Abstract: Age-related deterioration in physical and oral health reduces healthy life expectancy and is thus an important problem for very elderly people. We investigated the effects of satisfaction with dietary life (SDL) in everyday life on oral health-related quality of life (OHRQoL) and subjective well-being and examined associations between these factors. We evaluated 426 elders aged 85 years or older. All participants completed a questionnaire that inquired about age, gender, drinking status, body mass index, cognitive function, disability, and comorbidities, among other covariates. Oral, physical, and mental health conditions were also examined. Associations of questionnaire results for SDL with items on subjective well-being (Philadelphia Geriatric Center Morale Scale [PGC] and World Health Organization-5 [WHO-5]) and OHRQoL (Geriatric Oral Health Assessment Index [GOHAI]) were confirmed with multiple logistic regression analysis. In a multivariate model adjusted for various confounders, participants with self-reported “enjoyable” SDL had significantly lower risks for having the lowest scores on the GOHAI, PGC, and WHO-5 (odds ratio [OR] = 0.460, 95% confidence interval [CI] = 0.277-0.762; OR = 0.589, 95% CI = 0.348-0.996; and OR = 0.452, 95% CI = 0.263-0.775, respectively). These associations remained after further adjustment for number of teeth.

Keywords: very elderly people; enjoy eating; subjective well-being; OHRQoL; healthy life expectancy.

Introduction
Age-related physical decline and deterioration in oral health are important problems that reduce healthy life expectancy and threaten the independence of elderly individuals (1,2). Recent epidemiological research indicates that deterioration in quality of life (QoL) is associated with musculoskeletal disorders, oral diseases, and physical and mental health problems that affect elders (3-7). These effects are strongly associated with age-associated malnutrition, diabetes, chronic diseases, and impaired cognitive function, all of which may share a common cause. However, only a few epidemiological studies have evaluated relationships among measures of oral, mental, and physical function in very old (≥85 years) individuals (8,9). Iinuma et al. investigated the role of oral health in maintaining QoL and general health and found that occlusal force was strongly associated with grip strength and capacity for physical activity (e.g., lower-extremity
performance) in very old men (8). Decreased physical function is accompanied by a decreased capacity for physical activity, which limits an individual’s range of activities and ability to participate in social activities. Limitations in physical activity also reduce interpersonal communications and disrupt relationships with friends, acquaintances, and relatives, leading to a decreased sense of belonging and diminished pride as a member of the community.

The daily diet of very elderly people does not simply provide energy to live—it also allows them to experience seasonal changes associated with food availability and provides opportunities for conversation with others during meals. From this perspective, the daily diet has a greater meaning for very elderly people than for younger generations. Consequently, the role of dentists responsible for maintaining and improving oral function among the very elderly is significant, and further information on its importance is needed. For this reason, it is important to investigate the relationships between a healthy, happy life and dietary satisfaction in the very elderly. We consider this basic but important theme to be the backbone of our research.

The aim of this study was to investigate the effects of satisfaction with dietary life (SDL) in everyday life on oral health-related quality of life (OHRQoL) and subjective well-being and to examine associations among these factors in very old adults. However, assessment of SDL is complex because it is influenced by individual values and by ethnicity, lifestyle, and economic conditions. For that reason, we used a simple and universal question: “How often do you enjoy meals?” We also examined respondents’ physical, nutritional, and oral status and the associations of these variables with questionnaire responses.

Materials and Methods

Participants
This study was conducted between March 2008 and November 2009 as part of the Tokyo Oldest Old survey on Total Health (TOOTH) study. The participants were 542 participants who completed both the in-home interview and a medical/dental examination (236 men, 306 women; mean age ± standard deviation [SD], 87.8 ± 2.2 years; range, 85-102 years). Details of the design, recruitment, and entire procedure of the study have been described previously (8-10). In total, 12 people with missing questionnaire data on oral health were excluded. Individuals with a diagnosis of cognitive impairment (Mini-Mental State Examination score <24) (11) were also excluded. Ultimately, data from 426 (78.6%) participants were analyzed.

This study was approved by the Ethical Committee of Nihon University School of Dentistry (EP2003-20) and Keio University School of Medicine (no. 19-47, 2007) and was registered in the UMIN Clinical Trials Registry (ID: UMIN 000001842).

Oral health survey
The comprehensive oral health assessment consisted of a face-to-face interview, including a questionnaire on SDL and ability to eat food; a questionnaire regarding oral health behaviors; and a dental examination by trained dentists (8). Perceived SDL was assessed with the question, “How often do you enjoy meals?”. Answers of usually or often indicated that they felt satisfaction with their dietary life (enjoyable). Answers of sometimes, seldom, or never indicated “non-satisfaction” (dissatisfied). Chewing ability and recent dental care were assessed in the interview.

