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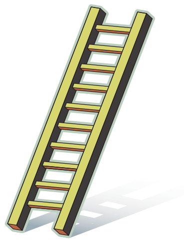

Adult Oral Health Status in California, 1995-2006: Demographic Factors Associated With Tooth Loss Due to Disease

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ABSTRACT The most recent 2006 estimates indicate that 60 percent of California adults did not experience tooth loss due to disease. However, about 39 percent were missing one or more teeth due to disease, and another 1 percent were edentulous. In an 11-year (1995-2006) pooled multivariate analysis, California adults who were older, less educated, racial/ethnic minorities, current or former smokers, or had lower annual incomes were more likely to be missing teeth. .

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Tooth loss due to disease and pain from preventable dental problems can have dramatic negative long-term effects on oral health and quality of life due to decreased ability to function and perform important everyday activities like chewing, eating, smiling, laughing, and talking. Oral diseases are progressive, chronic diseases, and if not detected and treated in the early stages, may become more difficult, painful, and costly to treat.[1] Advanced oral disease can result in tooth loss, or, in some cases, edentulism.

Despite the improvements in the nation's oral health in recent decades overall, significant levels of oral diseases still persist and are concentrated among the socioeconomically disadvantaged, many racial/ethnic minority groups, and the elderly.[1-3] While tooth loss due to disease has also generally declined, not all adults have been able to retain all their natural teeth.[4-6]

The United States has set several goals with specific targets to promote the nation's oral health, improve quality of life, and work to eliminate disparities. Healthy People 2010 Oral Health Objective No. 21-13 specified the need to increase the proportion of adults to 42 percent who have never had a permanent tooth extracted because of dental caries or periodontal disease.[7]

Baseline estimates indicated that only 31 percent of adults aged 35 to 44 years never had a permanent tooth extracted because of dental caries or periodontal disease in 1988-94. There is a need for current, state-specific empirical evidence assessing adult oral health and tooth loss to monitor California's progress in reaching the 2010 goals, and inform the establishment of new Healthy People 2020 goals.

Although it would be ideal to assess every adult's overall oral health status through clinical evaluations by a licensed dentist, this approach is prohibitively expensive and impractical when surveying such large population groups like the state of California.[8] Instead, a simple measure of oral health that can be accurately determined in telephone surveys and gives a good approximate picture of the oral health of a population is used. This measure is the self-reported number of teeth that an adult is missing due to disease.

A study by Lang et al. compared the measure of teeth missing due to disease with the Oral Health Status Index, OHSI, that combines information from a clinical examination of the teeth and the periodontium into an overall score of -54 to 100.[9] This OHSI was developed by Marcus et al. and validated in both general and minority populations.[10,11] Lang et al. found that the measure of missing teeth, a component of the OHSI, performed almost as well as the OHSI.[9] Additionally, collecting self-reported information about dentition via telephone has been validated among samples of adults over the age of 45 and elderly over the age of 70.[12,13]

The number of missing teeth due to disease is measured in the Behavioral Risk Factor Survey, BRFS. Recent age-adjusted California-specific estimates of missing teeth used 2002 and 2004 BRFS data and focused on the elderly, adults aged 65 and over. In 2002, California was among the top three states nationwide in terms of retention, with 60.5 percent of elderly retaining most of their natural teeth (defined in that analysis as losing five or fewer teeth to disease) and only a 13.3 percent edentulism rate.[6] The National Oral Health Surveillance System, NOHSS, estimated that 36.3 percent of California's elderly were missing six or more teeth due to disease, and a 13.8 percent edentulism rate in 2004.[14] However, more detailed current oral health status information about the entire California adult population that can account for the effects of financial and sociodemographic factors is needed.

PAST STUDIES INDICATE that tobacco use increases the risk of tooth loss over time, and cross-sectional comparisons show that smokers tend to have fewer teeth than their nonsmoking adult counterparts.

Several factors have been associated with tooth loss in the literature. In 10-year longitudinal studies in two cities, Copeland et. al. reported that baseline percentage of restored teeth, pocket depth, age, tobacco use, alcohol consumption, number of teeth present, and male gender were predictors of tooth loss, yet there were differences by population.[15] In another study analyzing data from the Third National Health and Nutrition Examination Survey, NHANES III, Marcus et. al. reported that age and race/ethnicity were related to tooth loss and retention, with non-Hispanic blacks generally experiencing the highest rates of loss.[4]

Californians are an especially socioeconomically and demographically diverse group. In order to accurately understand the oral health of Californians this diversity must be taken into account. To do so, the authors used statistical techniques that allowed for the examination of the relationship between oral health and key sociodemographic characteristics of individuals. The California BRFS also includes information on behaviors and health risk factors. Smoking status was also examined as an oral health risk factor in the models. Past studies indicate that tobacco use increases the risk of tooth loss over time, and cross-sectional comparisons show that smokers tend to have fewer teeth than their nonsmoking adult counterparts.[15-17]

This paper presents estimates of the probabilities in each category of adults in California missing teeth due to disease (no missing teeth, missing one to five teeth, missing six more teeth (but not all), and edentulous) using all available data over an 11-year span (using seven years of data), as well as examines the factors associated with varying levels of tooth loss, a proxy for oral health status.

