% CI
Tobacco-smoking history		
Current	1.33	1.18-1.51‡
Past	1.13	1.00-1.28†
Never	1.00	
Age (years)		
20-27	1.00	
28-36	1.56	1.36-1.80‡
37-44	2.70	2.36-3.09‡
Race/Ethnicity		
White-NH	1.00	
Black-NH	0.97	0.85-1.10
Mexican	0.80	0.71-0.90‡
Other	0.93	0.76-1.14
Country of birth		
United States	1.00	
Mexico	1.11	0.93-1.31
Other	1.33	1.08-1.64†
Poverty		
<100% FPL	1.07	0.95-1.22
100<200% FPL	0.97	0.85-1.10
≥200% FPL	1.00	
Education		
<High school	1.14	0.99-1.32
= High school	1.17	1.05-1.31†
>High school	1.00	
Health insurance status		
Private insurance	1.00	
Medicaid	1.10	0.94-1.30
No insurance	1.09	0.94-1.28
Marital status		
Never	0.96	0.82-1.11
Married	1.00	
Cohabitating	1.06	0.87-1.29
Widow/Divorced/Separated	0.96	0.85-1.09
Pregnancy status		
Pregnant	0.97	0.84-1.12
Non-pregnant/Not known	1.00	
Live births		
Any	1.23	1.06-1.41†
None	1.00	
Alcohol use		
Current drinker	0.88	0.79-0.98†
Non-drinker	1.00	
BMI (kg/m^2)		
Normal	1.00	
Overweight	1.04	0.93-1.16
Obesity	1.10	0.99-1.23
Underweight	1.08	0.85-1.38
Reason for the last dental visit		
Checkups	1.00	
Recommended treatment	1.38	1.11-1.71†
Problems	1.29	1.16-1.44‡

* Source: The National Health and Nutrition Examination Survey, 1999-2004.
† $P \leq 0.05$.
‡ $P < 0.001$.
DMFS, decayed, missing, and filled permanent tooth surfaces; IDR, incidence density ratio; CI, confidence interval; FPL, federal poverty level; BMI, body mass index.

dental caries in the offspring, therefore, might be explained, at least in part, by a common underlying mechanism.

While tobacco smoke and alcohol use are both often considered poor lifestyle factors and linked to various diseases and adverse health outcomes (6), alcohol use was found to be protective for untreated caries as well as greater DMFS count in this study. The inverse association between mean daily alcohol consumption and the number of missing teeth has also been reported previously (19). While characteristics among female alcohol users such as White race, ≥200% FPL and more than high school education (6) may have potentially confounded the results, future studies using a more detailed categorization of alcohol consumption may shed more light on this association.

The strong link found between untreated caries and live births independent of age and socioeconomic factors also deserves further investigation. The 2004 Pregnancy Risk Assessment Monitoring System data indicated that only about 30% of women made a dental visit for teeth cleaning during the postpartum period, whereas the prevalence of pregnancy dental visit**s** was reportedly 78% (20). We speculate that being a mother may be a barrier to obtaining dental services. It is also interesting to note here that the risk associated with untreated caries among Medicaid beneficiaries was as significant as among no health insurance holders (AOR, 1.6 versus 1.5 Medicaid and no insurance holder, respectively). In the previous study that analyzed data from the 1999-2002 National Survey of America's Families, it was reported that the probability of access to dental services among Medicaid beneficiaries between the ages of 19-64 was significantly lower than privately insured low-income samples in 9 of the 13 states (21). Meanwhile, they did not find a statistically significant difference between Medicaid and privately insured low-income samples affecting the probability of a

Table 5
Multivariable Logistic Regression, Smoker Model, for Periodontitis*: US Women Aged 20-44 Years† (*n* = 2050)

