Tobacco Use: A Modifiable Risk Factor for Dental Disease among the Elderly

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ABSTRACT

Objectives. Because the public health literature contains few analytic studies of modifiable behavioral risk factors for dental disease among older community-dwelling populations, the New England Elders Dental Study was undertaken as an epidemiologic study of the oral health status of a representative sample of older adults living within the six New England states.

Methods. Five dentists conducted comprehensive in-home oral health examinations on 1156 community-dwelling adults aged 70 and older to determine whether lifetime use of tobacco products was a significant risk factor for tooth loss, caries, and periodontal disease.

Results. Among New England elders, tobacco use was more common among men (18.1%) than women (7.9%), with a combined rate of 12.3%. Further, 64.7% of men and 36.6% of women were previous tobacco users. Years of exposure to tobacco products was a statistically significant risk factor for tooth loss, coronal and root caries, and periodontal disease, regardless of other social and behavioral factors.

Conclusions. Lifelong tobacco use is a modifiable risk factor for poor dental health among older adults. Dental practitioners need to intervene with all their adult patients to discourage use of tobacco products for oral as well as general preventive health care. (*Am J Public Health.* 1993;83:1271–1276)

Introduction

Recent demographic trends have focused attention on the oral health of older adults in the United States.[1,2] However, although many analytic studies in the public health field have examined sociodemographic characteristics such as age, race, sex, and socioeconomic status, relatively few have investigated the influence of modifiable behavioral and life-style characteristics on oral health in community-dwelling older populations. Thus, it is unclear whether the known social risk factors are associated with dental disease directly or indirectly through relationships with certain behavioral and life-style factors.[3]

Recent investigations of adult populations of all ages have identified the use of tobacco products as a consistent behavioral risk factor for poor dental health.[4–9] Using data on adults aged 25 to 74 from the first National Health and Nutrition Examination Survey (NHANES I), Ismail et al.[6] reported a significant association between smoking behavior and periodontal disease while controlling for age, income, oral hygiene, education, sex, and race. In a study of periodontal disease among a representative sample of Finnish adults aged 30 and older, smoking status was one of four factors associated with periodontal treatment costs. Smoking also emerged as a significant risk factor for periodontal disease among a sample of adults aged 20 to 70 in Tecumseh, Mich.[5]

Despite such findings, there have been few analytic studies of tobacco use and dental disease among older adults, a group, by virtue of advanced age, with potentially great exposure to tobacco products. In one comprehensive cross-sectional study of 690 dentate community-dwelling older Black and White adults in North Carolina, Beck and colleagues[10] reported significant periodontal disease associations for tobacco use while controlling for specific microorganisms, caries, a stress factor, and the individual's educational and economic characteristics, cognitive status, and frequency of visits to a dentist. In an analysis of 70-year-old adults living in Sweden, Osterberg and Mellstrom[11] identified tobacco smoking as a significant independent risk factor for tooth loss in elderly men. And in the only longitudinal study we could locate, Beck and colleagues[3] identified risk factors associated with the 18-month incidence of root caries among a sample of dentate adults, aged 65 and older, living in two Iowa counties, and found tobacco use to be significant in this regard.

These few existent studies in the United States and western Europe suggest that tobacco use is a significant risk factor associated with oral diseases among older adult populations, regardless of social and demographic factors. No study, however, has examined the impact of tobacco use across multiple dental disease conditions, and few studies have evaluated how duration of tobacco use affects dental health or determined whether the risk persists after use ceases.

The New England Elders Dental Study presented an opportunity to examine the association of lifetime tobacco use with dentate status, coronal and root caries, and periodontal disease in a representative sample of community-dwelling

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older adults while controlling for the major social and behavioral risk factors for dental disease reported in the literature. The major goal of the analysis was to test the hypothesis that lifetime use of tobacco was an important, modifiable risk factor for specific dental disease among older adults.