Methods

The authors analyzed California Behavioral Risk Factor Survey, BRFS, data, a survey designed by the U.S. Centers for Disease Control and Prevention to produce reliable state-level estimates of behaviors that are associated with premature morbidity and mortality. Oral health questions are an optional module in the BRFS and are not required to be included by states every year. The authors analyzed data for the years 1995, 1997, 1999, 2000, 2002, 2004, and 2006, all years in the last 11-year period which included oral health information. Data were collected from adults

aged 18 and older through a monthly random digit dial telephone survey.

The California BRFS has a sample size of about 4,000 per year, giving a total sample size of 27,693 adults across the 11-year period. Pooling the data across the seven available years provided more statistical power for multivariate analyses, and enabled the detection of trends over a period of time or significant changes in a given year. The year 1995 was selected as the baseline in the pooled analyses. Additional detailed information about the California survey and data collection methods are available elsewhere.[18]

The number of missing teeth due to disease was the main measure of oral health status for the population for adults in California. The BRFS survey question asked "How many of your permanent teeth have been removed because of tooth decay or gum disease? Include teeth lost to infection, but do not include teeth lost for other reasons, such as injury or orthodontics." The measure of missing teeth due to disease used in this study thus excluded teeth removed in the course of orthodontic treatment, teeth removed due to injury, and wisdom teeth removed for reasons other than tooth decay and gum disease. The data allowed for four levels of oral health analysis with regard to missing teeth: (1) no missing teeth, (2) one to five missing teeth, (3) missing six teeth or more, but not all, and (4) all teeth missing (edentulism). The few cases who refused to answer or did not know how many teeth they lost to disease were excluded.

The sociodemographic characteristics used in the analysis were as follows: age intervals (18-24, 25-34; 35-44; 45-54; 55-64, 65-74, and 75 or greater), gender (male, female), race/ethnicity (white, Asian/Pacific Islander, Hispanic, black, or other race), marital status (unmarried, married), smoking status (never, current, former smoker), annual household income intervals (less than $10,000, $10,000-14,999, $15,000-19,999, $20,000-24,999, $25,000-34,999, $35,000-49,999, $50,000-74,999, $75,000 or more), household size (one, two, three, or four or more) and education status (less than high school, high school graduate, post-high school training, college graduate, post-college).

The authors estimated the independent probability of each of sociodemographic characteristic being associated with the number of teeth a person was missing using ordered probit regression models for the 11-year pooled sample of 1995-2006 data. All analyses were conducted using Stata 9.2 statistical software and incorporated probability weighting.[19] Probability weights were standardized to the population of California according to the 2000 U.S. Census using weights supplied by the Survey Research Group, which is a section under the California Department of Public Health's Chronic Disease Surveillance and Research Branch. SRG is also a program of the Public Health Institute.

THE NUMBER OF missing teeth due to disease was the main measure of oral health status for the population for adults in California.

The actual ordered probit output that reports a single equation along with multiple cut-points (one less the number of ordered categories) is not reported since it is not immediately interpretable. Rather, the authors used the ordered probit coefficients and the appropriate cut-points to compute marginal probabilities on a scale from 0 to 1 (so a marginal probability of, for example, 0.05, implies a five percentage points increase in the probability that a person is included in the category of missing teeth being examined). That is to say, if being older increases the probability of having missing teeth by 5 percentage points, it does so for the person of average income, race, and other demographics. It does not take into account that older people may subsequently have more money and are predominantly of one gender.

Marginal probabilities were computed at the mean of the other independent variables. These estimates were used to then predict the overall probabilities of four select sociodemographic subgroups of adults missing one to five teeth or six or more, but not all teeth. These diverse subgroups were constructed for illustrative purposes to emphasize the variation in tooth loss among California adults of different sociodemographic backgrounds using data only from 2006. These are not the only subgroups that could have been chosen, but portray various groups of individuals in California. We purposively do not simply vary only one characteristic in presenting these subgroups, and selected different subsets of characteristics.

