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COVER STORY

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ABSTRACT

Background. Several studies have reported that impaired dentition status is associated with poor nutritional intake. However, most of these studies are cross-sectional and thus are unable to clarify the temporal sequence.

Methods. We assessed the longitudinal relation between tooth loss and changes in consumption of fruits and vegetables and of nutrients important for general health among 31,813 eligible male health professionals.

Results. Subjects who lost five or more teeth had a significantly smaller reduction in consumption of dietary cholesterol and vitamin B12, greater reduction in consumption of polyunsaturated fat and smaller increase in consumption of dietary fiber and whole fruit than did subjects who had lost no teeth. Men who had lost teeth also were more likely to stop eating apples, pears and raw carrots.

Conclusions. The results support the temporal association between tooth loss and detrimental changes in dietary intakes, which could contribute to increased risk of developing chronic diseases.

Practice Implications. Dietary evaluation and recommendations can be incorporated into dental visits to provide a greater benefit to patients.

JADA CE CONTINUING EDUCATION ARTICLE 1

The relationship between tooth loss and nutritional intake is important. Diet has a role in the cause and prevention of several systemic diseases such as cardiovascular diseases,[1] and detrimental changes in dietary intake caused by poor dental status are proposed as one of the mediators for poor oral health as a risk factor for cardiovascular disease.[2-15] Because of the high prevalence of tooth loss among older adults,[16-18] even a small excess risk of developing chronic diseases owing to dental disease would have a significant impact.

Dietary evaluation and recommendations can be incorporated into dental visits to provide a greater benefit to patients.

Tooth loss reduces masticatory ability and, hence, can alter food selection. The Veterans Administration Dental Longitudinal Study conducted in Boston among 1,231 men enrolled between 1963 and 1968 found tooth loss to be associated with decreases in masticatory performance, perceived ease of chewing and acceptability of some specific foods.[19-21] Several studies also reported an inverse association between progressively impaired dentition and intake of several nutrients and of fruits and vegetables.[22-27] However, many studies did not adjust for total calorie intake as well as other potential confounders, which limited the interpretation of the results.[23] These studies also measured dietary intake and dental status at the same time and were unable to clarify the temporal sequence.

Joshipura and colleagues[23] observed that edentulous subjects in a cohort of 49,501 men had significantly lower intake of vegetables, fiber and carotenoids and higher intake of cholesterol and saturated fat than did those with 25 or more teeth. The associations were independent of age, caloric intake, smoking status, profession and physical activity. Longitudinal analysis suggested that detrimental changes in dietary intake followed incidence of tooth loss, but there was insufficient power to detect significance.

After an extended period of follow-up with the same cohort, we now have substantially more power to examine the relationship between tooth loss and dietary changes. In this article, we present the longitudinal analyses between tooth loss and the consumption of specific foods and nutrients that have been associated with cardiovascular and other systemic diseases. These specific foods and nutrients include fruits, veg-

etables, vitamins B_6, B_{12}, C, D and E, carotene, beta-carotene, folic acid, fiber, flavonoids, potassium, cholesterol and specific types of fat.

SUBJECTS, MATERIALS AND METHODS

Study population. The Health Professionals' Follow-up Study was designed as a prospective cohort study initiated in 1986 with 51,529 male health professionals aged 40 to 75 years: 29,683 dentists, 3,745 optometrists, 4,185 pharmacists, 2,218 osteopathic physicians, 1,600 podiatrists and 10,098 veterinarians. Study participants answered detailed mailed questionnaires that included a comprehensive diet survey, questions on lifestyle practices and a medical history. The number of teeth present was assessed on the 1986 baseline questionnaire and questions on recent tooth loss were added to biennial questionnaires starting from 1988, which were used to update the information on potential risk factors and medical conditions. Semiquantitative food frequency questionnaires, or FFQs, were sent out in 1986, 1990 and 1994. This study has been approved by the human subjects committee of Harvard School of Public Health, Boston, and subjects' completion of self-administered questionnaires constituted informed consent.

By 1994, all subjects reduced their intakes of saturated fat and cholesterol and increased their intakes of most beneficial nutrients and fruits and vegetables.

