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Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-017946
Article Type:	Research
Date Submitted by the Author:	29-May-2017
Complete List of Authors:	Bando, Shino Tomata, Yasutake Aida, Jun; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Sugiyama, Kemmyo Sugawara, Yumi; Tohoku University Graduate School of Medicine, Division of Epidemiology, Department of Health Informatics and Public Health Tsuji, Ichiro; Tohoku University School of Medicine, Tohoku University Graduate School of Medicine, Division of Epidemiology, Department of Health Informatics and Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	teeth, tooth-brushing, denture, dental visit, disability

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6 2 Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese: The Ohsaki Cohort
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12 4 **Sources of support:**

13
14
15 5 Health Sciences Research grants (nos. H26-Junkankitou [Seisaku]-Ippan-001) from the Ministry of
16

17
18 6 Health, Labour and Welfare of Japan, and Research grants (H27-General Research grants) from the
19

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21 7 Foundation for Total Health Promotion.
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24 8
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26 9 **The number of words in the abstract:** 195 words

27
28
29
30 10 **The number of words in the text:** 2,785 words
31

32
33 11 **The number of tables:** 3 tables
34

35
36 12 **The number of references:** 30 references
37

38
39 13 **The number of supplementary material:** 1 table
40

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4 **1 Abstract**

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7 **2 Objectives:** To assess whether oral self-care (tooth-brushing, regular dental visits, and use of
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10 dentures) affects incident functional disability in elderly individuals with tooth loss.

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13 **4 Design:** A 5.7-year prospective cohort study.

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16 **5 Setting:** Ohsaki City, Japan.

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19 **6 Participants:** 12,370 community-dwelling individuals aged 65 years and older.

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22 **7 Primary outcome measures:** Incident functional disability (new LTCI certification).

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25 **8 Results:** In comparison with participants who had ≥ 20 teeth, the HRs (95% CIs) for incident
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28 functional disability among participants who had 10-19 and 0-9 teeth were 1.15 (1.01-1.30) and 1.20
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31 (1.07-1.34), respectively (P -trend $< .05$). However, the corresponding values for those who brushed
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34 their teeth ≥ 2 times per day were not significantly higher in the “10-19 teeth” and “0-9 teeth” groups
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37 [HRs (95% CI) 1.05 (0.91-1.21) for participants with 10-19 teeth, and 1.09 (0.96-1.23) for
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40 participants with 0-9 teeth], although HRs for those who brushed their teeth < 2 times per day were
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43 significantly higher [HRs (95% CI) 1.32 (1.12-1.55) for participants with 10-19 teeth, and 1.33
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46 (1.17-1.51) for participants with 0-9 teeth]. Such a negating association was not observed for other
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49 forms of oral self-care.

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52 **17 Conclusions:** Tooth-brushing may partially negate the increased risk of incident functional disability
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55 associated with having fewer remaining teeth.

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1 **Key words:** teeth, tooth-brushing, dental visit, denture, disability

2 **Strengths and limitations of this study**

3 • Our study is the first reported study to have demonstrated an impact of tooth brushing on the
4 increased risk of incident functional disability resulting from having fewer remaining teeth.

5 • This is a large population-based cohort study involving 12,370 individuals and it can take into
6 account considerable confounding factors.

7 • Although misclassification of the number of teeth and practicing oral self-care as a result of
8 self-reporting might have occurred, the validity of these have also been confirmed by previous
9 studies.

10

1 Introduction

2 As society ages, disability prevention has become an important public health issue. It has been
3 pointed out by the WHO that oral health is an important component of healthy aging, particularly in
4 the disadvantaged elderly.¹ Tooth loss is also known to be a risk factor for mortality in the elderly.^{2,3}
5 Periodontal disease, which is one of the main causes of tooth loss, is known to be related to coronary
6 heart disease,⁴ stroke,⁴ and pneumonia,⁵ which in turn are major causes of incident disability.⁶
7 Recently, several studies have indicated that tooth loss is related to incident disability.^{7,8} Therefore,
8 there is a need to decrease the excess risk of functional disability in elderly adults with missing teeth.

9 It has been suggested that oral self-care has a preventative impact on mortality.⁹ We have
10 reported that individuals who practiced three types of oral self-care (tooth brushing, regular dental
11 visits, and use of dentures) had a lower mortality risk than those who practiced none of the three.⁹
12 Those who practiced oral self-care also had a lower risk of dementia and cardiovascular disease.^{10,11}
13 These findings suggest that there are possible pathways linking oral self-care to incident disability.
14 Additionally, it has been reported that the intraoral environment affects the gut microbiota and may
15 cause systemic inflammation,¹² implying a new pathway whereby poor oral hygiene may be linked to
16 systemic disease. To our knowledge, however, only two studies have examined whether practicing
17 oral care affects the risk of functional disability among older people with tooth loss, and those
18 studies focused only on denture use¹³ or regular dental visits.¹⁴

19 The aim of the present cohort study was to assess whether three types of oral self-care (tooth

1 brushing, regular dental visits, and use of dentures) have an impact on incident functional disability

2 in individuals with tooth loss.

3

For peer review only

1 **Materials and Methods**

2 *Study design, setting, and participants*

3 The present study was based on data from the Ohsaki Cohort 2006 Study, whose design has been
4 described in detail elsewhere.¹⁵ In brief, the source population for the baseline survey comprised all
5 men and women aged 65 years or older living in Ohsaki City, Miyagi Prefecture, northeastern Japan,
6 on December 1, 2006. The survey included questions about the number of remaining teeth and oral
7 self-care status, as well as items on history of disease, education level, smoking, alcohol drinking,
8 body weight, height, psychological distress score, time spent walking per day, and food intake
9 frequency.