Results

Analysis of the most current single year, 2006, California BRFS data showed that approximately 40 percent of adults in the state suffer from reduced oral health status, that is, they are missing one or more teeth due to disease. Approximately 1 percent are edentulous, suffering the loss of all teeth. Another 5 percent suffer from the loss of six or more, but not all, teeth. Finally, approximately 33 percent suffer from the loss

of one to five teeth. **TABLE 1** presents the weighted means for the entire sample (years 1995, 1997, 1999, 2000, 2002, 2004, and 2006). Tooth loss estimates across the entire sample over the 11-year span were slightly higher, with about 44 percent of adults suffering from reduced oral health status. A higher proportion were edentulous (3.64 percent), just over 9 percent lost six or more teeth, and about 31 percent of adults were missing one to five teeth during the study period.

TABLE 2 presents the probabilities that adults in California with different characteristics will have differing numbers of teeth missing due to disease. In the analysis that follows, several socioeconomic and smoking behavior variables are related to each of the following dependent variables: (1) no missing teeth, (2) one to five missing teeth, (3) six or more missing teeth (but not all), and (4) all missing teeth. For each socioeconomic variable, a reference group is omitted. Each value for the socioeconomic variable should be understood as the probability (in percentage points) that a person of that characteristic will be missing teeth relative to the reference group. For example, for the socioeconomic variable "sex," "male" has been omitted. This means the coefficient reported for female should be interpreted as the additional probability (in percentage points) that females of a certain characteristic are missing teeth as compared to the reference group.

In column 2 of **TABLE 2**, the authors found that, in general, the older a person is, the more likely they are to have lost one to five teeth due to disease. Those aged 25 to 34 are 12.6 percentage points more likely, those 35 to 44 are 18.0 percentage points more likely, those aged 45-54 are 17.1 percentage points more likely, and those aged 55 to 64 are 7.3 percentage points more likely than those aged 18-24 (the reference group) to have lost one to five teeth due to disease. Those 65 and older are not more likely than those aged 18-24 to have lost one to five teeth due to disease. Of course, this is not because the teeth of adults over age 65 are as healthy as those in the reference group — but because adults over age 65 tend to experience more tooth loss and be in the next and more severe category, loss of six or more (but not all) teeth due to disease.

In column 3 of **TABLE 2**, the authors found, even more so than above, that the older a person is, the more likely they are to have lost six or more teeth (but not all) due to disease. Those aged 25 to 34 are 7.4 percentage points more likely, those 35 to 44 are 13.6 percentage points more likely, those aged 45-54 are 20.9 percentage points more likely, those aged 55 to 64 are 27.3 percentage points more likely, those aged 65 to 74 are 28.7 percentage points more likely, and those aged 75 and older are 27.7 percentage points more likely than those aged 18-24 to have lost six or more teeth (but not all) due to disease.

Compared to the white reference group, every other racial/ethnic group

TABLE 1

Weighted Sample Proportions, 1995-2006 California Behavorial Risk Factor Survey

Variables	Weighted sample proportions
GENDER	
Male	49.33%
Female	50.67%
AGE GROUP	
18-24	13.70%
25-34	20.88%
35-44	21.98%
45-54	17.72%
55-64	11.23%
65-74	8.49%
75+	6.00%
RACE/ETHNICITY	
White	51.81%
Black	6.29%
Asian/Pacific Islander	11.23%
Hispanic	28.21%
Other	2.46%
EDUCATION	
Less than high school	16.36%
High school diploma	24.12%
Some post-high school	27.60%
College graduate	20.37%
Post-college	11.55%
ANNUAL HOUSEHOLD INCOME	
< $10,000	10.00%
$10,000-$14,999	8.24%
$15,000-$19,999	7.52%
$20,000-$24,999	7.81%
$25,000-$34,999	11.86%
$35,000-$49,999	15.04%
$50,000-$74,999	16.49%
$75,000 and above	23.03%
HOUSEHOLD SIZE	
One	12.34%
Two	28.66%
Three	18.27%
Four or more	40.70%
MARRIED	
Yes	60.96%
No	39.04%
SMOKER STATUS	
Never	57.57%
Current	16.94%
Former	25.49%
TEETH MISSING	
None	55.80%
1 to 5	31.44%
6 or more (but not all)	9.11%
All	3.64%

considered was more likely to be missing teeth due to disease. In column 2, **TABLE 2**, blacks are 8.4 percentage points more likely, Asian/Pacific Islanders are 10.3 percentage points more likely, Hispanics are 1.4 percentage points more likely, and those of other races are 6.5 percentage points more likely than whites to be missing one to five teeth. In column 3, **TABLE 2**, blacks are 4.8 percentage points more likely, Asian/Pacific Islanders are 6.2 percentage points more likely, Hispanics are 0.6 percentage points more likely, and those of other races are 3.6 percentage points more likely than whites to be missing six or more (but not all) teeth.