Assessment of dietary intake. The assessment of dietary intake was described in detail previously.[28] We assessed dietary intake by semiquantitative FFQs, in which a commonly used unit or portion for all items of food was specified (such as one tomato, one glass of orange juice), and subjects indicated how often, on average, they had consumed that food over the past year. The validity and reproducibility of this FFQ have been published in previous studies.[28,29] The frequencies were reported in nine categories, ranging from less than once a month to six or more times per day. We computed nutrient intakes, excluding supplements, by multiplying the frequency with which each food was consumed by the nutrient content of the specified portions,[30] and we adjusted for total calorie intake by the residual method.[31]

We also calculated the total daily intakes of all fruits (with or without juice) and vegetables for each respondent from his reported consumption frequencies of individual fruits and vegetables. Compared with one-week diet records and corrected for within-person weekly variation, the Pearson correlation coefficients ranged from 0.35 for vitamin B_{12} without supplements to 0.5 for vegetables, 0.7 for fruits and 0.77 for vitamin C without supplements.[28,31]

Exposure measure. In biennial questionnaires, we asked the number of teeth lost in the previous two years in the categories of zero, one, two, three, four, five to nine, and 10 or more. We do not have information on the validity of self-reported incidence of tooth loss, but self-reported residual number of teeth was highly correlated with the actual number of teeth on clinical examination in the general population ($r = 0.97$),[32] hence, we expected a high validity for self-reported incident tooth loss.

Data analysis. In the analyses, we only included participants who answered all four questionnaires (1988, 1990, 1992 and 1994). We further excluded participants who reported an extreme daily energy intake (< 800 kilocalories or > 4,200 Kcal) or who left blank 70 or more questions in dietary questionnaires. Participants who did not report the baseline number of teeth or information on potentially confounding variables were further excluded. Since baseline number of teeth was reported in categories of zero, one to 10, 11 to 16, 17 to 24 and 25 to 32 teeth, and men with no teeth or one to 10 teeth might not have enough teeth to lose five or more teeth during follow-up, we included in the analyses only men who had 11 or more teeth at baseline. There were 31,813 eligible participants.

We used SAS software (Version 8, SAS Institute, Cary, N.C.) for the analyses. We summed the reported number of teeth lost every two years from four questionnaires, and categorized it into three groups of zero, one to four, and five or more teeth lost during this eight-year period from 1986 to 1994. We computed mean baseline intakes in 1986 and changes (intakes in 1994 minus intakes in 1986) in specific foods and nutrients of interest. We computed the least-square means of dietary change for the three categories of teeth lost using analysis of covariance with a general linear model adjusting for change in total energy intake, baseline dietary intake and number of teeth and age.

Since tooth loss and dietary intake both might be associated with healthy behavior and attitude and socioeconomic status, we evaluated other potential confounders, such as smoking, body mass index, physical activity, diabetes, hypertension, hypercholestermia, alcohol drinking, vitamin use and profession. However, adjusting for some of these factors did not influence the results appreciably. Hence, the final models only adjusted for change in total energy intake, baseline dietary intake, number of teeth, age, smoking status (current, former or nonsmoker), physical activity (five categories from lowest quintile to highest quintile) and profession (dentist or nondentist) in the analyses.

For testing the linear trends across number of teeth lost, we summed number of teeth lost in each two-year period. For those who indicated having lost five to nine teeth or 10 or more teeth, we assumed they lost seven and 10 teeth, respectively. Trends in the change of nutrients and foods intake across total number of teeth lost in an eight-year period were tested using an ordinal variable (zero, one, two, three, four or seven for five to nine teeth lost and 10 for 10 or more teeth lost). Since the changes in nutrient and food intake might not fit the assumption of normality, we performed similar analyses using the rank-transformation of the change in calorie-adjusted nutrients intake and daily intake of fruits and vegetables. The results showed very similar patterns. Hence, we present results only from parametric analyses.