10 The baseline survey was conducted between December 1 and December 15, 2006, and the
11 follow-up survey between April 1, 2007 and November 30, 2012. A questionnaire was distributed by
12 the heads of individual administrative districts to all individuals aged 65 years or older living in
13 Ohsaki city, and then collected by mail. Among 31,694 subjects (12,750 men and 18,944 women)
14 eligible for this analysis, 23,091 (9,605 men and 13,486 women) provided valid responses and
15 formed the study cohort. Among the latter respondents, we excluded 6,333 individuals who did not
16 provide written consent for review of their Long-term Care Insurance (LTCI) information, 2,102 who
17 had already been certified as having a disability by the LTCI before the starting date of follow-up
18 (March 30, 2007), 62 who had died or moved away before the starting date of follow-up, 188 for
19 whom the Doctor's Opinion Paper had been unavailable, and 2,036 who left blank the item

1 concerning dental health status. Thus, 12,370 responses were analyzed for the purpose of this study.

2 During the 5.7-year period covered by the study, only 158 individuals were lost to follow-up
3 because they moved away from the study area without developing any functional disability; thus, the
4 follow-up rate was 98.7%. From 61,581 person-years, incident functional disability was recorded in
5 2,329 persons, and the number of all-cause deaths was 1,446.

6 7 *Measurement of dental health status*

8 In the baseline questionnaire, we asked respondents to classify the number of their remaining teeth
9 into six categories: all (28 teeth), most (25-27 teeth), moderate (20-24 teeth), about half (10-19 teeth),
10 few (1-9 teeth), and none (0 teeth). Then, we divided the respondents into three groups: 1) ≥ 20 teeth,
11 2) 10-19 teeth, and 3) 0-9 teeth.

12 We also asked whether they used dentures and whether they visited a dental clinic at least
13 once a year. The respondents were asked to mark “yes” or “no” in reply. We also asked how many
14 times participants brushed their teeth daily.

15 16 *Measurements of other variables*

17 K6 was used as an indicator of psychological distress.^{16,17} Using six questions, respondents were
18 asked about their mental status over the last month. Total point scores ranged from 0 to 24. As the
19 optimal cut-off point for mental illness in the validation study, we classified individuals with scores

1 of ≥ 13 as having psychological distress.¹⁸

2 The amount of energy intake (except that from alcohol-drinking) and protein intake was
3 calculated based on the data from the baseline survey and divided into sex-specific tertiles. The
4 survey included questions about the frequency of recent average consumption of 39 daily food items.
5 For estimation of energy and protein intake from the food-frequency questionnaire (FFQ), a food
6 composition table was used that corresponded to the items listed in the questionnaire.¹⁹ A validation
7 study of the FFQ had been conducted previously.¹⁹

9 *LTCI system in Japan*

10 In this study, we defined incident functional disability as certification for LTCI in Japan, which uses
11 a nationally uniform standard of functional disability. LTCI is a mandatory system of social
12 insurance to assist the daily activity of frail elderly individuals.^{20,21} Everyone aged 40 years and over
13 pays premiums, and everyone aged 65 years and over is eligible for formal caregiving services.
14 When a person applies to the municipal government for benefits, an expert investigator visits his or
15 her home and assesses the degree of functional disability using a questionnaire developed by the
16 Ministry of Health, Labor, and Welfare. Then, the municipal government calculates the standardized
17 scores for physical and mental functions on the basis of the certification survey sheet and assesses
18 whether the applicant is eligible for LTCI benefits. If a person is judged to be thus eligible, the
19 Municipal Certification Committee decides on one of seven levels of support, ranging from Support

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4 1 Level 1 to 2, and Care Level 1 to Care Level 5. In brief, LTCI certification levels are defined as
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7 2 follows. Support Level 1: “limited in instrumental activities of daily living but independent in basic
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10 3 activities of daily living”; Care Level 2: “requiring assistance in at least one basic ADL task”; Care
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13 4 Level 5: “requiring care in all ADL tasks”. A community-based study has shown that levels of LTCI
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16 5 certification are well related to the ability to perform activities of daily living, and with Mini-Mental
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18 6 State Examination scores²². LTCI certification has already been used as a measure of incident
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21 7 functional disability in the elderly.^{7,23}
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28 ***Follow-up and case details***

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30 10 Incident functional disability was defined as LTCI certification, which was set as our endpoint. The
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33 11 primary outcome was new LTCI certification (Support Level 1 or higher), and deaths without LTCI
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36 12 certification were treated as censored. We obtained a data set that included information on the date of
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39 13 LTCI certification, emigration, or death from Ohsaki City Government based on an agreement about
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42 14 the secondary use of data. LTCI certification information was provided, including care level
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45 15 information. All data were transferred from the Ohsaki City Government yearly each December
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48 16 under the agreement related to Epidemiologic Research and Privacy Protection.
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54 ***Ethical issues***

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56 19 The return of completed questionnaires was considered to imply consent to participate in the study
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4 1 involving the baseline survey data and subsequent follow-up of death and emigration. Information
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7 2 regarding LTCI certification status was confirmed after obtaining written consent returned from the
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10 3 participants at the time of the baseline survey. The Ethics Committee of Tohoku University Graduate
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13 4 School of Medicine reviewed and approved the study protocol.
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6 *Statistical analysis*