Education is also associated with tooth loss due to disease, and a social gradient is apparent. With increasing education, there is a decreasing likelihood of tooth loss due to disease. High school graduates were 3.0 percentage points less likely, those who have attended some college are 7.5 percentage points less likely, and those who have graduated from college are 11.5 percentage points less likely, and those who have post-college education are 14.6 percentage points less likely to have lost one to five teeth due to disease relative to those with less than high school education. In column 3, **TABLE 2**, high school graduates are 1.2 percentage points less likely, those who have attended some college are 2.8 percentage points less likely, and those who have graduated from college are 4.0 percentage points less likely, and those who have post-college education are 4.5 percentage points less likely to have lost six or more (but not all) teeth due to disease relative to those with less than high school education.

Annual income is related with the loss of teeth due to disease. Only those individuals with family incomes greater than $25,000 annually are less likely to be missing teeth due to disease. As with education, there is an inverse relationship between annual income and likelihood of tooth loss that follows a social gradient pattern. Those earning in the $25,000-34,999 range annually are less likely to be missing one to five (5.1 percentage points) or six or more teeth (but not all) (1.9 percentage points) relative to those whose family income is less than $10,000 annually (reference group).

Those earning in the $35,000-49,999 range annually are less likely to be missing one to five (9.0 percentage points) or six or more teeth (but not all) (3.2 percentage points) relative to those in the reference group. Those in the next highest income bracket of $50,000-74,999 are less likely to be missing one to five (10.1 percentage points) or six or more teeth (but not all) (3.5 percentage points) relative to those in the reference group. The high end of the income range, those earning $75,000 and above annually are less likely to be missing one to five (15.1 percentage points) or six or more teeth (but not all) (5.1 percentage points) relative to those in the reference group.

> **ONLY THOSE** individuals with family incomes greater than $25,000 annually are less likely to be missing teeth due to disease.

Finally, smoking, both current smokers and former smokers, is associated with the loss of teeth due to disease. In columns 2 and 3 of **TABLE 2**, current smokers are far more likely than former smokers to have lost six or more (but not all) teeth. Current smokers are 10.2 percentage points more likely, while former smokers are only 6.4 percentage point more likely to have lost one to five teeth relative to those who have never smoked. Current smokers are 5.9 percentage points more likely, while former smokers are only 3.0 percentage point more likely than those who have never smoked to have lost six or more teeth (but not all) relative to those who have never smoked.

No significant associations were found for household size, marital status, or the year variables in the regression models.

Next, the authors assessed the variation in oral health status across four different specific socioeconomic subgroups of adults in 2006 the pooled ordered probit model. These subgroups are for purposes of illustration only and were chosen to show the diversity in the likelihood of missing teeth across different groups and help understand the socioeconomic variation.

The first subgroup was made up of white males, aged 45-54, who have post-college education, have incomes in the $50,000-74,999 range, have never smoked, and are married. The second subgroup was made up of black females, aged 25-34, who have a high school education, incomes between $35,000-49,999, are current smokers, and are unmarried. The third subgroup was made up of Hispanic males, aged 35-44, who have less than a high school education, incomes between $10,000-14,999, are current smokers, and are married. The final subgroup was made up of Asian females, aged 65-74, who have some college education, incomes between $20,000-24,999, have never smoked, and are unmarried.

As can be seen in **TABLE 3**, these subgroups vary a great deal in the overall probability that will they fall into a given category with regard to missing teeth.

TABLE 2

Pooled CA BRFS Model (1995-2006), 1995 as Base Year Marginal Probability (Standard Error)

