

Life-style Correlates of Tooth Loss in an Adult Midwestern Population

Barbara E. K. Klein, MD; Ronald Klein, MD; Michael D. Knudtson, MS

Abstract

Objectives: To describe life-style correlates of tooth loss in a representative rural American population. **Methods:** Information on tooth loss as well as past medical history and life-style factors was obtained in a well-defined cohort of 2,764 persons 53–96 years of age in Beaver Dam, WI (1998–2000). **Results:** There were 1,992 (68.2%) persons missing some and 447 (15.3%) missing all of their teeth. In univariable analyses, age, cigarette smoking, heavy drinking, education, multivitamin use, and diabetes status were associated with tooth loss. Tooth loss was associated with poorer self-rated health and with difficulty eating solid food and inability to enjoy some food. In multivariable models age, education, smoking, heavy drinking, and diabetes were significantly associated with tooth loss. **Conclusions:** Tooth loss is common in older persons and is associated with many risk factors including education, smoking, and heavy drinking. It is possible that modifying these may influence risk of tooth loss. [*J Public Health Dent* 2004;64(3):145–50]

Key Words: tooth loss, education, smoking, alcohol drinking, risk factors.

Tooth loss and other oral conditions such as periodontal disease have an impact on quality of life, being associated with lower morale and lower levels of life satisfaction (1–3), as well as being related to systemic conditions such as cardiovascular and pulmonary disease and to chronic inflammation (4–17). While poorer quality of life and illness may, in part, result from oral conditions, socioeconomic factors may be causally related to oral health because of the effects on access to care, utilization of oral care facilities (18–20), oral hygiene (21), possibly diet (21–23), and beliefs (25). Life-style factors, such as smoking (18,26–31) and alcohol drinking (27), are also related to tooth loss and oral health. The socioeconomic and life-style factors may have an additive effect with age (32–36), thus compounding risk of poor oral health for older adults. Additionally, there are other age-related conditions such as diabetes (37) and osteopenia (38), which may further burden some of these persons. Many studies of the frequencies of oral conditions and

their risk factors have been done in persons of limited socioeconomic status or in a particular ethnic group or in persons of older ages. We sought to determine the prevalence of tooth loss and its association with life style and socioeconomic factors in middle-aged and older adults in a representative Midwestern community.

Methods

Beaver Dam, Wisconsin, is located 63 km northeast of Madison, WI. It is a well-defined community of approximately 17,000 persons who are primarily white and of Northern European ancestry (39). Methods to define the population and characteristics descriptive of it appear in previous reports (40–43). In brief, 4,926 persons 43–86 years of age living in Beaver Dam participated in a baseline examination over a 2½-year period (1988–90). Follow-up evaluations were done 5 and 10 years after the baseline examination. The age range of the study participants at the 10-year follow-up was 53–96 years. Principles

of the Declaration of Helsinki were adhered to, including signed consent. Institutional review board approval at the University of Wisconsin School of Medicine was obtained for each examination.

Data from the 10-year follow-up are the basis of this report. Table 1 describes the characteristics at the baseline examination (1988–90) for those persons who participated in the baseline, 5-year, and 10-year examinations, for those who were known to be alive at the 10-year examination but did not participate, and for those who had died before the 10-year examination (Table 1). Live nonparticipants were older, had fewer years of education, were more likely to be hypertensive, and current smokers compared to participants. Compared to participants, those who died were older, more likely to be men, to have diabetes, and to have been current smokers.

Pertinent parts of the study evaluation included an examiner-administered interview with questions about all current medications, cigarette smoking, education, income, ethnicity, alcohol drinking, lost teeth, use of dentures, whether lost teeth have influenced enjoyment of food, periodontal disease, diabetes, and use of multivitamins all obtained at the 10-year examination. Overall self-reported health was assessed by asking the subject whether compared to persons their own age their health was excellent, good, fair, poor, or that they did not know (44). A blood specimen for glycosylated hemoglobin (45) was obtained.