We also examined the percentages of men consuming specific fruits and vegetables (bananas, cantaloupes, apples, pears and carrots) in 1994 among participants who reported consuming these foods at least once per week in 1986. With the Mantel-Haenszel test, we evaluated whether men with more tooth loss would have greater changes in their intake of harder foods after we adjusted for confounders.

RESULTS

Table 1 shows the distribution of tooth loss during an eight-year period by potential confounding variables among 31,813 men with at least 11 teeth in 1986. There were 78.3 percent of the men without any tooth loss, 18.8 percent who had lost one to four teeth and 2.8 percent who lost five or more teeth in the period from 1986 through 1994. Men who had lost more teeth were older than those who had had no tooth loss (mean age 52.5 for men who had lost no teeth, 57.3 for men who had lost one to four teeth and 60.2 for men who had lost five or more teeth). After adjusting for age, we found that subjects with tooth loss appeared to have worse profiles of potentially confounding variables than those without tooth loss. Among men who had lost five or more teeth, approximately 24 percent were current smokers, while only 7 percent of men without tooth loss were smokers in 1986. Number of teeth at baseline was associated negatively with tooth loss. Almost one-half of the men with 11 to 16 teeth experienced tooth loss, while only 20 percent of men with 25 to 32 teeth had tooth loss during the eight years.

Table 2 (page 1189) presents the crude means of baseline intakes in 1986 and differences in calorie-adjusted nutrients and fruits and vegetables from 1994 through 1986 among participants who had lost zero, one to four and five or more teeth. The three groups had similar average baseline dietary intake of these nutrients and fruits and vegetables. All groups seemed to have improved their dietary pattern over this eight-year period. By 1994, they reduced their intakes of saturated fat and cholesterol and increased their intakes of most beneficial nutrients and fruits and vegetables.

In the model adjusting for change in total energy intake and baseline age, dietary intake and teeth number (Table 3, page 1190), those who did not lose any teeth seemed to have greater improvement in dietary pattern during this eight-year period compared with men who lost teeth. There was no difference in the change of total energy intake. Men without tooth loss had greater reductions in daily dietary intake of saturated fat, cholesterol and vitamin B_{12} and greater increases in dietary fiber, carotene and fruits compared with men who lost teeth. However, when we additionally adjusted for smoking status, physical activity and profession, the results showed fewer differences among tooth loss groups. Participants who had lost one to four teeth were not significantly different from those without tooth loss in the changes of these dietary variables except for cholesterol and dietary fiber. Participants who had lost five or more teeth appeared to have a smaller reduction in dietary cholesterol (–36.7 milligrams per day versus –47.8 mg/day) and vitamin B_{12} (–0.64 micrograms per day versus –1.34 µg/day), and more reduction in polyunsaturated fat (–1.47 grams per day

TABLE 1

AGE STANDARDIZED BASELINE FACTORS BY NUMBER OF TEETH LOST 1986–1994.