Characteristics	Column (1) No Missing Teeth	Column (2) Missing 1-5 Teeth	Column (3) Missing 6+ But Not All	Column (4) Missing All Teeth
Female	-0.0237***	0.0155***	0.00658***	0.00161***
	(0.0081)	(0.0053)	(0.0022)	(0.00056)
Age 25-34	-0.222***	0.126***	0.0736***	0.0225***
	(0.018)	(0.0087)	(0.0070)	(0.0029)
Age 35-44	-0.367***	0.180***	0.136***	0.0510***
	(0.016)	(0.0058)	(0.0079)	(0.0045)
Age 45-54	-0.487***	0.171***	0.209***	0.107***
	(0.014)	(0.0047)	(0.0091)	(0.0080)
Age 55-64	-0.564***	0.0731***	0.273***	0.218***
	(0.010)	(0.010)	(0.0085)	(0.014)
Age 65-74	-0.594***	-0.0212	0.287***	0.328***
	(0.0076)	(0.013)	(0.0077)	(0.019)
Age 75+	-0.590***	-0.0847***	0.277***	0.397***
	(0.0063)	(0.014)	(0.0081)	(0.021)
Black	-0.146***	0.0835***	0.0483***	0.0144***
	(0.015)	(0.0075)	(0.0061)	(0.0022)
Asian/Pacific Islander	-0.184***	0.103***	0.0619***	0.0190***
	(0.016)	(0.0070)	(0.0067)	(0.0026)
Hispanic	-0.0220**	0.0143**	0.00619*	0.00154*
	(0.011)	(0.0071)	(0.0032)	(0.00080)
Other race/ethnicity	-0.111***	0.0654***	0.0358***	0.0103**
	(0.034)	(0.017)	(0.012)	(0.0042)
High school	0.0444***	-0.0297***	-0.0119***	-0.00284***
	(0.014)	(0.0094)	(0.0036)	(0.00086)
Some post-high school	0.110***	-0.0746***	-0.0286***	-0.00664***
	(0.014)	(0.0095)	(0.0034)	(0.00084)
College graduate	0.164***	-0.115***	-0.0402***	-0.00890***
	(0.015)	(0.011)	(0.0033)	(0.00085)
Post-college	0.200***	-0.146***	-0.0452***	-0.00938***
	(0.015)	(0.012)	(0.0030)	(0.00074)
$10,000-$14,999	-0.0285	0.0183	0.00816	0.00207
	(0.020)	(0.013)	(0.0060)	(0.0016)
$15,000-$19,999	0.0135	-0.00890	-0.00368	-0.000887
	(0.018)	(0.012)	(0.0049)	(0.0012)
$20,000-$24,999	0.0161	-0.0107	-0.00438	-0.00105
	(0.017)	(0.012)	(0.0047)	(0.0011)

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$25,000-$34,999	0.0741***	-0.0507***	-0.0190***	-0.00434***
	(0.016)	(0.012)	(0.0039)	(0.00083)
$35,000-$49,999	0.129***	-0.0903***	-0.0317***	-0.00699***
	(0.015)	(0.011)	(0.0033)	(0.00074)
$50,000-$74,999	0.144***	-0.101***	-0.0351***	-0.00772***
	(0.015)	(0.011)	(0.0033)	(0.00076)
$75,000 and above	0.214***	-0.151***	-0.0513***	-0.0113***
	(0.015)	(0.012)	(0.0034)	(0.00091)
Household size = 2	-0.00247	0.00161	0.000685	0.000168
	(0.012)	(0.0076)	(0.0032)	(0.00080)
Household size = 3	-0.00611	0.00399	0.00170	0.000420
	(0.014)	(0.0093)	(0.0040)	(0.00099)
Household size = 4+	-0.0228	0.0148	0.00635	0.00157
	(0.014)	(0.0094)	(0.0041)	(0.0010)
Married	-0.0137	0.00899	0.00380	0.000928
	(0.010)	(0.0066)	(0.0028)	(0.00069)
Current smoker	-0.178***	0.102***	0.0590***	0.0177***
	(0.010)	(0.0052)	(0.0043)	(0.0017)
Former smoker	-0.102***	0.0636***	0.0303***	0.00802***
	(0.0094)	(0.0057)	(0.0030)	(0.00094)
Year 1997	-0.0143	0.00929	0.00403	0.00100
	(0.013)	(0.0082)	(0.0036)	(0.00092)
Year 1999	-0.0114	0.00743	0.00321	0.000795
	(0.013)	(0.0083)	(0.0036)	(0.00091)
Year 2000	-0.000299	0.000196	0.0000830	0.0000203
	(0.013)	(0.0087)	(0.0037)	(0.00090)
Year 2002	0.0124	-0.00816	-0.00339	-0.000821
	(0.013)	(0.0084)	(0.0034)	(0.00082)
Year 2004	0.0159	-0.0105	-0.00436	-0.00105
	(0.013)	(0.0086)	(0.0035)	(0.00083)
Year 2006	0.0302	-0.0202	-0.00814	-0.00194*
	(0.019)	(0.013)	(0.0050)	(0.0012)
Observations	27,693	27,693	27,693	27693

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Reference categories (omitted from table): male, age 18-24, white, less than high school education, annual income less than $10,000, household size of one, not married, never smoked, Year 1995. California Behavorial Risk Factor Survey years included were: 1995, 1997, 1999, 2000, 2002, 2004, and 2006.