Definitions. Persons who smoked 100 or fewer cigarettes in their lifetime were considered to have never smoked. Those smoking more than 100 cigarettes were asked the number smoked per day, the number of

TABLE 1
Distribution of Baseline Characteristics Among Participants and Nonparticipants at 10-year Examination

Characteristics	Participants		Nonparticipants					
			Alive			Deceased		
	Crude (%)	(N)	Crude (%)	(N)	Age-adjusted P-value*	Crude (%)	(N)	Age-adjusted P-value†
Age at baseline (years)								
43-54	39.6	1,094	31.8	133		7.9	12	
55-64	30.8	852	29.2	122		17.8	27	
65-74	22.9	634	28.2	118		44.7	68	
75+	6.7	184	10.8	45	<.001‡	29.6	45	<.001‡
Sex								
Women	57.6	1,593	60.8	254		51.3	78	
Men	42.4	1,171	39.2	164	.44	48.7	74	.003
Education (years)								
0-11	19.3	534	34.2	143		38.8	59	
12	47.1	1,302	45.5	190		34.2	52	
13-15	16.3	449	13.4	56		15.8	24	
16+	17.3	477	6.9	29	<.001	11.2	17	.36
Hypertension								
No	68.7	1,896	61.2	256		57.2	87	
Yes	31.4	866	38.8	162	.03	42.8	65	.56
Cardiovascular disease								
No	86.9	2,370	87.5	358		74.3	113	
Yes	13.1	358	12.5	51	.21	25.7	39	.21
Cancer								
No	90.6	2,503	89.9	374		86.2	131	
Yes	9.4	259	10.1	42	.83	13.8	21	<.98
Diabetes								
No	93.5	2,574	93.5	388		86.1	130	
Yes	6.5	178	6.5	27	.83	13.9	21	.007
Alcohol consumption								
Never	12.1	335	12.4	52		19.7	30	
Ever	87.9	2,429	87.6	366	.84	80.3	122	.16
Smoking								
Never	47.4	1,310	40.5	169		38.6	59	
Past	35.3	974	33.3	139		34.0	52	
Current	17.3	479	26.1	109	<.001	37.5	42	<.001

*Comparison of participants to nonparticipants who were alive at follow-up.

†Comparison of participants with those who died after the start of the follow-up and who were not examined.

‡Mantel-Haenszel test of trend.

months they smoked, their current smoking status, and the date they stopped. For these analyses, smokers were characterized as never, past, or current smokers depending upon their response at the 10-year examination. Subjects were questioned about consumption of beer, wine, and liquor in the past year. We asked the number of each beverage type consumed per week. Those drinking an average of four or more drinks per day in the past year were considered current heavy drinkers. In addition, we asked

whether there had ever been a period in their lives prior to the past year when they had regularly drank four or more drinks per day. These people were considered to be past heavy drinkers.

Questions about oral conditions were structured with categorical responses and were adapted from the Keokuk Longitudinal Rural Study (46). We present results for missing teeth based on responses to this questionnaire.

Diabetes was defined as a history of

diabetes being treated with insulin, oral agents, and/or diet or a negative history, but glycosylated hemoglobin greater than two standard deviations above the relevant age-sex mean.

Statistical Analyses. Cross-tabulations and multivariable models were done using SAS Version 8.01 (47). For testing significance in the cross tabulations, the Cochran-Mantel-Haenszel procedure was used when there was a natural ordering to the risk factor. When this was not the case, the row means score difference test was used.