Chewing ability was evaluated using a food-intake questionnaire concerning 15 kinds of food divided into three groups according to texture and hardness (8). In this study, we counted the total number of foods that could be eaten easily (i.e., without effort). Participants were asked if they had received any dental care in the last year (yes/no). After the interview, the dentist performed a dental examination that included a count of the number of teeth present and measurement of maximum occlusal force (MOF), a measure of bite force during maximum voluntary clenching. MOF was measured with an occlusal force measuring device (Occlusal Force-Meter GM10; Nagano Keiki, Inc., Tokyo, Japan) and used as an index of oral function, according to standard procedure. MOF was measured unilaterally on the right and left sides, at the first molar. Dentures were inserted when present. The measurement range of the instrument was 0.0-999.6 N, with an accuracy of ±1.0 N (8).

Assessment of OHRQoL and subjective well-being
The Geriatric Oral Health Assessment Index (GOHAI) was used to evaluate OHRQoL, based on a total score of 60 points for 12 questions (12). Self-administered health questionnaires—the Philadelphia Geriatric Center Morale Scale (PGC) (13) and World Health Organization-5 (WHO-5) Well-being Index (14)—were used to assess well-being. Scoring was performed in compliance with conventional methods, and a total score was obtained. Higher scores indicated higher levels of OHRQoL and subjective well-being, and the scores were used to divide participants into three groups by tertiles. The numbers and percentages of participants with the lowest GOHAI
scores (namely, 23-52), the lowest PGC scores (2-11), and the lowest WHO-5 scores (1-16) were determined.

**Physical performance survey**
Handgrip strength and the timed up-and-go (TUG) test were used to evaluate physical performance. The TUG test, which is widely used to measure motor function in elderly individuals, was used to measure lower-extremity performance (15). The handgrip force of the dominant hand was measured using a handheld dynamometer (Tanita 6103; Tanita Corp., Tokyo, Japan).

**Demographics and general health assessment**
Face-to-face interviews were used to collect data on demographic and general health characteristics, including age, gender, household composition, education level, smoking and drinking habits, activities of daily living (ADL), cognitive function, and medical history. Ten ADL domains were assessed using the Barthel Index (16). Cognitive function was assessed using the Mini-Mental State Examination (MMSE). Body mass index (BMI) was measured as an anthropometric variable. Diseases were classified according to the International Classification of Diseases, 10th revision.

**Nutrition survey**
Dietary habits during the preceding month were assessed with a validated, brief, self-administered questionnaire on diet history (BDHQ) (17). Responses to the BDHQ were clarified by direct questioning of the participant. The BDHQ was obtained for a total of 56 food and beverage items commonly consumed by the general Japanese population, as it is possible to use these data to estimate total energy intake and micronutrient intakes. Total calories and the percentages of total caloric intake attributable to proteins, fats, and carbohydrates (PFC balance) were analyzed. A specific algorithm was used to calculate participants’ energy intake based on their BDHQ responses. To avoid outliers, we excluded women with an energy intake of >3,000 kcal/day and men with an energy intake of >3,750 kcal/day (18).

**Statistical analysis**
All analyses were performed using SPSS ver. 22.0 (SPSS, Chicago, IL, USA). Data on baseline characteristics were collected from the SDL. Data are presented as means (SDs) or medians (interquartile ranges [IQRs]) for continuous variables and as numbers (percentages) for categorical variables. The Mann-Whitney *U* test was used to evaluate continuous variables, and the chi-square or Fisher exact test was used to assess categorical variables. Multivariate regression models were fitted to assess associations of SDL (yes/no) with GOHAI, PGC, and WHO-5 scores (dichotomous variables, defined as the lowest tertiles vs. others). Using relevant criteria, we chose the following covariates to analyze factors that might affect physical and mental health: age, gender, drinking habits, BMI, MMSE, ability to perform ADL, physical performance (handgrip strength), comorbidities (cancer), and number of teeth present.

Four models were created for multivariate analyses. We adopted a sequential approach whereby estimates were initially adjusted for age (continuous) and gender (categorical: male/female) (Model 1), then further adjusted for drinking habit (categorical), BMI (continuous), MMSE score (categorical: lowest tertile vs. others), and ADL disability (categorical: ADL score <100 vs. others) (Model 2). A further adjustment was made for all factors in the second model plus handgrip strength (categorical: lowest tertile vs. others) and cancer (categorical) (Model 3). The final model consisted of the third model plus number of teeth present (continuous). Education was dichotomized as high or low according to whether individuals had graduated from high school. Smoking and drinking were dichotomized in terms of whether participants had ever or never smoked and ever or never consumed alcohol, respectively. This classification was based on a study of persons with non-small-cell lung cancer who had never smoked (19). The results were considered statistically significant at *P* < 0.05, and all tests were two-sided.

**Results**
Data on demographics and general health characteristics, in relation to SDL (enjoyable or dissatisfied), are shown in Table 1. In total, 340 (79.8%) participants reported “enjoyable” SDL. In terms of demographic characteristics, SDL was significantly associated with drinking but not with other demographic characteristics. Regarding medical history, SDL was significantly associated with the prevalence of diabetes mellitus. Data on oral health, physical performance, and nutrition in relation to SDL are shown in Table 2. Regarding oral health characteristics, SDL was significantly associated with the chewable foods index. SDL was significantly associated with handgrip strength (in men), the timed up-and-go test, and total energy (in men and women). As shown in Table 3, finding food enjoyable was significantly positively associated with GOHAI, PGC, and WHO-5 scores (all *P* < 0.001).