BASELINE FACTOR	NO. OF TEETH LOST		
	0	1-4	≥ 5
Number of Participants (%)	24,921 (78.3)	5,992 (18.8)	900 (2.8)
Mean Age in Years (± SD*)	52.5 (9.2)	57.3 (9.2)	60.2 (8.6)
Physical Activity (METs†)	20.7	19.0	15.9
Occupation			
Dentist	15,006 (60.9)	2,973 (49.3)	401 (43.6)
Nondentist	9,915 (39.1)	3,019 (50.7)	499 (56.4)
Total Number of Teeth			
11–16	322 (1.6)	237 (3.7)	133 (14.1)
17–24	2,141 (9.8)	1,129 (17.7)	326 (33.6)
25–32	22,458 (88.6)	4,626 (78.6)	441 (52.3)
Cigarette Smoking Status			
Never	12,707 (49.5)	2,326 (39.7)	263 (31.1)
Past	10,383 (43.5)	2,902 (47.2)	431 (45.0)
Current	1,832 (7.0)	764 (13.1)	206 (23.9)
Body Mass Index (%)			
< 21	993 (3.9)	209 (3.5)	42 (4.6)
21–22.99	4,067 (16.0)	789 (13.2)	100 (11.3)
23–24.99	7,282 (29.1)	1,568 (26.2)	212 (23.6)
25–29.99	10,557 (42.8)	2,754 (45.8)	403 (44.4)
30+	1,542 (6.1)	534 (9.1)	109 (12.6)
Unknown	480 (2.0)	138 (2.2)	34 (3.5)
Alcohol Intake (Grams/Day)			
None	5,421 (21.9)	1,346 (22.3)	220 (24.0)
> 0–4.99	6,077 (23.9)	1,438 (24.3)	203 (23.2)
5–14.99	7,079 (28.2)	1,622 (27.1)	236 (26.4)
15–20.99	3,486 (14.1)	793 (13.3)	97 (11.0)
30+	2,858 (11.9)	793 (12.9)	144 (15.3)
Regular Dietary Supplement Use			
None	10,296 (40.1)	2,513 (42.9)	353 (41.5)
Multivitamin	10,495 (42.8)	2,476 (40.7)	389 (41.8)
Other supplements	4,130 (17.0)	1,003 (16.4)	158 (16.7)
Diabetes			
Yes	493 (2.3)	219 (3.4)	47 (4.5)
No	24,428 (97.7)	5,773 (96.6)	853 (95.5)
Hypertension			
Yes	4,811 (21.5)	1,524 (23.7)	249 (23.7)
No	20,110 (78.5)	4,468 (76.3)	651 (76.3)
Elevated Cholesterol Level			
Yes	2,930 (12.7)	865 (13.9)	140 (14.3)
No	21,991 (87.3)	5,127 (86.1)	760 (85.7)

* SD: Standard deviation.
† METs: Metabolic equivalents.

versus –1.21 g/day) and vitamin E (–0.54 mg/day versus –0.14 mg/day) than those without any teeth lost, but the test for linear trend for vitamin E across number of lost teeth was of only borderline significance ($P = .07$). They also had a smaller increase in dietary fiber (1.16 g/day) and solid fruit (0.06 serving per day) than did participants without tooth loss, who increased dietary fiber intake by 1.69 g/day and consumption of whole fruits by 0.17 serving/day.

Table 4 (page 1191) shows, by number of teeth lost, the percentage of men who had consumed these specific food items at least once a week in 1986 and still consumed the items at least once per week in 1994. There was no association between tooth loss and change in consumption in bananas and cantaloupes, which we considered easy to chew. For participants who consumed apples or pears weekly in 1986, those who had lost five or more teeth were significantly more likely to stop eating apples or pears than were the other two groups; 79 percent of those without tooth loss, 78 percent of those who had lost one to four teeth and 70 percent of those who had lost five or more teeth remained frequent consumers. Among those who ate carrots at least once per week in 1986, a significantly higher percentage of those who lost teeth did not consume raw carrots frequently compared with those who had not lost any teeth. Although men with greater tooth loss were more likely to consume cooked carrots, the difference was not significant after we adjusted for other variables.

DISCUSSION

The results of this study support the detrimental impact of tooth loss on dietary intake. Although, in general, participants in these three groups changed their diet in a healthier manner over this eight-year period, men who lost five or more teeth

TABLE 2

BASELINE (1986) AND DIFFERENCES (1994) FOR DAILY INTAKE OF CALORIE-ADJUSTED NUTRIENTS, FRUITS AND VEGETABLES BY NUMBER OF TEETH LOST 1986–1994.*