TABLE 2
Characteristics Associated with Tooth Loss

Risk Factor	(N)	Missing Teeth Status (%)			P-value	Adjusted P-value*
		None	Some	All		
Age (years)						
53-64	1,134	26.5	66.6	7.0		
65-74	902	13.1	69.6	17.3		
75-84	672	8.0	70.5	21.4		
85+	214	5.1	63.1	31.8	<.001	
Sex						
Women	1,697	17.1	65.6	17.3		
Men	1,225	15.8	71.7	12.6	.11	.85
Smoking						
None	1,384	20.5	66.0	13.5		
Past	1,245	14.2	70.3	15.5		
Current	286	7.7	69.9	22.4	<.001	<.001
Heavy drinking						
Non-heavy	2,476	17.6	67.3	15.1		
Past/current	434	10.8	74.0	15.2	.02	<.001
Diabetes						
No	2,431	17.9	68.2	14.0		
Yes	351	9.1	65.5	25.4	<.001	<.001
Education (years)						
0-11	583	4.3	61.7	34.0		
12	1,367	13.8	73.0	13.2		
13-15	466	22.1	68.5	9.4		
16+	492	33.5	62.4	4.1	<.001	<.001
Multivitamins						
No	1,590	14.1	69.9	16.0		
Yes	1,332	19.4	66.1	14.5	.001	.01
Self-reported health						
Excellent	539	26.4	63.5	10.2		
Good	1,862	16.5	69.1	14.5		
Fair	415	6.3	71.3	22.4		
Poor	48	4.2	72.9	22.9	<.001	<.001
Difficulty eating solid food						
No	2,588	18.3	69.2	12.6		
Yes	324	3.1	60.5	36.4	<.001	<.001
Inability to eat favorite foods						
No	2,596	18.4	69.0	12.6		
Yes	311	1.9	61.1	37.0	<.001	<.001

*Adjusted for age and sex where appropriate.

Multivariable models were fit for missing teeth by dichotomizing the outcome to missing any teeth or missing no teeth. Logistic regression was then used for multivariable models. A stepwise procedure was used to eliminate nonsignificant factors. Due to the large correlation between education and income, separate models were fit with each of these risk factors. The models were similar, but because education was more consistently associ-

ated with the outcome, we present the model with education.

Results

There were 1,992 (68.2%) persons who were missing some and 447 (15.3%) missing all of their teeth. Periodontal disease was reported by 485 (16.5%) of participants. Current use of dentures of some kind was reported by 1,588 (53.6%) persons. There were 327 (11.1%) persons who reported dif-

ficulty eating solid foods and 315 (10.7%) who reported they could not eat some foods they enjoyed because of problems with their teeth. All of the previous conditions increased with age. Nearly half the population (49.0%) had visited a dentist within six months of the study examination and 85.3 percent had visited a dentist within four years. Numbers of participants contributing to our analyses vary because values may be missing

for some variables.

Table 2 shows the relationship of life-style factors and diabetes to tooth loss. Age was associated with tooth loss in both women and men. Relationships of other characteristics to tooth loss are given as crude and age and sex-adjusted comparisons. Current smokers were more likely to have lost teeth than nonsmokers, with past smokers intermediate between the two. Heavy drinking and diabetes were associated with tooth loss. Education and use of multivitamins were inversely associated with tooth loss. Difficulty eating solid food and inability to eat some foods they enjoy were more common in those who had lost some or all of their teeth. Self-reported health was significantly (inversely) associated with missing any teeth.

To investigate the effects of these characteristics on tooth loss, we developed a multivariable model (Table 3). Variables we considered were age, sex, smoking, heavy drinking, diabetes, and multivitamin use. Age was significantly associated with tooth loss, but sex was not. Education was associated with decreased odds, while smoking, especially current smoking and heavy drinking, were associated with increased odds of any tooth loss. Adding diabetes status and use of multivitamins to this model did not significantly alter the odds ratios associated with the other factors. However, diabetes was significantly associated with increased odds (1.73; 95% confidence interval [CI]=1.16, 2.57), while multivitamin use was not.