TABLE 3

The Overall Probability of Missing Teeth Due to Disease

Select subgroups		Probability of missing 1-5 teeth	Probability of missing 6+ (not all) teeth
		[95% confidence interval]	[95% confidence interval]
Subgroup (1):	Male, aged 45-54, white, post-college education, never smoked family income $75,000 or greater, married, household of 4 or more, 2006	0.2018 [0.2003, 0.2033]	0.0182 [0.0180, 0.0185]
Subgroup (2):	Female, aged 25-34, black, high school education, current smoker	0.4499 [0.4427, 0.4571]	0.1219 [0.1189, 0.1248]
Subgroup (3):	Male, aged 35-44, Hispanic, less than high school education, current smoker family income $15,000 - $19,999, married, family of 4 or more, 2006	0.4711 [0.4626, 0.4796]	0.1531 [0.1491, 0.1571]
Subgroup (4):	Female, aged 65-74, Asian/Pacific Islander, some college, never smoked, family income $50,000 - $74,999, unmarried, lives alone, 2006	0.4083 [0.3960, 0.4205]	0.3000 [0.2884, 0.3116]

Source: Petris Center analysis of data from the 1995-2006 California Behavioral Risk Factor Surveillance Survey.

The first subgroup has a low probability of missing teeth due to disease, having only a 20.2 percent probability of missing one to five teeth and a 1.8 percent probability of missing six or more teeth (but not all). The second subgroup has a drastically higher probability of missing any teeth due to disease, having a 45.0 percent probability of missing one to five teeth and a 12.2 percent probability of missing six or more teeth (but not all).

The third subgroup also has a high probability of missing teeth due to disease, having a 47.1 percent probability of missing one to five teeth and a 15.3 percent probability of missing six or more teeth (but not all). The final subgroup also has a high probability of missing teeth due to disease, having a 40.8 percent probability of missing one to five teeth and a 30.0 percent probability of missing six or more teeth (but not all).

Discussion

These findings identified the adult characteristics and subgroups at the greatest risk for tooth loss and possible edentulism. As expected, risk of tooth loss due to disease increased with age in the pooled model. Racial/ethnic minorities were also at higher risk for tooth loss, and a social gradient pattern of tooth loss was evident by income and education levels. Each incremental increase in education and in annual household income beyond the $25,000-$24,999 bracket yielded a lower probability of missing teeth. Higher levels of educational attainment and income were protective factors. These trends were similar to other findings in the literature that show an inverse relationship between socioeconomic status and oral health status.[20-23]

Watt suggested addressing the social determinants of oral health inequalities through focusing efforts on "upstream action" and rethinking the approach to preventive efforts.[24] Currently, dental practices are more oriented to providing curative treatment. Many dental providers offer some clinical preventive measures and dental education during visits, but these are "downstream" efforts that are not as effective in preventing future problems. Preventive action at the community and state levels around oral health promotion is needed if California aims to dramatically reduce oral health disparities.

Results also indicated an increased risk of tooth loss among current smokers, compared to nonsmokers. Former smokers were also at higher risk of tooth loss than nonsmokers, but the probability of loss was not as high as for current smokers. The negative impact of tobacco use on tooth retention has been previously documented, but there is an emerging literature estimating that former smokers' risk levels can be reduced to that of nonsmokers after about 10 years or more of refraining from smoking.[15-17,25]

The possibility of such dramatic risk reduction has implications for clinical practice; dental providers could include more smoking cessation counseling and support as part of their oral health promotion/education messages during routine visits. Current smokers could be targeted for these messages and referred to cessation programs, but it will also be important to offer encouragement and possibly refer former smokers to resources that will help them refrain from relapsing over time since the tooth loss risk reduction appears greatest after several years of no longer smoking.[25]

California is already a policy leader in the area of smoke-free laws, and smoking prevalence has decreased in the last few decades as a result.[26] In 2006, the smoking rate among all California adults was 14.9 percent, and among adult smokers aged 18-35, 54.8 percent had quit for more than one day.[27] Past

studies have explored whether dentists advised smokers to quit, and found that in the early 1990s, most did very little for their patients in this area.[28,29]

More recently, some pilot studies aiming to improve dental practices' ability to address tobacco use have shown success.[30,31] For instance, two two-hour dental clinic staff trainings helped improve staff knowledge about the importance of discussing smoking status with patients and led to higher rates of staff awareness and use of the "Five A's" of tobacco cessation (ask, advise, assess, assist, and arrange follow-up).[30]

Some evidence suggests that if a dental office can offer brief counsel and also refer a patient to a tobacco quitline, those referred to the quitline who complete all the telephone consultations had higher rates of abstaining from smoking.[31] These pilot projects suggest promising directions for supporting dental providers' efforts in providing patients with smoking cessation counseling and referrals.

Some studies suggested that smokers are less likely than nonsmokers to regularly visit the dentist, so it is possible there may be fewer opportunities for dental providers to offer smoking counseling or referrals to current smokers.[32] However, dentists and hygienists should use dental visits as an opportunity to communicate the oral health risks of tobacco use to all their patients as well as promote good oral hygiene practices.