Methods

Sample

The study population consisted of community-dwelling elders aged 70 and older living within the six New England states. A two-stage stratified cluster sampling design was used. In the first stage, investigators sampled 68 cities and towns stratified by population size. In the second stage, the Health Care Financing Administration (HCFA) provided a 10% random sample of beneficiaries 70 years of age and older in each city/town, from which investigators randomly selected the final sample of 3668 individuals. The combined probability of selection was the same for all participants. The HCFA estimates that the beneficiary lists achieve a 97% coverage of the 65-and-over population.

Excluded from the study were those elders who had suffered a myocardial infarction or major cerebrovascular accident within the previous 6 months and individuals with severe dementia who were not deemed able to withstand the examination. Persons with mild to moderate dementia were included and, where appropriate in a few cases, proxy respondents provided the interview data. Excluded from the periodontal assessment were those individuals who met the American Heart Association criteria for being at risk for bacterial endocarditis or who had a prosthetic joint replacement.

Data Collection and Measures

A two-stage field design was used to collect data. First, telephone interviews were conducted to screen for study eligibility and to collect data regarding sociodemographic characteristics, perceived physical and oral health status, and use of dental care. Of the 2598 persons determined eligible for the study, 2057 (79%) completed the stage 1 telephone interview.

The second stage of data collection was conducted with respondents at home. This entailed an oral examination, in which any oral lesions as well as the number and location of teeth (including root tips) were identified; any decayed, missing, and filled tooth surfaces were assessed; and a full-mouth periodontal examination was conducted. The in-home interview also gathered additional data from the respondents' description of their health status, use of health care, and lifestyle behaviors. Respondents were asked if they currently smoked cigarettes, cigarillos, a pipe, or cigars or if they chewed tobacco. Those who currently or previously used any form of tobacco were coded as current or past tobacco users. Stage 2 was completed by 1156 participants—that is, by 56% of those completing stage 1 and 45% of all eligible respondents.

Demographic characteristics of the telephone and home visit participants were very similar to those of eligible nonparticipants. Compared with the population of New England Medicare beneficiaries, the home visit sample underrepresented the oldest women by 4% and overrepresented the youngest men by 1% to 4%; all other subgroup proportions were virtually coincident. Details on the sampling design are available elsewhere.[12]

The National Institute of Dental Research diagnostic criteria[13] for dental examinations provided the basic operational definitions for the coronal caries, root caries, and periodontal examination. The full-mouth periodontal examination was performed on all dentulous respondents who were assessed neither to be at risk for subacute bacterial endocarditis nor to have a prosthetic joint replacement. Probing depth and distance from the free gingival margin to the cementoenamel junction were measured at four sites per tooth: buccal, mesiobuccal, distolingual, and a "deepest" site (if greater than the previous three sites). There were no placement rules for the probe at the site of the "greatest" loss of attachment other than it be pointed toward the apex. This measure was similar to the community periodontal index of treatment needs used by the World Health Organization.[14] Of the three principal endpoints for this study, dentate status was determined in all 1156 subjects; caries was assessed in the 721 dentulous subjects and in 11 who had root tips only; and periodontal disease was assessed in 558 subjects who met the eligibility criteria.

For current users, the duration of tobacco use was computed by subtracting the age at which an individual reported having begun to use tobacco products from that individual's age at the time of the study. For previous users, direct information on years of use was not available. Therefore, we estimated the age at which an individual began using tobacco by taking the average age at which current tobacco users of the same age reportedly began their habit, and we subtracted this value from the age at which the previous users stopped using tobacco.

Table 1 describes the operational definitions for all variables used in these analyses. For the independent variables as well as for edentulism, those definitions are self-explanatory. Current decay was defined as decayed coronal and root surfaces. Root decay was defined as one or more decayed root surfaces because it was a relatively rare condition in this sample.[15] Three or more decayed coronal surfaces was used as the cutoff because this extent of decay represented a relatively small proportion of the sample (11%) with most of the coronal disease (70%).[16] A cutoff of a more than 4-mm pocket depth was used to measure periodontal disease, consistent with the operational definition used in the National Institute of Dental Research reports and other periodontal disease literature.[10,17]