Variables	AOR	95% CI
Tobacco-smoking history		
Current	3.11	1.94-4.98¶
Previous	1.40	0.66-3.01
Never	1.00	
Age (years)		
20-27	1.00	
28-36	3.48	1.30-9.29‡
37-44	10.17	3.74-27.63¶
Race/Ethnicity		
White-NH	1.00	
Black-NH	1.11	0.61-2.04
Mexican	0.95	0.34-2.62
Other	0.96	0.53-1.75
Country of birth		
United States	1.00	
Mexico	0.77	0.29-2.05
Other	1.91	1.00-3.65‡
Poverty		
<100% FPL	1.59	0.81-3.12
100 < 200% FPL	1.64	0.92-2.92
≥200% FPL	1.00	
Education		
<High school	1.76	0.92-3.34
= High school	1.25	0.70-2.24
>High school	1.00	
Health insurance status		
Private insurance	1.00	
Medicaid	0.92	0.43-1.95
No insurance	1.91	1.03-3.56‡
Marital status		
Never	1.91	0.89-4.09
Married	1.00	
Cohabitating	2.20	0.91-5.34
Widow/Divorced/Separated	1.38	0.73-2.63
Live births		
Any	1.84	0.93-3.63
None	1.00	
BMI (kg/m^2)		
Normal	1.00	
Overweight	1.45	0.84-2.51
Obesity	1.11	0.64-1.94
Underweight	2.81	0.91-8.67
Total intake of carbohydrate as snack/beverage		
>Mean (77 g)	0.88	0.51-1.52
≤Mean	1.00	
Alcohol use		
Current drinker	0.58	0.33-1.01
Non-drinker	1.00	
Time of the last dental visit		
≤1 year	1.00	
>1 year	1.00	0.66-1.50
Reason for the last dental visit		
Checkups	1.00	
Recommended treatment	2.43	1.05-5.61‡
Problems	1.07	0.63-1.83

* The presence of one or more mesial and buccal/midfacial sites with ≥4 mm loss of tooth attachment.
† Source: The National Health and Nutrition Examination Survey, 1999-2004.
‡ $P \leq 0.05$.
¶ $P < 0.001$.
AOR, adjusted odds ratio; CI, confidence interval; FPL, federal poverty level; BMI, body mass index.

doctor visit and a woman's preventive care visit.

Consistent with the national trend (22), Black women of childbearing age were twice as likely to have untreated caries as White women. Mexican-Americans were slightly protected against greater DMFS count, while they presented an approximate 70% increased risk for gingivitis than Whites. Ismail *et al.* examined the Hispanic HANES 1982-1984 data and reported a high prevalence (80-90%) of gingivitis among Hispanic adults and children, including Mexicans (23). It was also observed previously that Hispanics, especially Mexicans, less frequently visited a dentist than non-Hispanic Whites (24). We also found that infrequent dental visits and obesity were both associated with gingivitis. Hujoel *et al.* reported the association between the frequency of flossing and obesity, two causally unrelated oral and general lifestyle characteristics, assessing 1,497 patients who visited a periodontist's office and concluded that daily flossing may be a marker for positive general health awareness (25). Although the interaction of genetic and environmental influences on the susceptibility to gingivitis in Mexican or obese women are not known at present, being Mexican and obese, as well as having infrequent dental visits that were found to be associated with gingivitis in this study, might be simply a marker for less health awareness and, in turn, poor oral health behaviors.

It is well known that pregnancy affects gingival health as a consequence of an exaggerated inflammatory response of periodontal tissues to local irritants such as plaque and calculus by the increase in steroid hormones during pregnancy (26). Our findings are consistent with this understanding. Furthermore, the present data clearly showed that neither dental caries nor periodontitis is particularly common during pregnancy.

Consistent with previous studies, smoking was a major risk factor for periodontitis among women of

Table 6
Multivariable Logistic Regression, Cotinine Model, for Gingivitis*: US Women Aged 20-44 Years† (*n* = 1509)

