General Health Status and Changes in Chewing Ability in Older Canadians over Seven Years

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Abstract

Objectives: The purpose of this study was to describe the onset of and recovery from chewing problems in an older adult population over a seven-year period and to describe factors associated with these changes. Of particular interest was the relationship between general health and changes in oral functioning. Methods: The data came from a longitudinal study of community-dwelling individuals who were aged 50 years and older when first recruited. Data were collected at baseline (n=907) and at three (n=611) and seven-year (n=425) follow-ups. Oral function was assessed by means of a six-item index of chewing ability. Data were weighted to account for loss to follow-up using weights derived from the seven-year response proportions for dentate and edentulous subjects. Logistic regression analysis using backward stepwise selection was used to identify predictors of onset and recovery. Results: At baseline, 25 percent of subjects reported a problem chewing. This rose to 26 percent at three years and 34 percent at seven years. The seven-year incidence of chewing dysfunction was 19 percent. Of those with a chewing problem at baseline, 21 percent did not have a problem at seven years. A logistic regression model predicting the seven-year incidence of chewing problems indicated that subjects aged 65 years or older, the edentulous, those rating their oral health as poor, those without dental insurance and those without a regular source of dental care were more likely to be an incident case. In addition, a variable denoting the number of chronic medical conditions at baseline also entered the model. A logistic regression model predicting recovery indicated that older subjects, the edentulous, those from low-income households, and those with limitations in activities of daily living were less likely to recover over the observation period. Conclusion: The results of this study indicate a marked increase in the prevalence of chewing problems in this older adult population over the seven-year observation period. Poorer general health at baseline increased the probability of the onset of a chewing problem and decreased the probability of recovery. [J Public Health Dent 2002;62(2):70-77]

Key Words: chewing ability, older adults, risk factors, general health, dental status.

Contemporary concepts of health encompass the three important dimensions of physical, mental, and social well-being. Physical well-being is perhaps the most fundamental, since it is the dimension most likely to be affected by diseases and disorders of various sorts. It concerns the ability to function with respect to usual and mundane activities of daily life such as moving around, self-care, and the ability to eat. In dentistry, multidimensional models of oral health have been developed that incorporate functional issues such as chewing and speaking and the extent to which they are affected by loss of teeth or other disease states (1-3). Moreover, ways of measuring oral dysfunction have been developed that rely on individuals' self-assessments of their ability to chew a range of foods of varying consistency and hardness (4).

The ability to chew is of obvious importance in that it influences the types of foods people choose to eat. A number of studies have indicated that tooth loss can result in a relatively poor diet (5-7). As chewing efficiency declines, people choose foods that are soft and easier to chew and this can lead to marked changes in dietary intakes of fiber and other nutrients (8-10). A UK study found that intakes of essential nutrients including protein, calcium, iron, and vitamin C were lower in those with no natural teeth compared with those retaining at least some of their teeth (10). Undernutrition has been observed in residents of a US long-term care facility, which was linked to eating problems (11), and chewing problems increased the likelihood of weight loss in nursing home residents (12). A study of institutionalized frail older adults found that those with compromised oral functional status had lower body mass index and serum albumin concentration (13). Edentulousness also has been found to be an independent risk factor for significant weight loss in community-dwelling older adults (14). Quality of life also may suffer when individuals experience problems chewing some foods. A study of older adults found that 39 percent of those with no teeth were prevented from eating foods they would like to eat, 29 percent reported a decline in their enjoyment of food, and 14 percent avoided eating with others (15).

Surveys using self-report measures of chewing ability have found that up to one-third of older individuals have trouble chewing or biting some foods; this may increase to three-quarters when the very old who have lost all of their natural teeth are considered (15-17). Oral functional problems are also prevalent in younger dentate populations. The Florida Dental Care Study found that 23 percent of subjects aged 45 years and older who retained at least one tooth had difficulty chewing one or more foods (18). While these cross-sectional studies provide valuable information on the extent of oral functional limitation, longitudinal

studies are necessary to explore the dynamics of chewing problems. Such studies provide information on the incidence of chewing difficulties and allow the characteristics of subjects most at risk to be identified. They also provide information on the extent to which chewing difficulties persist over time or are resolved as a result of dental care.