Reliability

Four oral epidemiology postdoctoral fellows and one full-time gerodontist who were licensed dentists in New England served as the dental examiners throughout the study. Intra- and interexaminer consistency was established initially through a series of training and calibration sessions held at the Harvard School of Dental Medicine. The actual level of interexaminer reliability achieved was evaluated by conducting in-home reexaminations on 51 subjects (4%) who participated in the New England Elders Dental Study in-home examination. The primary examiner was blinded as to the subject's eligibility for a secondary examination, which was scheduled within 1 week after the primary examination. Interexaminer reliability for coronal and root caries remained high throughout the study (κ = .67 for root caries and .86 for coronal caries). The intraclass correlation for the probing depth measure was .65. The Kappa estimates for locating the site on the tooth with the deepest pocket depth and the corresponding greatest loss of attachment were .53 and .52, respectively.

Statistical Methods

Edentulism and current decay, as dichotomous endpoints, were analyzed by multiple logistic regression whereas periodontal disease (measured by the number of affected teeth) was analyzed by multi-

ple linear regression. Backward and forward stepwise regression produced identical sets of statistically significant predictors. Backward regressions were examined step by step, and alternative models were constructed to rule out any misleading effects of collinearity among predictors.

Results

Among New England elders, tobacco use was more common among men than women (Table 2). The combined rate of use for the overall sample was 12.3%. Among tobacco users, cigarette smoking was the most common form of use for both men and women. Among smokers, men and women reported an average daily consumption of 14 cigarettes. A substantial proportion of the sample (64.7% of men and 36.6% of women) had used tobacco products at some time in their lives but had stopped by the time of the study.

Figure 1 illustrates the bivariate association between tobacco use and dentate status. The highest rate of total edentulism was found among current tobacco users (45.7%), as compared with subjects who never used (34.4%) or who previously used (38.0%) tobacco products. Table 3 shows the odds ratios for edentulism and current decay in smokers, ex-smokers, and never smokers in this sample.

Duration of tobacco use (current or past) was the only variable that entered significantly into the predictive models for all three endpoints: edentulism, current decay, and periodontal disease (Table 4). The odds of edentulism, as modeled by logistic regression, were increased by longer duration of tobacco use (past or present) as well as by lower education, fewer visits to the dentist, poorer physical functioning, and better general health. No tobacco-related variable other than duration of use had significant predictive power for edentulism. When potential confounders were added to the model (Table 5), none was statistically significant after controlling for duration of use, whereas duration of use remained significant after controlling for any of the confounders. Goodness-of-fit criteria were all satisfactory. Elimination of 21 outliers improved the fit but did not alter the structure of the model concerning tobacco use. Odds of edentulism increased with years of use at an equal cross-sectional rate in current and past users (χ^2 for interaction < 1.1, $P > .30$).

Logistic regression showed the odds of current decay increasing with duration

TABLE 1—Definitions of Variables Used in Regression Analyses

	Operational Definition
Independent variables	
Age	In years at time of exam
Sex	0 = female, 1 = male
Education	Years of education: 1 = 0–11, 2 = 12, 3 = 13–15, 4 = 16+ years
Urban region	A dummy taking a value of 1, if the individual lived in an urban setting; otherwise = 0
Suburban region	A dummy taking a value of 1 if the individual lived in a suburban setting; otherwise = 0
Number of teeth	0–28
Number of dentate arches	0, 1, or 2
General health	1 = excellent, 2 = very good, 3 = good, 4 = fair, 5 = poor
Physical function	0–12 on the Medical Outcomes Study scale where 0 = lowest function and 12 = highest function
Visits to dentist	In previous 12 months (up to six)
Past smoking	0 = no, 1 = yes
Duration of tobacco use	0–75 years of using one or more forms of tobacco for current and past users
Current smoking	0 = no, 1 = yes
Dose	Current cigarettes per day
Oral hygiene	Number (0–3) of the following oral hygiene practices performed: brush, floss, stimulate gums
Dependent variables	
Edentulism	0 = one or more teeth, 1 = no teeth
Current decay	0 = no root surfaces and < 3 coronal surfaces decayed 1 = any root surface or ≥3 coronal surfaces decayed
Periodontal disease	Number of teeth with a pocket deeper than 4 mm