Variables	AOR	95% CI
Cotinine		
≥15	1.23	0.79-1.92
<15, ≥0.05	1.43	1.02-2.00‡
<0.05	1.00	
Race/Ethnicity		
White-NH	1.00	
Black-NH	1.36	0.84-2.19
Mexican	1.71	1.03-2.85‡
Other	1.51	0.97-2.37
Country of birth		
United States	1.00	
Mexico	1.11	0.45-2.72
Other	1.05	0.58-1.92
Poverty		
<100% FPL	1.12	0.78-1.60
100 < 200% FPL	1.14	0.79-1.65
≥200% FPL	1.00	
Education		
<High school	0.97	0.62-1.53
= High school	1.21	0.90-1.64
>High school	1.00	
Health insurance status		
Private insurance	1.00	
Medicaid	1.31	0.80-2.15
No insurance	1.00	0.65-1.52
Pregnancy status		
Pregnant	1.77	1.00-3.11‡
Non-pregnant/Not known	1.00	
Live births		
Any	1.13	0.77-1.67
None	1.00	
BMI (kg/m^2)		
Normal	1.00	
Overweight	1.07	0.76-1.50
Obesity	1.44	1.04-1.99‡
Underweight	0.73	0.33-1.64
Time of the last dental visit		
≤1 year	1.00	
>1 year	1.48	1.12-1.96‡
Reason for the last dental visit		
Checkups	1.00	
Recommended treatment	0.74	0.45-1.23
Problems	0.98	0.72-1.34

* The presence of bleeding from one or more mesial and buccal/midfacial sites per probing.
† Source: The National Health and Nutrition Examination Survey, 1999-2004.
‡ $P \leq 0.05$.
AOR, adjusted odds ratio; CI, confidence interval; FPL, federal poverty level; BMI, body mass index.

childbearing age in this study (7,27). It was not surprising to find no association between gingivitis and smoking, as active smoking reportedly suppresses hemorrhagic response as measured by bleeding on probing (28). Tribble *et al*. found hypovitaminosis C in 24% of current and 12% of those exposed to ETS, but not in non-exposed non-smokers despite adequate dietary vitamin C intake in the sample of female adults (29). The association found between low cotinine levels (<15 ng/mL) and gingivitis may, in part, be explained by the compromised plasma ascorbic acid concentrations in individuals who are exposed to tobacco smoke. Meanwhile, the masking effect of active smoking on bleeding in periodontal tissues might explain no association found between gingivitis and cotinine levels ≥15 ng/mL in our study.

Our ability to categorize the status of smoking had limitations that were associated with the validity of self-reported data. Although we attempted to verify the self-reported status of current smoking with a biological measure, i.e., cotinine levels, concern still remains, as individuals with high ETS exposures might present cotinine levels that overlap with those of occasional/light smokers. Furthermore, although the use of tobacco products other than cigarettes such as cigars, chewing tobacco and/or snuff, as well as tobacco replacement products, was not common among the sample (less than 1% prevalence), it may have contributed to the various cotinine levels. A future line of study could address these issues to gain a better understanding of the dose-dependent effect of active smoking and ETS on oral health.

Other limitations of this study include the use of cross-sectional data to examine possible relationships between smoking as well as cotinine levels and oral health. The case definition of periodontitis used in this study might have led to underestimation of the true proportion of individuals with disease, especially in younger women who were affected by mild periodontitis that could potentially progress to destructive periodontitis in the future. In addition, as the periodontal examination was done in half of the mouth and two buccal/facial sites per tooth were examined, underestimation of the disease is likely (7). It is also suggested that the lingual periodontal sites of teeth may be most affected by cigarette smoking (7). However, it is unlikely that underestimation of the disease might have masked an association between periodontitis

and smoking that was found in this study. In addition, X-rays were not taken; therefore, we may have underestimated DMFS by not measuring untreated caries in proximal surfaces.

A major strength of this study is that it utilized data from a large, nationally representative sample of US women who are ethnically diverse, thereby reducing the potential for selection bias. To our knowledge, this is the first study that examined the gender specific risk of smoking on the oral health of US women of childbearing age.

In conclusion, these data suggest that dental caries and periodontitis are prevalent among certain subgroups of women during reproductive age. Smoking was found to be a significant and modifiable risk indicator for various negative oral health outcomes in women of childbearing age. This result emphasizes the need for dental professionals to address tobacco use with their patients and to provide appropriate interventions as recommended in the US Public Health Service guideline *Treating Tobacco Use and Dependence* (30). Clearly, more collaborative research is needed to determine gender-specific risk indicators and intervention strategies so that every woman enters her pregnancy with optimal oral and general health. Furthermore, we should better understand barriers to accessing dental care that were manifested by untreated caries among Black women, mothers, and Medicaid beneficiaries to effectively facilitate policy and system changes.

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