NUTRIENTS, FRUITS AND VEGETABLES CONSUMED	NO. OF LOST TEETH (NO. OF PARTICIPANTS)					
	0 (24,921)		1-4 (5,992)		≥ 5 (990)	
	Mean (± Standard Deviation) Baseline Intake and Difference					
	Baseline intake	Difference	Baseline intake	Difference	Baseline intake	Difference
Total Calories (Kilocalories)	1994 (604)	20.1 (550.7)	1,996 (603)	16.3 (571.8)	2,015 (624)	7.8 (625.8)
Carbohydrates (Grams)	230 (45)	22 (44)	234 (43)	21 (42)	235 (42)	21 (41)
Fats						
Saturated fat (g)	24.4 (6.0)	–2.69 (5.80)	24.5 (6.3)	–2.47 (5.98)	25.3 (6.5)	–2.32 (6.22)
Trans fat (g)	2.82 (1.11)	0.49 (1.35)	2.86 (1.17)	0.52 (1.42)	2.92 (1.24)	0.58 (1.44)
Monounsaturated fat (g)	27.2 (6.0)	–0.85 (6.81)	27.3 (6.1)	–0.81 (6.97)	27.8 (6.5)	–0.89 (6.92)
Polyunsaturated fat (g)	13.3 (3.5)	–1.22 (3.91)	13.1 (3.5)	–1.16 (4.02)	12.8 (3.6)	–1.19 (3.87)
Cholesterol (milligrams)	299 (106)	–53.0 (103.7)	305 (111)	–50.5 (113.1)	318 (120)	–47.8 (120.0)
Dietary Fiber (g)	21.1 (7.0)	2.22 (6.84)	21.0 (7.0)	2.20 (6.84)	20.2 (7.3)	1.98 (7.07)
Vitamins and Nutrients						
Vitamin C (mg)	166 (79)	1.14 (76.99)	167 (83)	1.90 (83.06)	164 (82)	5.24 (82.08)
Carotene (international units)	9,659 (7,557)	1,418 (8,323)	9,849 (8,370)	1,419 (9,248)	9,659 (8,641)	1,266 (9,655)
Beta-carotene (micrograms)	4,940 (3,386)	116 (3,524)	5,056 (3,693)	132 (3,897)	4,976 (3,874)	129 (4,264)
Vitamin E (mg)	8.11 (4.76)	0.03 (6.79)	8.17 (4.87)	0.03 (6.56)	7.98 (4.64)	–0.22 (5.82)
Vitamin B_6 (mg)	2.23 (0.60)	0.13 (0.65)	2.23 (0.60)	0.12 (0.65)	2.20 (0.62)	0.15 (0.63)
Vitamin B_{12} (µg)	8.77 (5.34)	–1.55 (6.48)	9.00 (5.48)	–1.35 (6.74)	9.37 (5.75)	–0.76 (7.27)
Folate (µg)	359 (118)	14.1 (128.8)	353 (114)	14.9 (126.4)	344 (112)	20.6 (123.7)
Potassium (mg)	3,375 (644)	71.8 (606.6)	3,396 (660)	64.9 (638.1)	3,383 (692)	94.2 (669.7)
Flavonoids (mg)	20.3 (14.5)	3.03 (15.6)	21.1 (15.3)	2.45 (16.7)	21.8 (18.7)	1.86 (19.93)
Fruits and Vegetables						
Fruits (servings)	2.42 (1.61)	0.21 (1.57)	2.49 (1.75)	0.25 (1.88)	2.42 (1.76)	0.21 (1.80)
Fruits excluding juices and sauces (servings)	1.62 (1.26)	0.19 (1.22)	1.70 (1.39)	0.22 (1.50)	1.65 (1.41)	0.12 (1.46)
Vegetables (servings)	3.32 (1.83)	0.24 (1.89)	3.33 (1.87)	0.22 (1.96)	3.28 (1.93)	0.13 (2.23)

* In 31,813 men with 11 or more teeth in 1986.

changed their dietary intake differently than did those who had no tooth loss during the eight-year period. They had greater reductions in intake of dietary polyunsaturated fat and vitamin E, smaller reductions in intake of dietary cholesterol and vitamin B_{12} and smaller increases in intake of dietary fiber and whole fruits than did those who did not lose any teeth. Men who had lost teeth were more likely to reduce consumption of apples or pears and raw carrots, which are considered as hard to chew. We did not find significant differences in the change of dietary intake between men who lost one to four teeth and men who lost no teeth except in intake of dietary cholesterol.

Our results are consistent with the findings of several cross-sectional studies that reported that perceived ease of chewing would be altered only when severe dentition losses occur.[20,21,33] Participants with tooth loss might increase intake in foods that do not require a lot of chewing to substitute for other foods as resources of calories. We found no differences in change in total calorie intake among those with or without tooth loss. We also found that men who had lost more teeth were more likely to stop eating hard-to-chew foods such as apples, pears and raw carrots while they maintained similar or increased consumption of soft foods such as bananas, cantaloupes and cooked carrots.