Accordingly, this study provides data on change with respect to the chewing problems experienced by a sample of community-dwelling adults who were aged 50 years and older when first assessed. These individuals took part in a three-phase study over a seven-year period. One aim of the study was to investigate changes in the oral health-related quality of life of an older population as it aged. Of particular interest was the relationship between general health at baseline and changes in oral function over time. This interest arose out of the view that oral health and general health are not separate entities. Evidence is accumulating of a reciprocal relationship; oral disease can increase the risk of systemic disease and systemic disease can increase the risk of oral disease (19). The study described in this paper sought to determine if this link can be observed at the level of oral functioning by examining the association between poor general health at baseline and changes in chewing ability over the next seven years. While chewing problems may contribute to poor general health because of food avoidance and a nutritionally poor diet, it is also possible that those in poor general health are at greatest risk of a decline in oral functional capacity.

Methods

Study Design and Sample. The data on which this paper is based were obtained from the Ontario Study of the Oral Health of Older Adults. This is an observational cohort study of a random sample of community-dwelling individuals who were aged 50 years and older when first recruited. The main aim of the study was to document the natural history of oral diseases and disorders in an older adult population. The study consisted of a baseline phase with follow-ups at three and seven years. At baseline, subjects were identified using a telephone interview survey based on random digit dialing. Following recruit-

ment, 907 completed a personal interview concerning their oral health, use of dental services, general health, and personal and household characteristics. Three years later, 611 subjects completed a further personal interview; seven years after baseline, 425 completed a telephone interview. Clinical oral examinations were undertaken at baseline and three years, but not at the seven-year follow-up. Each phase was approved by the University of Toronto's Human Subjects Certification Committee. Details of these phases along with the characteristics of subjects participating at each phase have been reported elsewhere (20-22).

Measures. At each phase of the study, an identical set of questions was used to measure oral and general health and other relevant variables. Chewing ability was assessed using an index consisting of six indicator foods. These foods included a piece of fresh carrot, boiled vegetables, fresh lettuce salad, firm meats such as steaks or chops, a piece from a whole fresh apple, and hamburger (4). Subjects unable to chew or bite one or more of these foods were defined as having a problem chewing. Questions were asked concerning oral health status (dentate/edentulous) and global self-rating of oral health (excellent, very good, good, fair, poor). An inventory of oral symptoms was used to collect data on other problems such as dry mouth that may affect the ability to chew. Information on dental visiting was obtained using questions concerning the availability of a regular source of dental care and the frequency of preventive dental visits.

General health was measured by means of a global self-rating, a checklist of nine major chronic medical conditions, and a nine-item index assessing limitations in the performance of activities of daily living such as dressing and managing household chores. At three and seven years, subjects were also asked if their health had improved, stayed the same, or worsened over the period since the previous interview.

Data on personal and household characteristics included age, sex, marital status, education, dental insurance coverage, and household income. A low-income household was defined as a household in which the annual income from all sources was equal to or

less than $19,999. Households with $20,000 or more per annum were designated as high income.

Statistical Analysis. Statistical analysis was undertaken using SPSS 8.0 for Windows. Simple descriptive statistics were used to document changes in the proportion of subjects who reported a problem chewing over the course of the study. Proportions were computed for all subjects and for the dentate and edentulous separately. Differences in proportions across the three phases of the study were tested using Cochran's Q for k-related samples. McNemar's test was used to ascertain the statistical significance of differences in proportions between baseline and three years and three years and seven years.

Patterns of change across the three waves of the study also were explored. The incidence of chewing problems between baseline and seven years was computed and bivariate analyses undertaken to identify variables associated with incidence. Chi-square tests were used to determine the significance of these associations. Relative risks (RR) and 95 percent confidence intervals (CI) were calculated from these incidence data. Logistic regression analysis was then used to identify which of the predictor variables had significant independent effects. Models were constructed using backward stepwise procedures for all subjects and for the dentate and edentulous separately. Here, all variables examined at the bivariate level were entered into the model and progressively removed based on their Wald statistics and associated P-values. Variables remained in the models if the P-value was less than .10. Since some subjects reported chewing problems at baseline that had resolved over the seven-year observation period, the bivariate and multivariate analyses were repeated so that those with chronic dysfunction and those whose ability to chew had improved could be compared.