Discussion

Tooth loss was a common occurrence in adults in Beaver Dam, with 68.2 percent missing some and 15.3 percent missing all teeth, increasing monotonically with age such that 7 percent of persons 53–64 years of age and 31.8 percent of persons 85 years of age or older were edentulous. While the latter percentages are more favorable than persons of similar age who participated in the NHANES III Phase 1 (18), they are substantial and occurred despite relatively high prevalence of dental care. Although persons may have sought dental care only after experiencing symptoms related to oral conditions that lead to tooth loss, it also may be that processes associated with aging are not entirely successfully treated through dental care

TABLE 3
Life-style Correlates of Tooth Loss, Multivariable Model

Life-style Factor	OR (95% CI)*	P-value
Age/10 years	1.98 (1.75, 2.25)	<.001
Women versus men	0.87 (0.69, 1.09)	.22
Education/category increase†	0.57 (0.51, 0.64)	<.001
Current vs nonsmoker	4.04 (2.52, 6.49)	<.001
Past vs nonsmoker	1.57 (1.25, 1.98)	<.001
Heavy vs nondrinking‡	1.44 (1.01, 2.05)	.05

*Odds ratios and 95% confidence interval for missing some or all teeth.

†See Table 2 for education categories.

‡Heavy drinking includes past and current heavy drinkers.

alone.

Because of the relationship of age to tooth loss and to associated characteristics, we present age-adjusted analyses of associated life-style factors as well as unadjusted analyses. However, age adjustment did not markedly influence the significance of the associations for most variables. This suggests that exposures to these life-style factors add to the burden incurred due to aging alone.

While our data are cross-sectional, it is reasonable to entertain the possibility that these life-style factors preceded tooth loss. This would need to be confirmed in prospective studies in our population. There have been other studies suggesting such a temporal relationship, especially for smoking (48,49). While not implying that altering such behavior is easily accomplished, they may be more amenable to modification than increasing education, another characteristic we found to be associated with tooth loss. Additional follow-up data in our cohort would provide incidence data concerning these exposures. Hunt et al. (50) found that smoking was associated with incidence of tooth loss in older persons in North Carolina.

Nutrition may be an important mediator of a relationship between systemic disease and oral conditions (51,52). We are unable to assess such effects. However, we did find an apparent protective effect of multivitamins on tooth loss in crude and age-adjusted analyses. This is in keeping with the finding of a beneficial effect of calcium and vitamin D supplements on tooth retention that was reported from a trial of the protective effects of such supplements on osteoporosis (53). Most multivitamin preparations

used in Beaver Dam contain at least the Recommended Daily Allowance (RDA) of vitamin D and calcium (not previously reported). We found that after considering other life-style characteristics, multivitamin use was no longer significant, suggesting the possibility that multivitamin use in our population reflects education and income advantages.

Because education and income were highly correlated, we did not include both in the multivariable analyses. We chose to include education because its relationship to tooth loss was more consistent than income. We suspect that education may provide a better indicator of a healthy life style than current income in our population, possibly because many persons are in transition from employment to retirement. Also, there were fewer missing values for education in our data, possibly because some persons were reluctant to divulge their income.

Limitations of our study include that it was cross-sectional; therefore, temporal relationships of life style correlates to tooth loss cannot be determined. In addition, our data on tooth loss are self-reported. However, since we used broad categories of no lost teeth, some lost teeth, and all teeth lost, we believe these endpoints are reliable. This population is virtually all white and of Northern European extraction, not unlike many Midwestern communities. While this may appear to be a limitation, the results suggest that the life-style factors we found to be important correlates of tooth loss are similar to those found in different population groups described in the literature suggesting that the effects of these environmental factors may be universal. Another limitation is that

our population is composed of survivors of a cohort initially defined in 1987. Thus, selective mortality may have influenced our findings. The mortality rate for this population has not been extraordinary, but was greater in those who were older, more likely to have smoked, and to have had less education than those who participated in the 10-year examination. Despite this, we still found life-style characteristics to be associated with tooth loss. Selective mortality may have caused us to underestimate the importance of these correlates in explaining tooth loss.