7 Baseline characteristics were evaluated using the chi-squared test for categorical variables and
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10 8 analysis of variance for continuous variables. We used these methods to compare variables among
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13 9 groups with varying numbers of teeth.
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30 10 First, we examined the relationship between the number of remaining teeth and incident
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33 11 functional disability in the entire study population. The Cox proportional hazards model was used to
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36 12 calculate the hazard ratios (HRs) and 95% confidence intervals (CIs) for incident functional
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39 13 disability according to the categories for different numbers of remaining teeth. Participants having
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42 14 ≥ 20 teeth were used as a reference category. The multivariate models were adjusted for the following
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45 15 variables: age (65-69, 70-74, 75-79, 80-84, and ≥ 85 years), sex, education level (age upon final
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48 16 graduation from school < 16 , 16-18, ≥ 19 years, missing), smoking (never, former, current, missing),
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51 17 alcohol drinking (never, former, current, missing), body mass index (kg/m^2 ; < 18.5 , 18.5-24.9, ≥ 25.0 ,
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54 18 missing), time spent walking daily (< 30 minutes per day, 30 minutes per day-1 hour per day, > 1 hour
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57 19 per day, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus),
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4 1 psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and
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7 2 protein intake (sex-specific tertile, missing).
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10 3 Second, in comparison with individuals who had ≥20 teeth, we examined whether oral
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12 4 self-care factors (“tooth brushing ≥2 times per day”, “visiting a dentist ≥1 times per year”, and “use
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14 5 of dentures” being defined as “practicing oral self-care”) were related to the risk of functional
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16 6 disability in individuals with <20 teeth. For this, participants were divided into the following five
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18 7 categories based on three oral self-care measures: 1) “having ≥20 teeth”, 2) “practicing oral self-care
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20 8 and having 10-19 teeth”, 3) “non-practicing and having 10-19 teeth”, 4) “practicing and having 0-9
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22 9 teeth”, and 5) “non-practicing and having 0-9 teeth”. Cox proportional hazards models were used to
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30 10 calculate the HRs and 95% CIs for incident functional disability to compare the four categories of
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33 11 missing teeth with the ≥20 teeth category.
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36 12 All statistical analyses were performed with SAS version 9.4 (SAS Inc., Cary, NC, USA),
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39 13 and all statistical tests were 2-sided. Differences at P <0.05 were considered to be statistically
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1 Results

2 *Baseline characteristics*

3 In the study population, women accounted for 54.3% and the mean (SD) age was 73.5 (5.4) years.
4 Table 1 shows the participant characteristics. Those who had more teeth were younger, and were less
5 likely to be women, current smokers, and to have a history of stroke, myocardial infarction, or
6 diabetes mellitus. Having more teeth was also related to being better educated, spending more time
7 walking, being a current drinker, and having higher energy and protein intake.

9 *Number of teeth and incident functional disability*

10 The number of remaining teeth was significantly associated with a higher risk of incident functional
11 disability. The multiple adjusted HRs (95% CIs) for incident functional disability among participants
12 having 10-19 and 0-9 teeth were 1.15 (1.01-1.30) and 1.20 (1.07-1.34), respectively, compared with
13 participants having ≥ 20 teeth (P -trend $< .05$) (see online supplementary table S1).

15 *Oral self-care and incident functional disability*

16 Table 2 shows the relationship between oral self-care (tooth-brushing, dental visits, and use of
17 dentures) and incident functional disability in the five categories. Compared with participants who
18 had 20 or more teeth, HRs for participants who brushed their teeth < 2 times per day were
19 significantly higher [multivariate HRs (95% CI) 1.32 (1.12-1.55) for participants with 10-19 teeth,

1 and 1.33 (1.17-1.51) for participants with 0-9 teeth], but HRs for participants who brushed their teeth
2 ≥ 2 times per day were not significantly higher in the “10-19 teeth” and “0-9 teeth” groups
3 [multivariate HRs (95% CI) 1.05 (0.91-1.21) for participants with 10-19 teeth, and 1.09 (0.96-1.23)
4 for participants with 0-9 teeth]. There was no significant difference in the increased risk between
5 these two subgroups, irrespective of whether or not participants undertook dental visits or used
6 dentures.

7 Additionally, we compared HRs for participants who did and did not practice oral self-care
8 in each of the “10-19 teeth” and “0-9 teeth” subgroups (Table 3). Compared with participants who
9 brushed their teeth < 2 times per day, HRs for participants who brushed their teeth ≥ 2 times per day
10 were significantly lower [multivariate HRs (95% CI) 0.80 (0.66-0.96) for participants with 10-19
11 teeth (P -value $< .001$), and 0.81 (0.73-0.91) for participants with 0-9 teeth (P -value $< .05$)]. However,
12 there was no significant difference in either of these subgroups, irrespective of whether or not
13 participants undertook dental visits or used dentures.