Results

Loss to Follow-up. Table 1 shows the characteristics of subjects taking part at each study phase using variables collected at baseline. The mean age of subjects when first recruited was 63 years. While the age and sex composition of the sample remained constant over the three waves of the

study, subjects remaining in the study at seven years were more likely to be dentate, rated their general health more favorably, were more likely to have dental insurance, and were more likely to make regular dental visits. Although the magnitude of the differences in the characteristics of the sample over the phases of the study was not large, data were weighted to take account of loss to follow-up. Since dental status is a major determinant of chewing ability, nonresponse weights were calculated using seven-year follow-up rates for dentate and edentulous subjects (23,24). These rates were 50.5 percent for the dentate and 30.9 percent for the edentulous. Nonresponse weights were derived from the reciprocal of the response proportions and were 1.98 (1/0.505) for the former and 3.24 for (1/0.309) the latter. After weighting, the effective sample size was 907 subjects. All data presented below are weighted estimates.

General Health Status at Baseline and Follow-up. At baseline, 21.1 percent of subjects reported that their general health was only fair or poor. Two-thirds had one or more chronic major conditions and 16.6 percent reported one or more limitations in activities of daily living. At the seven-year follow-up, 46.6 percent of subjects reported deterioration in their general health over the course of the study. Just over half, 51.5 percent, had acquired one or more chronic conditions and 12.3 percent had higher scores on the activities of daily living (ADL) index, indicating a decline in physical functioning.

Prevalence and Incidence of Edentulism. At baseline, 21.4 percent of subjects were edentulous. The prevalence rate at seven years was 22.9 percent. Of the 713 subjects who were dentate at baseline, 14 (2.0%) were edentulous at the seven-year follow-up. This represents an annualized incidence rate of 0.3 percent. The clinical examinations undertaken at baseline and three years revealed that among the dentate, 19.4 percent lost one or more teeth over the first phase of the study.

Change in Proportion with a Problem Chewing. The percentage of subjects with a chewing problem increased from 24.7 percent at baseline to 34.1 percent at the final follow-up (P<.001) (Table 2). The increase between baseline and the three-year follow-up was small and not significant.

TABLE 1
Characteristics of Study Subjects at Each Study Phase According to Baseline Variables

Characteristics	Baseline (N=907)	3 Years (N=611)	7 Years (N=425)
Percent female	57.1	56.2	59.0
Mean age at baseline (years)	63.0	62.6	62.0
Percent dentate	78.6	82.4	85.7
Percent rating oral health fair or poor	24.6	24.7	23.1
Percent rating general health fair or poor	21.1	19.4	17.1
Percent regular dental visits	54.0	59.4	61.4
Percent with dental insurance	46.9	51.0	54.7
Percent low-income household	38.2	34.2	37.2

TABLE 2
Percent with Problem Chewing at Baseline, 3 Years, and 7 Years

	Baseline	3 Years	7 Years	P-value*
All subjects	24.7	25.9	34.1	<.001
Dentate	17.0	16.7	23.2	<.001
Edentulous	53.0	57.9	70.7	<.001
P-value†	<.001	<.001	<.001	

*P-values from Cochran's Q tests comparing differences in proportions across periods.
†P-values from chi-square tests comparing dentate and edentulous.

However, the increase between three years and seven years was larger and significant (McNemar's test: P<.001). The same pattern was observed for both the dentate and the edentulous, with the greater part of the increase in prevalence taking place between the three- and seven-year follow-up phases. At the time of the seven-year follow-up, 23.3 percent of the dentate and 70.7 percent of the edentulous were unable to chew or bite one of the indicator foods comprising the index of chewing ability.

Patterns of Change. While the prevalence data in Table 2 are useful, they conceal rather than reveal patterns of change. Figure 1 shows the distribution of study subjects according to whether or not they had a problem chewing at baseline, three years, and seven years. This method of classifying subjects gives rise to eight groups. Group 1 consists of 520 subjects (57.4 percent of the total) who did not have a problem chewing at any of the three data collection points, while group 8 consists of 142 subjects (15.7 percent of the total) who had a prob-

lem chewing at all three phases of the study.

The data in Figure 1 can be used to make a number of observations concerning changes in study subjects' ability to chew. First, 42.7 percent had a problem chewing at one or more of the data collection points. Second, while some subjects acquired a chewing problem over the course of the study, others recovered. Third, while groups 1 and 2 (73.1% of subjects) were stable over the observation period, groups 2, 4, 5, and 7 changed (19.7% of subjects) and groups 3 and 6 fluctuated (7.2%). Fourth, several incidence and recovery rates can be calculated from these data. The way in which these rates were calculated is shown in Table 3.