Finally, although we assume that tooth loss reflects age, chronic illness, as well as life-style factors, it is likely that dental practices in the past which differ from current patterns have influenced the percentages we report from our cross-sectional study (54). However, we are unable to assess the effect this might have on the magnitude of risk factor associations we report here.

We note that persons with tooth loss were more likely to have poorer self-rated health than those without tooth loss. While this is not unexpected and may be because those with tooth loss have additional medical problems contributing to poorer self-rated health, it is plausible that tooth loss adds to this burden. There were 327 (11%) persons who reported difficulty eating solid food and 315 (11%) who reported they could not eat some foods they enjoyed because of problems with their teeth. Thus, oral conditions may be important contributors to ill health and to quality of life in older persons. Further research on factors that could be altered to diminish the burden due to oral conditions is needed.

In conclusion, we found that tooth loss was common in adults in Beaver Dam. Tooth loss has been found to be associated with systemic conditions and life-style factors. While there may be little that can be done about concurrent diseases, modification of smoking and heavy drinking and possibly increasing the level of education may have positive effects on tooth loss.

References

- McGrath C, Bedi R. Population based norming of the UK oral health-related quality of life measure (OHQoL-UK®). *Br Dent J* 2002;193:521-4.
- Yoshida Y, Hatanaka Y, Imaki M, Ogawa Y, Miyatani S, Tanada S. Epidemiological study on improving the QOL and oral conditions of the aged. Part 1. The relationship between the status of tooth preservation and QOL. *J Physiol Anthropol Appl Human Sci* 2001;20:363-8.
- Locker D, Matear D, Stephens M, Jokovic A. Oral health-related quality of life of a population of medically compromised elderly people. *Community Dent Health* 2002;19:90-7.
- Joshihira KJ, Douglass CW, Willett WC. Possible explanations for the tooth loss and cardiovascular disease relationship. *Ann Periodontol* 1998;3:175-83.
- Jansson L, Lavstedt S, Frithiof L, Theobald H. Relationship between oral health and mortality in cardiovascular diseases. *J Clin Periodontol* 2001;28:762-8.
- Beck J, Garcia R, Heiss G, Vokonas PS, Offenbacher S. Periodontal disease and cardiovascular disease. *J Periodontol* 1996;67:1123-37.
- Wu T, Trevisan M, Genco RJ, Dorn JP, Falkner KL, Sempos CT. Periodontal disease and risk of cerebrovascular disease. The first national health and nutrition examination survey and its follow-up study. *Arch Intern Med* 2000;160:2749-55.
- Scannapieco FA, Ho AW. Potential associations between chronic respiratory disease and periodontal disease: analysis of National Health and Nutrition Examination Survey III. *J Periodontol* 2001;72:50-6.
- Scannapieco FA, Genco RJ. Association of periodontal infections with atherosclerotic and pulmonary diseases. *J Periodontol Res* 1999;34:340-5.
- Grau AJ, Buggle F, Ziegler C, Schwarz W, Meuser J, Tasman AJ, et al. Association between acute cerebrovascular ischemia and chronic and recurrent infection. *Stroke* 1997;28:1724-9.
- Arbes SJ Jr, Slade GD, Beck JD. Association between extent of periodontal attachment loss and self-reported history of heart attack: an analysis of NHANES III data. *J Dent Res* 1999;78:1777-82.
- Morrison HI, Ellison LF, Taylor GW. Periodontal disease and risk of fatal coronary heart and cerebrovascular diseases. *J Cardiovasc Risk* 1999;6:7-11.