1 Discussion

2 This cohort study investigated the association between oral self-care and incident functional
3 disability. First, we found that tooth loss was significantly associated with an increased risk of
4 incident functional disability, in agreement with previous studies.^{7,8} However, even among
5 participants who had fewer remaining teeth, the risk for those who brushed their teeth frequently was
6 not significantly higher. Our study suggested that if individuals with fewer than 20 teeth practiced
7 good oral self-care habits such as regular tooth-brushing, they might partially negate the expected
8 increase in incident functional disability. The present study had a number of strengths: 1) it was a
9 large population-based cohort study involving 12,370 individuals, 2) it had a follow-up rate of almost
10 100%, 3) it took into account considerable confounding factors, and 4) it is the first reported study to
11 have demonstrated an impact of tooth brushing on the increased risk of incident functional disability
12 resulting from having fewer remaining teeth.

13 There are several possible pathways linking oral self-care to incident functional disability.
14 First, periodontal disease is related to systemic inflammation through oral inflammation.²⁴ Second, a
15 recent report has suggested that swallowing of oral bacteria affects the gut microbiota, causing
16 systemic inflammation.¹² Chronic inflammation is known to be a risk factor for atherosclerotic
17 diseases including stroke²⁵ and dementia,²⁶ and may cause autoimmune disease, particularly
18 rheumatoid arthritis.²⁷ These diseases and their symptoms are common causes of functional disability
19 in the Japanese elderly population.²⁸ Indeed, a previous study has suggested that tooth brushing

1 ameliorates the risk of cardiovascular disease.¹¹ Therefore, better oral hygiene through
2 tooth-brushing may reduce the risk of functional disability in the elderly.

3 The present study had several limitations. First, misclassification of the number of teeth and
4 practicing oral self-care as a result of self-reporting might have occurred. However, the validity of
5 the self-reported number of teeth has been confirmed by previous studies,²⁹ and similarly the validity
6 of self-reported dental visits has also been confirmed.³⁰ Second, among the source population of
7 31,694, the rate of valid responses (72.9%, n =23,091) for this study was not high. In addition, the
8 valid responses would have shown a bias toward healthier people living in the community. However,
9 this bias would not have affected the internal validity of the association between oral self-care and
10 incident functional disability. Third, we did not consider causes of incident functional disability.
11 Thus, the mechanisms responsible for the reduction of incident functional disability risk resulting
12 from oral self-care remained unidentified.

13 In conclusion, this study has shown that tooth-brushing may partially negate the increased
14 risk of incident functional disability resulting from having fewer remaining teeth. Further studies will
15 need to confirm the effects of oral self-care on incident functional disability in individuals with
16 missing teeth.

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1 Acknowledgments

2 We would like to thank Yoshiko Nakata and Mami Takahashi for their technical assistance.

3
4 **Contributions:** Study concept and design: YT, IT. Acquisition of data: YT, KS, IT. Analysis and
5 interpretation of data: SB, YT, JA, YS, IT. Drafting of the manuscript: SB, YT, IT. Critical revision
6 of the manuscript for important intellectual content: SB, YT, JA, KS, YS, IT. All authors read and
7 approved final manuscript.

8
9 **Funding:** This study was supported by grants from the Foundation for Total Health Promotion
10 (H27-General Research grants), and Health Sciences Research grants (nos. H26-Junkankitou
11 [Seisaku]-Ippan-001) from the Ministry of Health, Labour and Welfare of Japan. The authors declare
12 no potential conflicts of interest with respect to the authorship and/or publication of this article.

13
14 **Competing interests:** None declared.

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16 **Ethics approval:** The Ethics Committee of Tohoku University Graduate School of Medicine
17 reviewed and approved the study protocol.

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19 **Provenance and peer review:** Not commissioned; externally peer reviewed.

1 **Data sharing statement:** No additional data are available.

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2 TABLES

Table 1. Relationship Between Number of Teeth and Participant Characteristic (n=12,370)

Characteristic	Number of Teeth		
	≥20, n = 4,047	10-19, n = 3,108	0-9, n = 5,215
Women, %	50.0	53.4	58.2
Age, mean ± SD	71.3 ± 4.8	72.8 ± 5.2	75.6 ± 6.2
Body mass index, kg/m ² , %			
<18.5	3.2	4.9	6.2
18.5-24.9	63.8	64.0	65.3
≥25.0	32.9	31.1	28.5
Current smoking, %	11.0	14.5	14.6
Current alcohol drinking, %	46.1	41.3	31.7
Education < 16 years, %	22.9	27.2	33.7
Daily walking time ≥ 1 hour, %	29.3	29.1	26.0
Medical history, %			
Stroke	2.2	2.9	3.1
Hypertension	43.5	43.5	43.5
Myocardial infarction	3.8	4.4	5.9
Diabetes mellitus	10.5	11.5	12.6
Psychological distress, % ^a	3.4	4.2	5.6
Energy intake, kcal/d, mean ± SD ^b	1463.5 ± 406.9	1451.9 ± 401.7	1413.8 ± 393.7
Protein intake, g/d, mean ± SD	54.7 ± 14.0	53.6 ± 14.3	52.5 ± 14.4
Use of dentures, %	27.3	75.1	93.0
Tooth brushing (times/d)	2.0 ± 0.9	1.9 ± 1.1	1.8 ± 0.9
≥ 1 dental visits per year, %			
For treatment	57.3	63.5	43.8
For other reason	39.5	34.3	19.7

^a Kessler six-item psychological distress scale score ≥ 13.

^b Excluding alcohol.

SD = standard deviation.

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Table 2. Relationship Between Oral Self-Care and Incident Functional Disability Stratified According to Number of Teeth (n=12,370).