With respect to incidence, among the 683 subjects who could bite or chew all six indicator foods at baseline, 75 (10.9%) reported a chewing problem at three years. However, 30 of these reported no problem at seven years. Among the 673 with no problem at three years, the incidence between three and seven years was 18.3 per-

FIGURE 1

Classification of Study Subjects According to Presence or Absence of a Chewing
Problem at Each Study Phase
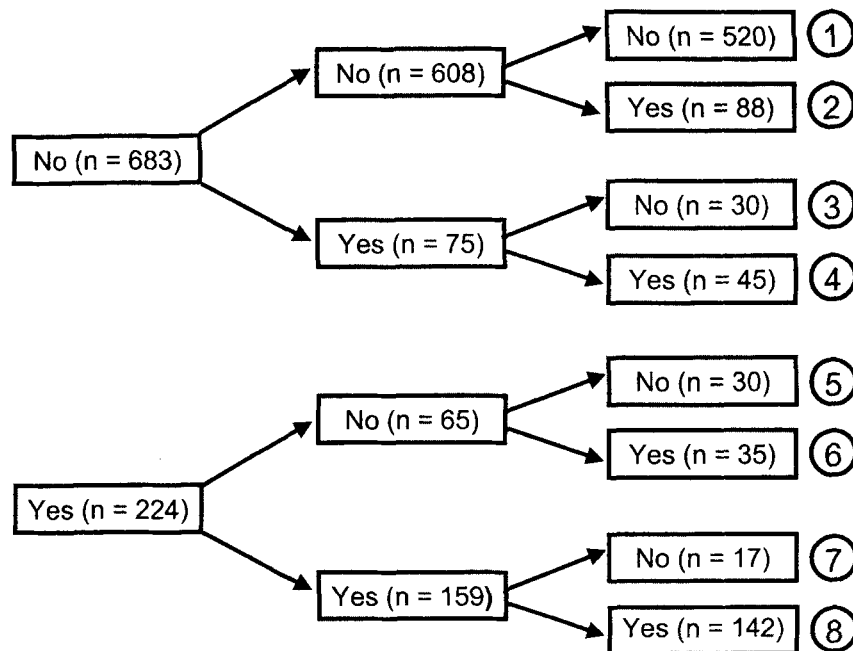
TABLE 3

Calculation of Incidence and Recovery Rates of Chewing Problems

	Calculation	Rate (%)
Incidence rates		
Baseline to 3 years	$\dfrac{75}{683}$	10.9
3 to 7 years	$\dfrac{88+35}{608+65}$	18.3
Baseline to 7 years	$\dfrac{88+45}{683}$	19.5
Recovery rates		
Baseline to 3 years	$\dfrac{65}{224}$	29.0
3 to 7 years	$\dfrac{30+17}{75+159}$	20.1
Baseline to 7 years	$\dfrac{47}{224}$	21.0

cent. Thirty-five of these incident cases had a chewing problem at baseline, but not at three years. If the three-year phase is ignored, the incidence rate between baseline and seven years was 19.5 percent.

Regarding recovery, of the 224 subjects with a chewing problem at baseline, only 159 had a problem at three years, representing a recovery rate of 29.0 percent. Further, 47 (20.1%) of the 234 subjects with a problem at three

years had recovered at seven years. However, more than half of those recovering at three years reported a problem at seven years, so that the recovery rate between baseline and seven years was 20.2 percent.

Predictors of Onset Between Baseline and Seven Years. Bivariate and multivariate analyses were undertaken to identify baseline variables associated with the onset of a chewing problem. In these analyses an incident

case was defined as an individual who did not have a problem chewing at baseline, but reported a problem at seven years. Consequently, those with a problem at three but not seven years (n=30) were not designated as an incident case.

Incidence rates were higher among those aged 65 years and older, the edentulous, those rating their oral health as poor, and those rating their general health as poor (Table 4). Incident cases reported more chronic medical conditions than noncases (means of 1.29 and 0.91, respectively; t-test: $P<.001$) and higher scores on the limitations in activities of daily living scale (means of 0.39 and 0.17, respectively; t-test: $P<.05$). Incidence rates were also higher among those from low-income households, those without dental insurance, those not making regular dental visits, and those who did not have a regular dental care provider. Among the dentate, those wearing one or more partial dentures had a higher incidence of chewing problems than those not wearing dentures. In addition, those losing one or more teeth between baseline and three years were more likely to experience onset. Unadjusted odds ratios (OR) indicated that the strongest predictor was dental status; the edentulous were at 3.40 times the risk of onset than the dentate.