TABLE 2—Tobacco Use among New England Elders Aged 70 Years and Older

	Men (n = 496)		Women (n = 658)		Total (= 1154)	
	No.	%	No.	%	No.	%
Current user	90	18.1	52	7.9	142	12.3
Cigarettes	51	10.3	51	7.8	102	8.8
Cigarillos	1	0.2	0	0.0	1	0.1
Pipe	22	4.4	0	0.0	22	1.9
Cigars	29	5.8	0	0.0	29	2.5
Chew tobacco	10	2.0	1	0.2	11	1.0
Previous user	321	64.7	241	36.6	562	48.7
Never used tobacco	85	17.1	365	55.5	450	39.0

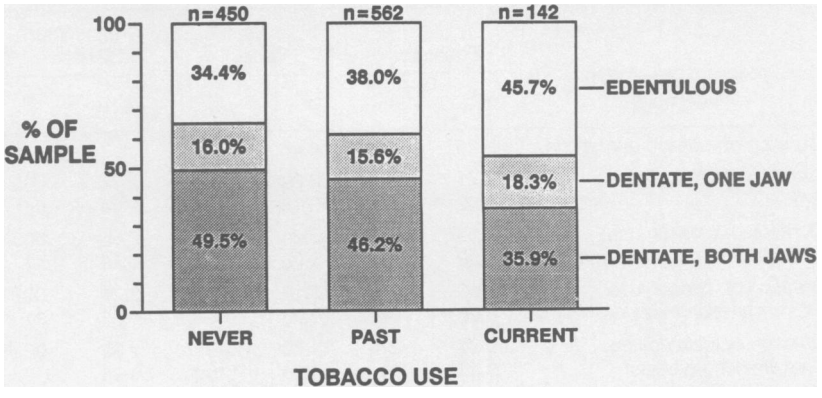


FIGURE 1—Dentate status of adults aged 70 years and older living in New England, by tobacco use.

TABLE 3—Odds Ratios (ORs) for Edentulism and Current Decay in Smokers, Ex-Smokers, and Never-Smokers Aged 70 to 96 Years

	Edentulism		Current Decay	
	OR	95% CI	OR	95% CI
Current smoker[a]				
Male	1.68	1.16, 2.44	1.52	0.90, 2.58
Female	1.70	1.12, 2.57	1.59	0.84, 3.00
All	1.55	1.19, 2.02	1.47	1.00, 2.17
Ex-smoker[a]				
Male	1.10	0.82, 1.47	1.31	0.88, 1.97
Female	0.78	0.59, 1.04	0.81	0.53, 1.25
All	0.88	0.73, 1.06	1.02	0.78, 1.34
Never smoked[a]				
Male	0.54	0.36, 0.82	0.50	0.29, 0.88
Female	0.75	0.57, 0.99	0.77	0.52, 1.16
All	0.73	0.60, 0.89	0.67	0.50, 0.89

Note. CI = confidence interval.
[a]Odds ratio compared with all smoking categories combined.

TABLE 4—Predictors of Dental Conditions in New Englanders Aged 70 to 96 Years, Based on Subjects with Complete Data

	Edentulism (n = 955)		Current Decay (n = 601)		Periodontal Disease (n = 465)
	OR	95% CI[a]	OR	95% CI[a]	Number of Affected Teeth[b]
Duration tobacco use, per 10 y	1.11	1.04, 1.19	1.10	1.01, 1.20	0.19 ± 0.07
General health scale, per unit	0.81	0.69, 0.96	1.52	1.27, 1.83	...
Sex, male–female		...		...	0.60 ± 0.30
Visits to dentist, per visit	0.41	0.35, 0.49		...	...
Education scale, per unit	0.63	0.54, 0.74		...	...
Hygiene, per practice		...	0.68	0.52, 0.88	−0.81 ± 0.18
Number of teeth, per tooth		...		...	0.14 ± 0.02
Urban residence, urban–other		...		...	0.81 ± 0.28
Physical function scale, per unit	0.93	0.88, 0.99		...	...

Note. Ellipses indicate not significantly different from null effect, $P > .05$. OR = odds ratio; CI = confidence interval.
[a]Odds ratios and confidence intervals obtained from logistic regression.
[b]Linear regression coefficient ± SE.