Oral Self-care and Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ^{*1}	Model 2 ^{*2}
Tooth brushing					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with brushing teeth ≥2 per day	1,977	10,200	300 (15.2)	1.05 (0.91-1.22)	1.05 (0.91-1.21)
10-19 with brushing teeth <2 per day	1,131	5,529	230 (20.3)	1.44 (1.23-1.69)	1.32 (1.12-1.55)
0-9 with brushing teeth ≥2 per day	2,840	13,888	634 (22.3)	1.15 (1.01-1.30)	1.09 (0.96-1.23)
0-9 with brushing teeth <2 per day	2,375	10,812	689 (29.0)	1.52 (1.35-1.72)	1.33 (1.17-1.51)
≥1 dental visits per year					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with dental visits	2,010	10,208	335 (16.7)	1.17 (1.02-1.35)	1.14 (0.99-1.32)
10-19 with no dental visits	1,098	5,521	195 (17.8)	1.23 (1.04-1.46)	1.16 (0.98-1.38)
0-9 with dental visits	2,343	11,502	528 (22.5)	1.26 (1.11-1.42)	1.15 (1.01-1.31)
0-9 with no dental visits	2,872	13,198	795 (27.7)	1.36 (1.21-1.54)	1.23 (1.09-1.39)
Use of dentures					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with use of dentures	2,333	11,770	411 (17.6)	1.18 (1.04-1.35)	1.15 (1.01-1.32)
10-19 with no use of dentures	775	3,958	119 (15.4)	1.22 (1.00-1.49)	1.13 (0.92-1.38)
0-9 with use of dentures	4,850	23,087	1220 (25.2)	1.29 (1.15-1.44)	1.19 (1.06-1.33)
0-9 with no use of dentures	365	1,613	103 (28.2)	1.66 (1.34-2.06)	1.35 (1.09-1.68)

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

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Table 3. Sensitivity Analysis of the Relationship Between Oral Self-Care and Incident Functional Disability According to Number of Teeth (n=8,323).

Oral Self-care and Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ¹	Model 2 ²
10-19 teeth (n=3,108)					
Brushing teeth <2 per day	1,131	5,529	230 (20.3)	1.00 (reference)	1.00 (reference)
Brushing teeth ≥2 per day	1,977	10,200	300 (15.2)	0.73 (0.61-0.87)	0.80 (0.66-0.96)
No dental visits	1,098	5,521	195 (17.8)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2,010	10,208	335 (16.7)	0.95 (0.79-1.13)	0.98 (0.82-1.17)
No use of dentures	775	3,958	119 (15.4)	1.00 (reference)	1.00 (reference)
Use of dentures	2,333	11,770	411 (17.6)	0.97 (0.79-1.19)	1.00 (0.81-1.23)
0-9 teeth (n=5,215)					
Brushing teeth <2 per day	2,375	10,812	689 (29.0)	1.00 (reference)	1.00 (reference)
Brushing teeth ≥2 per day	2,840	13,888	634 (22.3)	0.75 (0.67-0.84)	0.81 (0.73-0.91)
No dental visits	2,872	13,198	795 (27.7)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2,343	11,502	528 (22.5)	0.92 (0.82-1.03)	0.94 (0.84-1.05)
No use of dentures	365	1,613	103 (28.2)	1.00 (reference)	1.00 (reference)
Use of dentures	4,850	23,087	1220 (25.2)	0.78 (0.64-0.96)	0.88 (0.71-1.07)

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

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Supplementary table S1. Number of Teeth in Relation to Incident Functional Disability (n=12,370).

Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ^{*1}	Model 2 ^{*2}
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19	3,108	15,729	530 (17.1)	1.19 (1.05-1.35)	1.15 (1.01-1.30)
0-9	5,215	24,700	1,323 (25.4)	1.31 (1.18-1.47)	1.20 (1.07-1.34)
P-trend	-	-	-	<.001	.002

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

Title: Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese: The Ohsaki Cohort 2006 Study

Authors: Shino Bando MSc, ¹ Yasutake Tomata PhD, ¹ Jun Aida DDS, PhD, ² Kemmyo Sugiyama MD, PhD, ¹ Yumi Sugawara PhD, ¹ and Ichiro Tsuji MD, PhD ¹

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page or line numbers where the checklist items are located in this paper*
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Line 2-3, Page 1 Line 4, Page 3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Line 1-18, Page 3
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	Line 2-18, Page 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Line 13, Page 5 Line 19, Page 5 - Line 1-2, Page 6
Methods			
Study design	4	Present key elements of study design early in the paper	Line 2, Page 7 – Line 1, Page 8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Line 4-13 page 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Line 10, Page 7 – Line 1, Page 8 Line 9-16, page 10
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	(This is not a matched studies)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Line 7, Page 8 - Line 16, Page 10
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Line 7, Page 8 - Line 7, Page 10
Bias	9	Describe any efforts to address potential sources of bias	Line 14, Page 11 - Line 2, Page 12
Study size	10	Explain how the study size was arrived at	Line 4-6, 10-15, Page 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Line 18, Page 8 – Line 1, Page 9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Line 6, page 11-Line 14, page 12
		(b) Describe any methods used to examine subgroups and interactions	Line 7-8, Page 14
		(c) Explain how missing data were addressed	Line 14, Page 11 - Line 2, Page 12
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	Line 2-5, Page 8
		(e) Describe any sensitivity analyses	Line 7-8, page 14

*Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study

Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Line 13, Page 7 – Line 1, Page 8
		(b) Give reasons for non-participation at each stage	Line 13, Page 7 – Line 1, Page 8
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Line 2-7, Page 13 Table 1, Page 24
		(b) Indicate number of participants with missing data for each variable of interest	Line 15, Page 7 – Line 1, Page 8
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	Line 4-5, Page 8 Table 2, Page 25
Outcome data	15	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	Line 4-5, Page 8 Table 2, Page 25
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2, Page 25 Line 16, Page 13-Line 6, Page 14
		(b) Report category boundaries when continuous variables were categorized	Line 14, Page 11 - Line 2, Page 12
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Line 7-13, Page 14 Table 3, Page 26
Discussion			
Key results	18	Summarise key results with reference to study objectives	Line 3-6, Page 15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Line 3-12, Page 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Line 3-8, Page 15 Line 13, Page 15-Line 2, Page 16
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Line 9-12, Page 17

**Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study*

BMJ Open

Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-017946.R1
Article Type:	Research
Date Submitted by the Author:	07-Aug-2017
Complete List of Authors:	Bando, Shino Tomata, Yasutake Aida, Jun; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Sugiyama, Kemmyo Sugawara, Yumi; Tohoku University Graduate School of Medicine, Division of Epidemiology, Department of Health Informatics and Public Health Tsuji, Ichiro; Tohoku University School of Medicine, Tohoku University Graduate School of Medicine, Division of Epidemiology, Department of Health Informatics and Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	teeth, tooth-brushing, denture, dental visit, disability

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4 1 **Title:**

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7 2 Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese: The Ohsaki Cohort
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10 3 2006 Study

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4 **Sources of support:**

5 Health Sciences Research grants (nos. H26-Junkankitou [Seisaku]-Ippan-001 and
6 H29-Junkankitou-Ippan-003) from the Ministry of Health, Labour and Welfare of Japan, and
7 Research grants (H27-General Research grants) from the Foundation for Total Health Promotion.

8

9 **The number of words in the abstract:** 203 words

10 **The number of words in the text:** 2,955 words

11 **The number of tables:** 3 tables

12 **The number of references:** 30 references

13 **The number of supplementary material:** 2 table

14

1 Abstract

2 **Objectives:** To assess whether oral self-care (tooth-brushing, regular dental visits, and use of
3 dentures) affects incident functional disability in elderly individuals with tooth loss.

4 **Design:** A 5.7-year prospective cohort study.

5 **Setting:** Ohsaki City, Japan.

6 **Participants:** 12,370 community-dwelling individuals aged 65 years and older.

7 **Primary outcome measures:** Incident functional disability (new LTCI certification).

8 **Results:** The 5.7-year incidence rate of disability was 18.8%. In comparison with participants who
9 had ≥ 20 teeth, the HRs (95% CIs) for incident functional disability among participants who had
10 10-19 and 0-9 teeth were 1.15 (1.01-1.30) and 1.20 (1.07-1.34), respectively (P -trend $< .05$).
11 However, the corresponding values for those who brushed their teeth ≥ 2 times per day were not
12 significantly higher in the “10-19 teeth” and “0-9 teeth” groups [HRs (95% CI) 1.05 (0.91-1.21) for
13 participants with 10-19 teeth, and 1.09 (0.96-1.23) for participants with 0-9 teeth], although HRs for
14 those who brushed their teeth < 2 times per day were significantly higher [HRs (95% CI) 1.32
15 (1.12-1.55) for participants with 10-19 teeth, and 1.33 (1.17-1.51) for participants with 0-9 teeth].

16 Such a negating association was not observed for other forms of oral self-care.

17 **Conclusions:** Tooth-brushing may partially negate the increased risk of incident functional disability
18 associated with having fewer remaining teeth.

19

1 **Key words:** teeth, tooth-brushing, dental visit, denture, disability

2 **Strengths and limitations of this study**

3 • Our study is the first reported study to have demonstrated an impact of tooth brushing on the
4 increased risk of incident functional disability resulting from having fewer remaining teeth.

5 • This is a large population-based cohort study involving 12,370 individuals and it can take into
6 account considerable confounding factors.

7 • Although misclassification of the number of teeth and practicing oral self-care as a result of
8 self-reporting might have occurred, the validity of these have also been confirmed by previous
9 studies.

10

1 Introduction

2 As society ages, disability prevention has become an important public health issue. It has been
3 pointed out by the WHO that oral health is an important component of healthy aging, particularly in
4 the disadvantaged elderly.¹ Tooth loss is also known to be a risk factor for mortality in the elderly.^{2,3}
5 Periodontal disease, which is one of the main causes of tooth loss, is known to be related to coronary
6 heart disease,⁴ stroke,⁴ and pneumonia,⁵ which in turn are major causes of incident disability.⁶
7 Recently, several studies have indicated that tooth loss is related to incident disability.^{7,8} Therefore,
8 there is a need to decrease the excess risk of functional disability in elderly adults with missing teeth.

9 It has been suggested that oral self-care has a preventative impact on mortality.⁹ We have
10 reported that individuals who practiced three types of oral self-care (tooth brushing, regular dental
11 visits, and use of dentures) had a lower mortality risk than those who practiced none of the three.⁹
12 Those who practiced oral self-care also had a lower risk of dementia and cardiovascular disease.^{10,11}
13 These findings suggest that there are possible pathways linking oral self-care to incident disability.
14 Additionally, it has been reported that the intraoral environment affects the gut microbiota and may
15 cause systemic inflammation,¹² implying a new pathway whereby poor oral hygiene may be linked to
16 systemic disease. To our knowledge, however, only two studies have examined whether practicing
17 oral care affects the risk of functional disability among older people with tooth loss, and those
18 studies focused only on denture use¹³ or regular dental visits.¹⁴

19 The aim of the present cohort study was to assess whether three types of oral self-care (tooth

1 brushing, regular dental visits, and use of dentures) have an impact on incident functional disability

2 in individuals with tooth loss.