- Hujoel PP, Drangsholt M, Spiekerman C, DeRouen TA. Periodontal disease and coronary heart disease risk. *JAMA* 2000;284:1406-10.
- Joshihira KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC. Poor oral health and coronary heart disease. *J Dent Res* 1996;75:1631-6.
- Loesche WJ, Schork A, Terpenning MS, Chen YM, Dominguez BL, Grossman N. Assessing the relationship between dental disease and coronary heart disease in elderly US veterans. *J Am Dent Assoc* 1998;129:301-11.
- Slade GD, Offenbacher S, Beck JD, Heiss G, Pankow JS. Acute-phase inflammatory response to periodontal disease in the US population. *J Dent Res* 2000;79:49-57.
- Shapira L, Soskolne WA, Sela MN, Offenbacher S, Barak V. The secretion of PGE₂, IL-1 beta, IL-6, and TNF alpha by adherent mononuclear cells from early onset periodontitis patients. *J Periodontol* 1994;65:139-46.
- Marcus SE, Drury TF, Brown LJ, Zion GR. Tooth retention and tooth loss in the permanent dentition of adults: United States, 1988-1991. *J Dent Res* 1996;75:684-95.
- Gervasio NC, Escoto ET, Chan WY. Oral health status of institutionalized geriatric residents in Metro Manila. *J Philipp Dent Assoc* 1998;50:4-23.
- Randolph WM, Ostir GV, Markides KS. Prevalence of tooth loss and dental service use in older Mexican Americans. *J Am Geriatr Soc* 2001;49:585-9.
- Whittaker DK, Molleson T. Caries prevalence in the dentition of a late eighteenth century population. *Arch Oral Biol* 1996;41:55-61.
- Papas AS, Joshi A, Giunta JL, Palmer CA. Relationships among education, dentate status, and diet in adults. *Spec Care Dentist* 1998;18:26-32.
- Ong G. Periodontal disease and tooth loss. *Int Dent J* 1998;48:233-8.
- Sakashita R, Inoue M, Inoue N, Pan Q, Zhu H. Dental disease in the Chinese Yin-Shang period with respect to relationships between citizens and slaves. *Am J Phys Anthropol* 1997;103:401-8.
- Gilbert GH, Stoller EP, Duncan RP, Earls JL, Campbell AM. Dental self-care among dentate adults: contrasting problem-oriented dental attenders and regular dental attenders. *Spec Care Dentist* 2000;20:155-63.
- Albandar JM, Streckfus CF, Adesanya MR, Winn DM. Cigar, pipe, and cigarette smoking as risk factors for periodontal disease and tooth loss. *J Periodontol* 2000;71:1874-81.
- Enberg N, Wolf J, Ainamo A, Alho H, Heinälä P, Lenander-Lumikari M. Dental diseases and loss of teeth in a group of Finnish alcoholics: a radiological study. *Acta Odontol Scand* 2001;59:341-7.
- Hamasha AA, Sasa I, Al-Qudah M. Risk indicators associated with tooth loss in Jordanian adults. *Community Dent Oral Epidemiol* 2000;28:67-72.
- Haffajee AD, Socransky SS. Relationship of cigarette smoking to attachment level profiles. *J Clin Periodontol* 2001;28:283-95.
- Chen X, Wolff L, Aeppli D, Guo Z, Luan W, Baelum V, Fejeskov O. Cigarette smoking, salivary/gingival crevicular fluid cotinine and periodontal status. A 10-year longitudinal study. *J Clin Periodontol* 2001;28:331-9.
- Jansson L, Lavstedt S. Influence of smoking on marginal bone loss and tooth loss: a prospective study over 20 years. *J Clin Periodontol* 2002;29:750-6.
- Locker D, Miller Y. Subjectively reported oral health status in an adult population. *Community Dent Oral Epidemiol* 1994;22:425-30.
- Gilbert GH, Shelton BJ, Chavers LS, Bradford EH Jr. Predicting tooth loss during a population-based study: role of attachment level in the presence of other dental conditions. *J Periodontol* 2002;73:1427-36.
- Hand JS, Hunt RJ, Kohout FJ. Five-year incidence of tooth loss in Iowans aged 65 and older. *Community Dent Oral Epidemiol*