Regular dental visits are necessary to help prevent disease, treat problems early before tooth loss occurs, and promote optimal oral health throughout the lifespan. Tooth loss due to disease is an avoidable experience. Yet, fear of the dentist is fairly prevalent, and, in 1995, it was the third most common reason given by California adults for not going to the dentist (reported by 9.2 percent).[33]

Additionally, many adults, especially those from lower socioeconomic backgrounds, encounter substantial barriers (such as lack of insurance, financial resources, transportation) to regular access to dental care.[33,34] Even those with Medi-Cal coverage have experienced problems accessing needed dental care. A typical issue with many Medicaid programs is a lack of providers.[35]

Another recently identified problem in California is that a significant portion of adults on Medi-Cal do not realize they

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also have Denti-Cal.[36] However, Medicaid access issues are no longer the greatest concern. Federal law does not require states to offer adult dental benefits under Medicaid, and this coverage can be eliminated. Although adult dental is one of the most commonly offered optional Medicaid benefits, during budget crises, many states put it on the chopping block. California cut most adult Medicaid dental benefits beginning July 1, 2009.[37]

Some of the only dental services that will be available to the adult Medicaid population will include tooth removal for the relief of pain and infection, while virtually all preventive and restorative services will no longer be covered.[38] This policy change puts many adults already at the greatest risk for losing teeth due to disease at an even higher risk for this outcome. California needs to promote the enactment of programs and policies that will enhance rather than reduce access to routine comprehensive dental care for all adults, particularly its most vulnerable, in the future.

There were some limitations to the present study to note. First was the lack of dental insurance as a variable in the model. While it is commendable that California has included the optional oral health module in its BRFS data collection often, not all years contain information on dental insurance. Unfortunately, the dental insurance question was only included in the 1995, 1997, and 2000 BRFS, but not in the more recent years oral health data was collected, thus limiting the ability to examine the relationship between dental insurance and adult tooth loss. All BRFS data was self-reported and answers may be subject to recall and social desirability biases.

Conclusion

A significant proportion (almost 40 percent) of California adults suffered the loss of one or more teeth due to disease in 2006. In the 11-year (1995-2006) pooled multivariate analysis, Californians who are older, less educated, racial/ethnic minorities, have lower annual household incomes, and are current or former smokers are more likely to be part of this group. As the population ages, it will become increasingly more important to understand the trends and work to prevent tooth loss among adults in California. ■■■■

REFERENCES

1. U.S. Department of Health and Human Services, Oral health in America: A report of the surgeon general executive summary. 2000, National Institutes of Health: Rockville, Md., U.S. Department of Health and Human Services, National Institute of Dental and Craniofacial Research.
2. United States General Accounting Office, Oral health: dental disease is a chronic problem among low-income populations. 2000, GAO: USA.
3. Drury TF, Garcia I, Adesanya M, Socioeconomic disparities in adult oral health in the United States. *Annals NY Acad*