When compared with our findings, previous studies have reported substantially stronger cross-sectional associations after the researchers controlled for total energy intakes and several

TABLE 3

LEAST-SQUARE MEANS OF DIFFERENCES FOR DAILY INTAKE OF CALORIE-ADJUSTED NUTRIENTS, FRUITS AND VEGETABLES BY NUMBER OF LOST TEETH 1986–1994.*

NUTRIENTS, FRUITS AND VEGETABLES CONSUMED	LEAST-SQUARE MEANS OF DIFFERENCES IN DAILY INTAKE BY NO. OF LOST TEETH							
	Least-Square Means: Model 1†				Least-Square Means: Model 2‡			
	No. of lost teeth			*P* value for trend	No. of lost teeth			*P* value for trend§
	0	1-4	≥ 5	.74	0	1-4	≥ 5	.63
Total Calories (Kilocalories)	26.4	21.9	19.0	< .001	29.2	20.6	16.4	
Carbohydrates (Grams)	21.6	20.2¶	18.3#	< .001	18.9	18.7	18.2	.38
Fats								
Saturated fat (g)	−2.51	−2.30#	−1.93#	< .001	−2.19	−2.14	−1.96	.22
Trans fat (g)	0.58	0.60	0.64	.22	0.63	0.62	0.61	.21
Monounsaturated fat (g)	−0.79	−0.65	−0.47	.04	−0.45	−0.45	−0.49	.69
Polyunsaturated fat (g)	−1.28	−1.24	−1.43	.49	−1.21	−1.21	−1.47#	.046
Cholesterol (milligrams)	−52.1	−46.1#	−36.6#	< .001	−47.8	−43.6#	−36.7#	< .001
Dietary Fiber (g)	2.03	1.72#	1.15#	< .001	1.69	1.53	1.16#	.004
Vitamins and Nutrients								
Vitamin C (mg)	0.10	−0.98	−0.19	.14	−2.91	−2.04	0.94	.12
Carotene (international units)	1,294	1,106¶	775#	.001	1,074	1,035	880	.27
Beta-carotene (micrograms)	70.5	23.3	−62.3	.02	−15.3	−1.49	−17.3	.83
Vitamin E (mg)	−0.12	−0.23	−0.63	.005	−0.14	−0.19	−0.54	.07
Vitamin B_6 (mg)	0.11	0.09	0.10	.05	0.09	0.09	0.11	.81
Vitamin B_{12} (µg)	−1.49	−1.38	−0.67#	< .001	−1.34	−1.28	−0.64#	< .001
Folate (µg)	8.94	4.76	6.89	.08	4.41	3.12	8.51	.49
Potassium (mg)	57.2	40.2	63.0	.11	37.4	29.1	65.4	.51
Flavonoids (mg)	2.42	2.22	2.16	.20	2.15	2.11	2.23	.85
Fruits and Vegetables	0.24	2.24	0.14#	.001	0.18	0.21	0.15	.46
Fruits (servings)								
Fruits excluding juices and sauces (servings)	0.21	0.21	0.08#	< .001	0.17	0.19	0.06#	.01
Vegetables (servings)	0.14	0.12	0.06	.09	0.11	0.11	0.08	.72

* 31,813 men.
† Model 1: Least-square means adjusted for change in total energy intake and for baseline dietary intake, age and number of teeth.
‡ Model 2: Least-square means adjusted for change in total energy intake and for baseline dietary intake, age, number of teeth, smoking status, physical activity and profession.
§ *P* value for trend across men with zero, one, two, three, four, five to nine, and 10 or more teeth lost.
¶ $P < .10$ for testing differences of least-square means of men with one to four or five or more teeth lost compared with men who had no tooth loss for dietary variables with *P* value < .05 for linear trend across number of teeth lost.
# $P < .05$ for testing differences of least-square means of men with one to four or five or more teeth lost compared with men who had no tooth loss for dietary variables with *P* value < .05 for linear trend across number of teeth lost.