3

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1 **Materials and Methods**

2 *Study design, setting, and participants*

3 The present study was based on data from the Ohsaki Cohort 2006 Study, whose design has been
4 described in detail elsewhere.¹⁵ In brief, the source population for the baseline survey comprised all
5 men and women aged 65 years or older living in Ohsaki City, Miyagi Prefecture, northeastern Japan,
6 on December 1, 2006. The survey included questions about the number of remaining teeth and oral
7 self-care status, as well as items on history of disease, education level, smoking, alcohol drinking,
8 body weight, height, psychological distress score, time spent walking per day, and food intake
9 frequency.

10 The baseline survey was conducted between December 1 and December 15, 2006, and the
11 follow-up survey between April 1, 2007 and November 30, 2012. A questionnaire was distributed by
12 the heads of individual administrative districts to all individuals aged 65 years or older living in
13 Ohsaki city, and then collected by mail. Among 31,694 subjects (12,750 men and 18,944 women)
14 eligible for this analysis, 23,091 (9,605 men and 13,486 women) provided valid responses and
15 formed the study cohort. Among the latter respondents, we excluded 6,333 individuals who did not
16 provide written consent for review of their Long-term Care Insurance (LTCI) information, 2,102 who
17 had already been certified as having a disability by the LTCI before the starting date of follow-up
18 (March 30, 2007), 62 who had died or moved away before the starting date of follow-up, 188 for
19 whom the Doctor's Opinion Paper had been unavailable, and 2,036 who left blank the item

1 concerning dental health status. Thus, 12,370 responses were analyzed for the purpose of this study.

2 During the 5.7-year period covered by the study, only 158 individuals were lost to follow-up
3 because they moved away from the study area without developing any functional disability; thus, the
4 follow-up rate was 98.7%. From 61,581 person-years, incident functional disability was recorded in
5 2,329 persons, and the number of all-cause deaths was 1,446.

6 7 *Measurement of dental health status*

8 In the baseline questionnaire, we asked respondents to classify the number of their remaining teeth
9 into six categories: all (28 teeth), most (25-27 teeth), moderate (20-24 teeth), about half (10-19 teeth),
10 few (1-9 teeth), and none (0 teeth). Then, we divided the respondents into three groups: 1) ≥ 20 teeth,
11 2) 10-19 teeth, and 3) 0-9 teeth.

12 We also asked whether they used dentures and whether they visited a dental clinic
13 (including as reasons “treatment” and “other reasons such as dental check-ups and scaling”) at least
14 once a year. The respondents were asked to mark “yes” or “no” in reply. We also asked how many
15 times participants brushed their teeth daily.

16 17 *Measurements of other variables*

18 K6 was used as an indicator of psychological distress.^{16,17} Using six questions, respondents were
19 asked about their mental status over the last month. Total point scores ranged from 0 to 24. As the

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4 1 optimal cut-off point for mental illness in the validation study, we classified individuals with scores
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7 2 of ≥ 13 as having psychological distress.¹⁸
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10 3 The amount of energy intake (except that from alcohol-drinking) and protein intake was
11
12 4 calculated based on the data from the baseline survey and divided into sex-specific tertiles. The
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14 5 survey included questions about the frequency of recent average consumption of 39 daily food items.
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16 6 For estimation of energy and protein intake from the food-frequency questionnaire (FFQ), a food
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18 7 composition table was used that corresponded to the items listed in the questionnaire.¹⁹ A validation
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20 8 study of the FFQ had been conducted previously.¹⁹
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30 *LTCI system in Japan*

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33 11 In this study, we defined incident functional disability as certification for LTCI in Japan, which uses
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35 12 a nationally uniform standard of functional disability. LTCI is a mandatory system of social
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37 13 insurance to assist the daily activity of frail elderly individuals.^{20,21} Everyone aged 40 years and over
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39 14 pays premiums, and everyone aged 65 years and over is eligible for formal caregiving services.
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42 15 When a person applies to the municipal government for benefits, an expert investigator visits his or
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44 16 her home and assesses the degree of functional disability using a questionnaire developed by the
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47 17 Ministry of Health, Labor, and Welfare. Then, the municipal government calculates the standardized
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49 18 scores for physical and mental functions on the basis of the certification survey sheet and assesses
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51 19 whether the applicant is eligible for LTCI benefits. If a person is judged to be thus eligible, the
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4 1 Municipal Certification Committee decides on one of seven levels of support, ranging from Support
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7 2 Level 1 to 2, and Care Level 1 to Care Level 5. In brief, LTCI certification levels are defined as
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9
10 3 follows. Support Level 1: “limited in instrumental activities of daily living but independent in basic
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12 4 activities of daily living”; Care Level 2: “requiring assistance in at least one basic ADL task”; Care
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15 5 Level 5: “requiring care in all ADL tasks”. A community-based study has shown that levels of LTCI
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18 6 certification are well related to the ability to perform activities of daily living, and with Mini-Mental
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21 7 State Examination scores²². LTCI certification has already been used as a measure of incident
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24 8 functional disability in the elderly.^{7,23}
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30 *Follow-up and case details*