A logistic regression analysis using weighted data and including all subjects indicated that six variables had significant independent effects (Table 5). Not having a regular dental care provider and being edentulous were the two strongest predictors of being an incident case (ORs of 3.39 and 2.80, respectively), after controlling for the effect of the other variables in the model. The variable denoting the number of chronic medical conditions also stayed in the model with an OR of 1.33. Other variables in the model were dental insurance, self-rated oral health, and age.

When separate models were constructed for the dentate and edentulous (data not shown), the number of chronic medical conditions remained in the model for dentate subjects ($P<.05$; OR=1.35) along with dental insurance ($P=.09$; OR=1.62), wearing one or more dentures ($P<.0001$; OR=2.35), loss of one or more teeth between baseline and three years ($P<.05$; OR=2.12), and not having a

TABLE 4
Associations Between Baseline Characteristics and Incidence of Chewing Problem Between Baseline and 7 Years

	% with Onset	P-value*	Relative Risk (95% CI)
Age (years)			
65 and older	24.3	<.05	1.40
50–64	16.8		(1.06, 1.96)
Sex			
Female	20.6	NS	1.16
Male	17.8		(0.85,1.60)
Dental status			
Edentulous	50.0	<.0001	3.40
Dentate	17.7		(2.56, 4.51)
Self-rated oral health			
Fair/poor	24.6	NS	1.33
Excellent/good	18.5		(0.92, 1.91)
Self-rated general health			
Fair/poor	32.6	<.001	1.91
Excellent/good	17.1		(1.38, 2.65)
Household income			
Low	36.1	<.0001	2.26
High	15.9		(1.66, 3.08)
Dental insurance coverage			
No	23.5	<.001	1.55
Yes	15.2		(1.13, 2.12)
Regular preventive dental visits			
No	30.5	<.001	2.24
Yes	13.6		(1.65, 3.04)
Regular source of dental care			
No	46.6	<.0001	3.38
Yes	13.8		(2.55, 4.49)
Wears 1 or more dentures (dentate only)			
Yes	26.7	<.0001	3.11
No	8.6		(2.10, 4.63)
Lost 1 or more teeth between baseline and 3 years (dentate only)			
Yes	22.0	<.05	1.70
No	13.0		(1.10, 2.62)

*P-values obtained from chi-square tests.

regular source of care (P<.05; OR=2.48). The ADL score remained in the model for edentulous subjects with an odds ratio of 4.25 (P<.05). Edentulous males were less likely than edentulous females to be an incident case (P=.08; OR=0.39), while those without a regular source of care were more likely to be an incident case (P<.01; OR=8.85). These models indicated that poor general health at baseline was a risk factor for the onset of a chewing problem for all subjects and the dentate and edentulous separately.

Predictors of Recovery Between Baseline and Seven Years. Bivariate and multivariate analyses were also undertaken to identify baseline variables associated with recovery. In these analyses, a recovered case was defined as an individual who had a problem chewing at baseline but not at seven years. Consequently, the 35 subjects who recovered at three years but relapsed at seven years were considered to be persistent rather than recovered cases.

In the bivariate analyses, the pattern of associations between baseline variables and recovery was more or less the same as that between these variables and onset. That is, older subjects,

the edentulous, and those disadvantaged in terms of income and access to dental services were less likely to have recovered by the time of the seven-year follow-up. Those with poorer general health at baseline were also less likely to recover. For example, only 11.3 percent of subjects rating their general health as poor at baseline had recovered at seven years compared with 25.0 percent of those rating their health as excellent or good (P<.05; RR=0.45). In addition, recovered cases had fewer chronic medical conditions at baseline than cases who did not recover (means of 0.84 and 1.32; P<.01) and lower scores on the ADL scale (means of 0.15 vs 0.55, respectively; P<.001). Among the dentate, those wearing one or more dentures were less likely to recover (P<.0001; RR=3.68). However, tooth loss between baseline and three years was not associated with recovery.