- miol 1991;19:48-51.
35. Hunt RJ, Hand JS, Kohout FJ, Beck JD. Incidence of tooth loss among elderly Iowans. *Am J Public Health* 1988;78:1330-2.
36. Hunt RJ, Drake CW, Beck JD. Eighteen-month incidence of tooth loss among older adults in North Carolina. *Am J Public Health* 1995;85:561-3.
37. Moore PA, Weyant RJ, Etzel KR, Guggenheimer J, Mongelluzzo MB, Mzers DE, et al. Type 1 diabetes mellitus and oral health: assessment of coronal and root caries. *Community Dent Oral Epidemiol* 2001;29:183-94.
38. Weyant RJ, Pearlstein ME, Churak AP, Forrest K, Famili P, Cauley JA. The association between osteopenia and periodontal attachment loss in older women. *J Periodontol* 1999;70:982-91.
39. Linton KLP, Klein BEK, Klein R. The validity of self-reported and surrogate-reported cataract and age-related macular degeneration in the Beaver Dam Eye Study. *Am J Epidemiol* 1991;134:1438-46.
40. Campbell JA, Palit CD. Total digit dialing for a small area census by phone. *Proceedings of the American Statistical Association* 1988:549-51.
41. Klein R, Klein BEK, Linton KLP, De Mets DL. The Beaver Dam Eye Study: visual acuity. *Ophthalmology* 1991;98:1310-15.
42. Klein R, Klein BE, Lee KE. Changes in visual acuity in a population. The Beaver Dam Eye Study. *Ophthalmology* 1996;103:1169-78.
43. Klein R, Klein BEK. Beaver Dam Eye Study III. Manual of operations. Springfield, VA: US Department of Commerce, 1999; NTIS Accession no PB99-137861.
44. Ware JE. SF-36 Health Survey. Manual and interpretation guide. Boston, MA: The Medical Outcomes Trust, 1993:B7, B9 Appendix.
45. Moss SE, Klein R, Klein BE, Spennetta TL, Shrago ES. Methodologic considerations in measuring glycosylated hemoglobin in epidemiologic studies. *J Clin Epidemiol* 1988;41:645-9.
46. Stromquist AM, Merchant JA, Burmeister LF, Zwerling C, Reynolds SJ. The Keokuk County Rural Health Study: methodology and demographics. *J Agromedicine* 1997;4:243-8.
47. SAS/STAT user's guide. Version 8. Cary, NC: SAS Institute Inc., 1999.
48. Jansson L, Lavstedt S, Zimmerman M. Prediction of marginal bone loss and tooth loss—a prospective study over 20 years. *J Clin Periodontol* 2002;29:672-8.
49. Bergstrom J, Eliasson S, Dock J. A 10-year prospective study of tobacco smoking and periodontal health. *J Periodontol* 2000;71:1338-47.
50. Hunt RJ, Drake CW, Beck JD. Eighteen-month incidence of tooth loss among older adults in North Carolina. *Am J Public Health* 1995;85:561-3.
51. Ritchie CS. Oral health, taste, and olfaction. *Clin Geriatr Med* 2002;18:709-17.
52. Nowjack-Raymer RE, Sheiham A. Association of edentulism and diet and nutrition in US adults. *J Dent Res* 2003;82:123-6.
53. Krall EA, Wehler C, Garcia RI, Harris SS, Dawson-Hughes B. Calcium and vitamin D supplements reduce tooth loss in the elderly. *Am J Med* 2001;111:452-6.
54. Burt BA, Eklund SA. Dentistry, dental practice, and the community. 5th ed. Philadelphia: WB Saunders, 1999:203-211.

Copyright of Journal of Public Health Dentistry is the property of American Association of Public Health Dentistry and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.