potential confounding factors.[23,27] Healthy behavior and socioeconomic status may confound the association between nutrition and oral health, and their confounding effects are unlikely to be eliminated completely, especially in cross-sectional studies. These previous studies indicate that a change in dietary pattern and oral health may be affected by not only dentition status, but also by intake of several nutrients such as vitamins A, B_6, C and D, calcium, niacin and thiamin.[34] When adjusted for number of teeth and dietary intake at baseline, and when evaluated for within-person change, our results would be less susceptible to these biases. However, we collected data on dietary intake in the past year by FFQ, which might not be able to reflect the effect of the tooth loss occurring at the end of the follow-up period. Also, loss of five or more teeth may not be severe enough to alter the dietary intake in this population. Furthermore, since we calculated change of dietary intake from two measurements of diet, the attenuation of associations caused by

nondifferential measurement errors in both FFQs would be higher than in cross-sectional studies, which only use a single measurement.

The pattern of dietary change of men with five or more teeth lost is unhealthier than that of men who lost no teeth, even though the longitudinal effects of tooth loss were relatively small in absolute terms. The combined detrimental effects from various foods and nutrients could lead to higher risk of developing chronic diseases. This cohort of health professionals is less susceptible to potential confounding owing to their homogeneity in socioeconomic status and health awareness. Also, the effect of tooth loss might be smaller, as these participants would be more likely to seek dental care to restore their chewing function than would general populations and also would be more likely to maintain a healthy consumption in nutrients by modifying food sources thanks to their relatively high socioeconomic status. Compared with the findings of the Third National Health and Nutritional Examination Survey, in which only 90 percent of completely edentulous people had both upper and lower dentures and 81 percent of people who were edentulous in the lower arch had dentures,[35] the participants in this cohort who had 17 or fewer teeth all had prostheses. Hence, we expect that the effect of tooth loss on dietary intake might be greater in the general population. Also, this cohort consisted of only men, and the associations may be different among women. We need further studies among women.

In our cohort, men with 11 to 16 teeth at baseline were more likely to lose teeth than men with 25 to 32 teeth. This result might suggest that risk factors causing initial tooth loss could be associated with continuing tooth loss. Clinicians need a better understanding of the factors underlying a patient's risk of experiencing oral diseases and take appropriate preventive strategies to eliminate the risk factors and thus stop continuing tooth loss.

We did not collect data on the location of teeth lost and their replacement status in this study.

TABLE 4

PARTICIPANTS' CONSUMPTION OF SELECTED FRUIT AND VEGETABLE ITEMS, 1986 AND 1994.

FRUITS AND VEGETABLES CONSUMED	TOTAL NO. OF PARTICIPANTS CONSUMING SPECIFIED FOOD ITEMS ONCE PER WEEK OR MORE IN 1986	% OF THOSE PARTICIPANTS STILL CONSUMING THOSE FOOD ITEMS IN 1994, BY NO. OF TEETH LOST		
		0	1-4	≥ 5
Banana	19,438	87.0	86.6	85.1
Cantaloupe	8,457	49.2	50.7	49.8
Apple or Pear*	21,376	79.3	77.9	69.9
Cooked Carrot	19,399	49.7	53.1	56.7
Raw Carrot*	19,399	70.2	62.5	55.5

* *P* value for trend < .05 after adjustment for baseline dietary intake, age, number of teeth, smoking status, physical activity and profession.

We expect that most of these health professionals who lost a substantial number of teeth had prosthodontic treatment. Previous studies also have reported only small and inconsistent differences in dietary intake comparing different types of prosthetic treatments: implant-supported dentures versus conventional mandibular dentures, or dentures versus no dentures.[36-42] Hence, lack of information of prosthetic treatments is unlikely to affect our findings significantly.

CONCLUSION

We found significant associations between changes in dental status and dietary intake of specific nutrients. Our results suggest that changes in diet owing to tooth loss could contribute to the increased risk of chronic disease that has been associated with poor dentition. ■

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