Sciences 896:322-4, 1999.
4. Marcus M, et al, Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988-1991. *J Dent Res* 75 Spec:684-95, 1996.
5. Beltran-Aguilar ED, Barker LK, et al. Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis - United States, 1988-1994 and 1999-2002. *MMWR* 54, 1-43. 2005.
6. Centers for Disease Control and Prevention, Public health and aging: retention of natural teeth among older adults, United States, 2002. *MMWR* 52(50):1226-9, 2003.
7. U.S. Department of Health and Human Services, Healthy People 2010. Understanding and improving health. Objectives for improving health. 2 vols., 2000, U.S. Government Printing Office: Washington, D.C.
8. Beltrán-Aguilar ED, Malvitz DM, et al, Oral health surveillance: past, present, and future challenges. *J Public Health Dent* 63(3):141-9, Summer 2003.
9. Lang WP, Borgnakke WS, et al, Evaluation and use of an index of oral health status. *J Public Health Dent* 57(4):233-42, Fall 1997.
10. Marcus M, Koch AL, Gershen JA, An empirically derived measure of oral health status for adult populations. *J Public Health Dent* 40(4):334-45, 1980.
11. Spolsky VW, Marcus M, et al, An empirical test of the validity of the oral health status index (OHSI) on a minority population. *J Dent Res* 79(12):1983-8, December 2000.
12. Gilbert GH, Duncan RP, Kulley AM, Validity of self-reported tooth counts during a telephone screening interview. *J Public Health Dent* 57(3):176-80, 1997.
13. Douglass CW, Berlin J, Tennstedt S, The validity of self-reported oral health status in the elderly. *J Public Health Dent* 51(4):220-2, 1991.
14. National Oral Health Surveillance Center, Center for Disease Control and Prevention. Prevalence data for 2004, Adults aged 65+ who have lost six or more teeth due to tooth decay or gum disease. http://apps.nccd.cdc.gov/nohss/ListV.asp?qkey=7&DataSet=2. Accessed June 12, 2009.
15. Copeland LB, Krall EA, et al, Predictors of tooth loss in two U.S. adult populations. *J Public Health Dent* 64(1):31-7, Winter2004.
16. Axelsson P, Paulartder J, Lindhe J, Relationship between smoking and dental status in 35-, 50-, 65-, and 75-year-old individuals. *J Clin Periodont* 25(4):297-305, 1998.
17. Dietrich T, Maserejian NN, et al, Tobacco use and incidence of tooth loss among U.S. male health professionals. *J Dent Res* 86(4):373-7, April 2007.
18. California Behavioral Risk Factor Survey SAS dataset documentation and technical report. 2007, Survey Research Group, California Department of Health Services.
19. StataCorp. 2005. Stata Statistical Software: Release 9. College Station, Texas, StataCorp LP.
20. Eklund SA, Burt B, Risk factors for total tooth loss in the United States: longitudinal analysis of national data. *J Public Health Dent* 54(1):5-14, 1994.
21. Chen M, Oral health of disadvantaged populations. In Cohen L, ed., disease prevention and oral health promotion: socio-dental sciences in action, Munksgaard, Copenhagen, pages 154-212, 1995.
22. Watt R, Sheiham A, Health policy: Inequalities in oral health: a review of the evidence and recommendations for action. *Br Dent* J 187(1):6, 1999.
23. Sabbah W, Tsakos G, et al, Social gradients in oral and general health. *J Dent Research* 86(10):992-6, October 2007.
24. Watt RG, From victim blaming to upstream action: tackling the social determinants of oral health inequalities. *Community Dent Oral Epidemiol* 35:1-11, 2007.
25. Krall EA, Dietrich T, et al, Risk of tooth loss after cigarette smoking cessation. Prev Chronic Dis 3(4):Epub 1-8, 2006. http://www.cdc.gov/pcd/issues/2006/oct/05_0243.htm. Accessed June 12, 2009.
26. California Department of Health Services Tobacco Control Section, Adult smoking prevalence, 2006. http://www.cdph.ca.gov/programs/Tobacco/Documents/CTCPAdultSmoking06.pdf. Accessed June 12, 2009.
27. Centers for Disease Control and Prevention, state-specific prevalence of cigarette smoking among adults and quitting among persons aged 18-35 years, United States, 2006. *MMWR* 56(38):993-6, 2007.
28. Tomar SL, Husten CG, Manley MW, Do dentists and physicians advise tobacco users to quit? *J Am Dent Assoc* 127(2):259-65, 1996.
29. Warnakulasuriya S, Effectiveness of tobacco counseling in the dental office. *J Dent Educ* 66(9):1079-87, 2002.
30. Havlicek D, Stafne E, Pronk NP, Tobacco cessation interventions in dental networks: a practice-based evaluation of the impact of education on provider knowledge, referrals, and pharmacotherapy use. *Prev Chronic Dis* 3(3):A96 (Epub June 15, 2006), 2006.
31. Ebbert JO, Carr AB, et al, Tobacco use quitline enrollment through dental practices: a pilot study. *J Am Dent Assoc* 138(5):595-601, May 2007.
32. Drilea SK, Reid BC, et al, Dental visits among smoking and nonsmoking U.S. adults in 2000. *Amer J Health Behav* 29(5):462-71, September 2005.
33. Tomar SL, Azevedo AB, Lawson R, Adult dental visits in California: successes and challenges. *J Public Health Dent* 58:275-80, 1998.
34. Manski RJ, Macek MD, Moeller JF, Private dental coverage: who has it and how does it influence dental visits and expenditures? *J Am Dent Assoc* 133:1551-9, 2002.
35. California Healthcare Foundation. Increasing Access to Dental Care in Medicaid: Does Raising Provider Rates Work? 2008. http://www.chcf.org/topics/view.cfm?itemID=133606. Accessed June 17, 2009.
36. California Healthcare Foundation. Denti-Cal Facts and figures: a look at California's Medicaid dental program. 2007. http://www.chcf.org/documents/policy/DentiCalFactsAndFigures.pdf. Accessed June 12, 2009.
37. California Medi-Cal Dental Program. Denti-Cal: Elimination of most adult dental services, Beneficiary Frequently Asked Questions. http://www.denti-cal.ca.gov/WSI/Default.jsp?fname=Default. Accessed June 17, 2009.
38. California Medi-Cal Dental Program. Elimination of most adult dental services. Denti-Cal Bulletin 25(22): 1-7. May 2009. http://www.denti-cal.ca.gov/WSI/Default.jsp?fname=Default. Accessed June 17, 2009.

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