Multiple logistic regression was used to estimate the risks for having the lowest OHRQoL and subjective well-
being scores by SDL status (Table 4). In the multivariate model adjusted for age, gender, drinking status, BMI, cognitive function, disability, physical performance, and comorbidity (Model 3), participants who reported “enjoyable” SDL had significantly lower risks for having the lowest scores on the GOHAI, PGC, and WHO-5 (OR = 0.460, 95% CI = 0.277-0.762; OR = 0.589, 95% CI = 0.348-0.996; and OR = 0.452, 95% CI = 0.272-0.766, respectively). After further adjustment for number of teeth present (Model 4), the association remained for the total sample. Overall, the risks for poor subjective well-being and OHRQoL scores remained higher in participants who were dissatisfied with their dietary life.
Discussion

This cross-sectional study of community-dwelling adults aged 85 years or older without cognitive impairment found that SDL score was significantly associated with number of chewable foods, physical performance, and total energy. SDL score was also significantly associated with OHRQoL items and subjective well-being (WHO-5 and PGC scores). Thus, this study confirmed that SDL is strongly associated with nutrition. Furthermore, SDL was significantly associated with maintenance of subjective well-being and good health through consumption of a diet based on a wide variety of foods. The fundamental elements of QoL include physical status and functional abilities, psychological status and well-being, social interactions, economic status, and religious status (Spilker B. Quality of life and pharmacoconomics in clinical trials. Lippincott-Raven, 1996). QoL is multifaceted and is thus measured and evaluated using multidimensional scales. Similarly, OHRQoL is multifaceted and should be measured using multidimensional scales (e.g., the Oral Health Impact Profile and GOHAI) (12,20). In this study, the GOHAI was used.

Elders often suffer strokes and fractures and subsequently require care. However, disease and injury are not the only reasons for nursing care in very old individuals. Diet is a highly influential factor in a large proportion of the oldest people, who require care because of malnutrition and frailty caused by aging (21). Moreover, oral conditions and OHRQoL in elders strongly affect malnutrition (22,23). Some studies reported that well-being is strongly related to age, living conditions, level of education, and relationships with friends (Cabinet office, Government of Japan. White Paper on the National Lifestyle, 2008). The present results revealed that the subjective well-being of...
very old individuals was also strongly associated with SDL. Moreover, this relationship was not affected by age, gender, cognitive function, ADL-related disability, physical performance, disease, or number of teeth present, all of which have previously been considered strong influences. In this study, most participants (94%) routinely used dentures. Thus, recovery of function by means of dental treatment can maintain the relationship between SDL and OHRQoL (i.e. subjective well-being). Additionally, GOHAI was significantly associated with SDL, and participants with poor dietary life had lower GOHAI scores. These findings indicate that satisfaction with dietary life is important to very elderly people, as it extends their healthy life expectancy.

We believe that lifestyle changes associated with decreased physical activity, including associated reductions in the frequency of social outings and everyday stimulation, are not the primary causes of decreased GOHAI and subjective well-being scores. Rather, we believe this decrease was caused by a reduction in SDL caused by a decline in food variety. For example, individuals may limit what they eat because of impaired oral function or diseases such as diabetes mellitus. A reduction in oral function, such as chewing ability and bite force, will limit the numbers of foods that can be eaten. Additionally, diseases such as diabetes mellitus lead to various dietary restrictions, which create obstacles to experiencing the pleasure associated with eating.

Furthermore, such restrictions can cause individuals to lose hope and resign themselves to their current situation of limited independence, which leads to further deterioration in subjective well-being. One report underscored the effect of decreased self-efficacy on the QoL of very elderly people (24). Thus, it is important that very elderly people maintain self-efficacy by experiencing a fulfilling dietary life and that dentists work to maintain and improve oral function in this subgroup.

Our study has several limitations. First, it targeted independent very old people. Because the life expectancy of very old people will increase in the future, they are likely to need long-term nursing care. Thus, future studies should target people receiving long-term nursing care. Second, our sample size was relatively small and was limited to seniors living in the Tokyo metropolitan area. Subjective well-being might be directly affected not only by regional variation but also, to some extent, by religion, education, poverty, and other factors. Thus, our findings must be validated on a larger scale in other cohorts. Finally, it is important to study food- and eating-related factors that lead to satisfaction and well-being among very elderly adults. Additionally, it is necessary to develop and promote a simple method to improve oral function among the very elderly in functional domains such as bite force.

In conclusion, among participants with normal cognitive function who participated in the TOOTH study, SDL was significantly associated with limb muscle strength, exercise capacity, the presence of disease, and chewing ability, which can be greatly improved by routine dental care and treatment. Furthermore, SDL was significantly associated with OHRQoL and subjective well-being, even after adjusting for potential confounders such as age, drinking habits, cognitive function, physical fitness, presence of disease, and loss of teeth. These results suggest that dental professionals can contribute to the lives of very elderly individuals by helping maintain their oral health.

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Conflict of interest
None declared.

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Epidemiol 37, 231-240.