TABLE 5—Duration of Tobacco Use: Comparison with Potential Confounders as to Statistical Significance in Regression Analysis of Dental Conditions[a]

Predictors Included in Regression	Edentulism		Current Decay		Periodontal Disease[b]	
	χ^2_1	P	χ^2_1	P	t_1	P
Duration of tobacco use, alone	8.76	.003	4.46	.03	[b]	
Duration of tobacco use	9.71	.002	3.09	.08	2.74	.006
Sex	1.02	.31	0.48	.49	2.04	.04
Duration of tobacco use	6.36	.01	2.44	.12	2.86	.005
Current dose (cigarettes/day)	0.20	.65	1.06	.30	−0.83	.41
Duration of tobacco use	6.50	.01	3.12	.08	2.71	.007
Current smoking (yes/no)	0.00	.98	0.02	.88	−0.65	.51
Duration of tobacco use	8.24	.004	2.72	.10	2.33	.02
Past smoking (yes/no)	0.33	.56	0.15	.70	0.18	.85

[a]Controlling for all other variables in the regression model.
[b]All periodontal models include sex.

of tobacco use (current or past), poorer health, and less practice of oral hygiene (Table 4). The duration variable consistently outperformed its potential confounders (current use, current dose, past use, sex) when entered together with them in regression models, but its predictive power dropped below the conventional cutoffs for statistical significance when the competing variable was controlled for (Table 5). Goodness-of-fit was satisfactory in relative terms but not in absolute terms, suggesting that other variables outside our list of predictors may be important.

Periodontal disease, modeled by linear regression of the number of affected teeth, was predicted by longer duration of tobacco use, male sex, and less practice of dental hygiene (Table 4). Additionally, the mean number of affected teeth was higher in urban areas and increased in proportion to the subject's total number of teeth. Men had 0.60 more affected teeth than women on the average. As in the case of edentulism, no tobacco-related variable predicted periodontal disease significantly when duration of use (past or present) was controlled for, whereas duration of use remained a strong predictor after the other tobacco variables were controlled for (Table 5). Goodness-of-fit criteria were satisfactory, as were residual patterns. The dependency on duration applied to both current and past users, as illustrated in Figure 2. The number of additional affected teeth per year of use did not differ between current and past smokers (statistical test for interaction: $|t| < 1, P > .30$).

Discussion

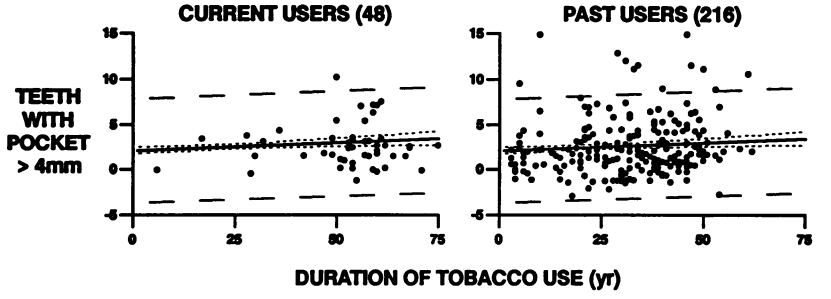
The deleterious effects of tobacco use on morbidity and mortality among older adults are well known.[18] The impact of tobacco use on the extent of dental disease in older adults, however, is not well documented. Our results, along with previous research, confirm that exposure to tobacco is a significant, modifiable risk factor for tooth loss, current decay, and periodontal disease in older adults, independent of selected social and behavioral risk factors. In the New England Elders Dental Study sample, duration of tobacco use was related to three different dental disease indicators. To our knowledge, this is the first investigation that has documented the impact of tobacco use on three different indicators of poor oral health among a sample of older adults representative of an entire region of the country.