The logistic regression model predicting recovery among all subjects contained four variables. Older subjects (P<.01; OR=0.28), the edentulous (P<.01; OR=0.30), those from low-income households (P<.01; OR=0.27) and those with limitations in activities of daily living (P<.05; OR=0.44) were less likely to have recovered at the seven-year follow-up. The limitations in activities of daily living score also entered the model predicting recovery in dentate subjects with an odds ratio of 0.36 (P=.06). A model predicting recovery among edentulous subjects could not be fitted to the data because of the small number of subjects involved.

Change in General Health and in Chewing Ability. Incidence rates for chewing dysfunction were higher among those who reported that their general health deteriorated during the course of the study than among those whose general health remained stable or improved (26.3% vs 13.4%: P<.0001; RR=1.97, 95% CI=1.43, 2.72). For those with a chewing problem at baseline, recovery rates were lower for subjects who deteriorated than subjects who were stable or improved (15.4% vs 27.6%: P<.05; RR=0.56; 95% CI=0.33, 0.94).

Discussion

In this longitudinal study, loss to follow-up was high, with only 47 percent of baseline subjects participating at the seven-year phase. Although dif-

TABLE 5
Results of Logistic Regression Analysis: Baseline Predictors of Incidence of a Chewing Problem

Independent Variable	Beta Estimate	Wald Chi-square	P-value	Odds Ratio (95% CI)
Age at baseline (50–64 years=0; 65 and older=1)	0.4566	3.06	.08	1.58 (0.95, 2.63)
Dental status (dentate=0; edentulous=1)	1.0295	8.28	<.01	2.80 (1.39, 5.65)
Self-rated oral health (excellent/good=0; fair/poor=1)	0.6310	4.04	<.05	1.88 (1.06, 3.48)
Number of chronic medical conditions	0.2865	6.08	<.05	1.33 (1.06, 1.67)
Dental insurance (yes=0; no=1)	0.4992	3.96	<.05	1.65 (1.01, 2.69)
Regular source of dental care (yes=0, no=1)	1.2210	14.67	<.001	3.33 (1.82, 6.33)

Dependent variable: incident case=1; noncase=0. Model chi-square=89.7; P<.0001; sensitivity=35.01%; specificity=94.64%.

ferences in the characteristics of those taking part at baseline and those taking part at the final follow-up were not large, those remaining in the study were more likely to be dentate, in better health, and more advantaged in terms of dental insurance coverage and use of dental services. However, when data were weighted to account for nonresponse, differences between unweighted and weighted estimates of the main dependent variables were small. For example, after weighting, the seven-year incidence of chewing problems increased by only 1.5 percent.

The data from this study revealed a marked increase in the prevalence of chewing problems in this community-dwelling sample of older adults over the seven-year observation period. At baseline one-fourth were unable to chew or bite one or more indicator foods comprising the index of chewing capacity. By the time of the final follow-up, this had increased to slightly more than one-third. There was little change between baseline and three years, with most of the increase occurring between the assessments at three and seven years. The mean age of the sample increased from 66 years to 70 years over this period. It was also the case that the increase was more marked among the edentulous than the dentate. The prevalence rate increased by 6.3 percent in the dentate and 17.7 percent in the edentulous. The change profile also differed somewhat according to dental status. Among the dentate, the percentage

with a problem remained stable over the first observation period and then increased. For the edentulous, increases were observed between baseline and three years and three and seven years, although only the latter was significant.

While prevalence data for each study phase are informative, they conceal patterns of onset of and recovery from chewing problems. These patterns became apparent when subjects were classified into eight groups based on the presence or absence of a chewing problem at each of the data collection points. The onset rate for the first observation period was 10.9 percent and for the second, 18.3 percent. Recovery rates were 29.0 percent and 20.1 percent, respectively. If the three-year phase is ignored, seven-year incidence and recovery rates were 19.5 and 21.0 percent, respectively.

Annualized incidence rates between baseline and three years and three years and seven years suggested that the probability of onset of a chewing problem increased with aging, while the probability of recovery decreased. Moreover, even though overall incidence and recovery rates were comparable, the number of subjects reporting onset was three times that of those reporting recovery. This accounts for the fact that the prevalence of chewing problems increased over the seven-year period of the study.