Duration of tobacco use among current and past tobacco users was consis-

tently associated with dental diseases. Duration of use remained a significant risk factor in oral health after controlling for any of the confounders included in our analyses. That exposure to tobacco products remains a risk factor when controlling for oral hygiene, dental visits, age, sex, education, physical function, and overall health suggests that the observed difference in dental disease status was indeed related to long-term exposure to tobacco and not to potential confounding effects. This consistent finding stands in contrast to Ismail et al.'s[6] finding using the NHANES I data set, in which duration of cigarette smoking among adults aged 25 to 74 was not significantly associated with periodontal disease after controlling for potential confounding factors. In the Ismail study, current dose of tobacco use was a stronger risk factor for oral disease among adults than was years of exposure to tobacco. The different findings in the New England and Ismail studies may largely be due to the different age distribution of the two samples. Among the New England sample, which had a mean age of 80, years of exposure to tobacco products may have been far more important than dosage at the time of the study. This interpretation is supported by Osterberg and Mellstrom's work,[11] in which duration of exposure to tobacco among 70-year-olds was significantly related to loss of teeth.

Although duration of tobacco use emerged as a consistent modifiable risk factor for dental disease among older persons, a relatively modest magnitude of increased risk was observed. With respect to risk for edentulism and current decay, 20 years of tobacco use was associated with an approximately 20% increase in the risk of each of these conditions. For periodontal disease, an average increase of 0.2 affected teeth was associated with every decade of tobacco use. Nonetheless, the public health implications are impressive in a sample that exhibited, on average, more than a quarter of a century of tobacco use.

The finding that poor physical functioning was related to loss of teeth is new and disturbing. To our knowledge, this association has not been shown in previous research on dental disease in the elderly. Disabled older adults represent a special, high-risk population in which chronic conditions and their medical treatment may either alter the person's ability to maintain adequate self-care or raise barriers to that person's receiving competent and timely professional care for emerging oral problems. The fact that functional disability remained a significant predictor after controlling for the effects of overall health, oral hygiene, and visits to the dentist suggests that both the meaning of this relationship and the mechanism of impact are complex. This result clearly deserves further investigation and scrutiny.



Note. Relation was observed in both current and past tobacco users. Data adjusted for covariates, viz, number of teeth, hygiene practices, area of residence, and sex. Solid line is fitted regression. Dashed lines indicate 95% confidence band for true line (inner) and one observation (outer).

FIGURE 2—Association of lifetime tobacco use with periodontal disease, as measured by number of teeth with gingival pocket > 4 mm.

The association of worsening health with increased risk of decay is consistent with existing literature[19,20] that has identified poor health status as a risk factor for dental disease among the elderly. The positive relationship between general health and edentulism is inconsistent with past research[20] and is likely to be an artifact of the confounding of a lifetime pattern of dental care use with health status.

As in all investigations, there are limitations to the New England Elders Dental study. Although it focused on a representative sample of community-dwelling older persons living in an entire region of the United States, it was cross-sectional. Therefore, we cannot draw cause-and-effect conclusions because the time sequence between the potential risk factors and the oral health indices cannot be determined. Nonetheless, cross-sectional findings on representative samples can strongly suggest causal relationships when potential confounding variables are included, as they were in this analysis.

The representative nature of the sample adds further strength to the findings. Although the two-stage field design presents the potential for bias by introducing the possibility of study nonresponse at two points in the data collection, our comparison of study participants with Medicare beneficiaries in the study area indicated that the sample was indeed a representative group.[12] Therefore, we are confident in the generalizability of these findings to older adults in New England, and we consider the findings likely to be representative of older adults throughout the country.

The consistent, unambiguous findings from the New England Elders Dental Study confirm that tobacco use is a major risk factor for poor oral health among older adults. More importantly, these data suggest that the effects of extended tobacco use are not reversible. The findings have at least two implications for dental care. In older adults, years of tobacco use can be used for screening and assessment to indicate the need for dental examination and treatment. Although encouraging older smokers to quit using tobacco is certainly indicated, these data suggest that, for lifelong smokers, the damage is already done and the most important intervention is secondary, not primary, prevention. However, a primary prevention approach for younger adult populations is clearly indicated. Dental disease should be added to the list of health conditions for which tobacco use is a high-risk behavior. Dentists should both discourage use of tobacco products and encourage cessation for patients who smoke. □

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