In the bivariate and multivariate analyses reported in this paper, an incident case was defined as an individual with no problem at baseline but a

problem at the seven-year follow-up. This definition excludes the 30 individuals who suffered onset between baseline and three years, but recovered by seven years (group 3 in Figure 1), and the 35 individuals who recovered between baseline and three years, but relapsed by seven years (group 6 in Figure 1). Since subjects in group 3 are included when incidence between baseline and three years is calculated, and subjects in group 6 are included in calculations of incidence between the three and seven-year follow-ups, the definition used may be open to question. However, our classification of incident cases conforms to the classic definition of incidence. Such classification problems do not arise in studies having only two data collection points or in studies with multiple data collection points where recovery and relapse cannot legitimately occur. Using our definition of incidence, six variables entered a prediction model when all subjects were considered, and five and three variables entered models for the dentate and edentulous, respectively. A variable common to all models, and the one with the strongest independent effect, was not having a regular source of dental care. Not having dental insurance was a predictor for all subjects and the dentate. These findings indicate the importance of access to dental services in terms of maintaining oral function in this aging population.

One limitation of the study is that a clinical examination was not conducted as part of the seven-year fol-

low-up. Consequently, the full effect of tooth loss on the onset of chewing problems in the dentate cannot be assessed. Tooth loss between baseline and the three-year phase was associated with the seven-year incidence of chewing problems in dentate subjects so that tooth loss over three years may be acting as a proxy for tooth loss over seven years. However, since incidence rates were higher in the edentulous than the dentate, the lack of tooth loss data may not seriously compromise the study when the sample as a whole is being considered. One unexpected finding was that the seven-year incidence of chewing problems among the edentulous was 50 percent. This seems to suggest that even when prosthetic replacements may restore oral function, the benefit is often temporary and many of these individuals will experience a decline in their ability to chew as they age. Whether technologies such as osseointegrated implants can restore oral functioning over the longer term remains to be seen.

One of the aims of the bivariate and multivariate analyses was to determine if poor general health at baseline increased the risk of onset of a chewing problem over seven years. At the bivariate level, incident cases had poorer health on all three measures used. They were more likely to rate their health as poor, had more chronic medical conditions, and experienced more limitations in activities of daily living. The number of chronic medical conditions had significant independent effects in logistic regression models for all subjects and the dentate, and the score on the ADL scale had a significant independent effect in the model for the edentulous. The score on the ADL scale also entered the models predicting recovery among all subjects and the dentate and indicated that those with functional limitations were less likely to recover over the course of study. It was also the case that subjects who reported a deterioration in their general health over the seven-year observation period were more likely to suffer onset and less likely to experience recovery. This variable was not included in the prediction models because these reports were retrospective and so logically cannot be considered to be predictors. However, this finding lends further support to the bivariate and multivariate analyses suggesting links between poor general health and

oral functional decline over time.

The mechanism linking poor general heath and the onset of chewing problems is not immediately clear. Since the association is independent of age, it does not appear that it is due to aging per se. Possibly, among the dentate, those with poor general health are at greater risk of tooth loss, while in the edentulous poor general health may be linked to increased loss of alveolar bone. However, since the number of chronic medical conditions at baseline was a predictor of the onset of a chewing problem among the dentate after controlling for tooth loss over the first three years of the study, this explanation is not entirely plausible. The link may be functional, whereby poor general health leads to a decline in bite force and chewing efficiency.

A more plausible explanation is that those in poor general health are at greater risk of developing dry mouth as a result of increased medication use. Foerster et al. (18) noted that dry mouth was strongly associated with chewing difficulty in a younger dentate population and an earlier analysis of data from our study indicated that poor general health at baseline was a risk factor for the incidence of dry mouth at the three-year follow-up (25). Here, the baseline prevalence of dry mouth in those without a chewing problem was 13.7 percent. At the seven-year follow-up the prevalence was significantly higher in incident than nonincident cases (47.6% vs 28.4%; $P<.0001$). This suggests that dry mouth may be an important contributor to the decline in oral function in this population. Finally, since both general health and chewing ability were measured by self-reports, perceptual and psychological factors may be involved. Further work is needed to fully elucidate the links between general health and functioning and oral health and functioning in aging populations.

What is more certain is that those in poor general health are at increased risk in terms of the onset of chewing problems and less likely to recover following onset. This may, in turn, compromise the food intakes and dietary patterns of those most vulnerable to the systemic effects of nutritional deficiency. Further research is indicated to assess changes in the nutritional status of older adults with chronic or disabling medical conditions in relation

to changes in chewing ability and aging.

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