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33 11 Incident functional disability was defined as LTCI certification, which was set as our endpoint. The
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36 12 primary outcome was new LTCI certification (Support Level 1 or higher), and deaths without LTCI
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39 13 certification were treated as censored. We obtained a data set that included information on the date of
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42 14 LTCI certification, emigration, or death from Ohsaki City Government based on an agreement about
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45 15 the secondary use of data. LTCI certification information was provided, including care level
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48 16 information. All data were transferred from the Ohsaki City Government yearly each December
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51 17 under the agreement related to Epidemiologic Research and Privacy Protection.
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4 1 *Ethical issues*
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7 2 The return of completed questionnaires was considered to imply consent to participate in the study
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10 3 involving the baseline survey data and subsequent follow-up of death and emigration. Information
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12 4 regarding LTCI certification status was confirmed after obtaining written consent returned from the
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15 5 participants at the time of the baseline survey. The Ethics Committee of Tohoku University Graduate
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18 6 School of Medicine reviewed and approved the study protocol.
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24 8 *Statistical analysis*
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27 9 Baseline characteristics were evaluated using the chi-squared test for categorical variables and
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30 10 analysis of variance for continuous variables. We used these methods to compare variables among
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33 11 groups with varying numbers of teeth.
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36 12 First, we examined the relationship between the number of remaining teeth and incident
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39 13 functional disability in the entire study population. The Cox proportional hazards model was used to
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42 14 calculate the hazard ratios (HRs) and 95% confidence intervals (CIs) for incident functional
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45 15 disability according to the categories for different numbers of remaining teeth. Participants having
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48 16 ≥ 20 teeth were used as a reference category. The multivariate models were adjusted for the following
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51 17 variables: age (65-69, 70-74, 75-79, 80-84, and ≥ 85 years), sex, education level (age upon final
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54 18 graduation from school <16, 16-18, ≥ 19 years, missing), smoking (never, former, current, missing),
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57 19 alcohol drinking (never, former, current, missing), body mass index (kg/m^2 ; <18.5, 18.5-24.9, ≥ 25.0 ,
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1 missing), time spent walking daily (<30 minutes per day, 30 minutes per day-1 hour per day, >1 hour
2 per day, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus),
3 psychological distress score (<13, \geq 13, missing), energy intake (sex-specific tertile, missing), and
4 protein intake (sex-specific tertile, missing).

5 Second, in this analysis, we examined whether a higher risk of incident disability among
6 participants with fewer teeth would persist irrespective of whether they practice oral self-care (“tooth
7 brushing \geq 2 times per day”, “visiting a dentist \geq 1 times per year”, and “use of dentures” being
8 defined as “practicing oral self-care”). For this, participants were divided into the following five
9 categories based on three oral self-care measures: 1) “having \geq 20 teeth”, 2) “practicing oral self-care
10 and having 10-19 teeth”, 3) “non-practicing and having 10-19 teeth”, 4) “practicing and having 0-9
11 teeth”, and 5) “non-practicing and having 0-9 teeth”. Cox proportional hazards models were used to
12 calculate the HRs and 95% CIs for incident functional disability to compare the four categories of
13 missing teeth with the \geq 20 teeth category.

14 All statistical analyses were performed with SAS version 9.4 (SAS Inc., Cary, NC, USA),
15 and all statistical tests were 2-sided. Differences at $P < 0.05$ were considered to be statistically
16 significant.

17

1 **Results**

2 *Baseline characteristics*

3 In the study population, women accounted for 54.3% and the mean (SD) age was 73.5 (5.4) years.
4 Table 1 shows the participant characteristics. Those who had more teeth were younger, and were less
5 likely to be women, current smokers, and to have a history of stroke, myocardial infarction, or
6 diabetes mellitus. Having more teeth was also related to being better educated, spending more time
7 walking, being a current drinker, and having higher energy and protein intake.

9 *Number of teeth and incident functional disability*

10 The number of remaining teeth was significantly associated with a higher risk of incident functional
11 disability. The multiple adjusted HRs (95% CIs) for incident functional disability among participants
12 having 10-19 and 0-9 teeth were 1.15 (1.01-1.30) and 1.20 (1.07-1.34), respectively, compared with
13 participants having ≥ 20 teeth (P -trend $< .05$) (see online supplementary table S1).

15 *Oral self-care and incident functional disability*

16 Table 2 shows the relationship between oral self-care (tooth-brushing, dental visits, and use of
17 dentures) and incident functional disability in the five categories. Compared with participants who
18 had 20 or more teeth, HRs for participants who brushed their teeth < 2 times per day were
19 significantly higher [multivariate HRs (95% CI) 1.32 (1.12-1.55) for participants with 10-19 teeth,

1 and 1.33 (1.17-1.51) for participants with 0-9 teeth], but HRs for participants who brushed their teeth
2 ≥ 2 times per day were not significantly higher in the "10-19 teeth" and "0-9 teeth" groups
3 [multivariate HRs (95% CI) 1.05 (0.91-1.21) for participants with 10-19 teeth, and 1.09 (0.96-1.23)
4 for participants with 0-9 teeth]. There was no significant difference in the increased risk between
5 these two subgroups, irrespective of whether or not participants undertook dental visits or used
6 dentures.

7 We analysed "dental visits for other reasons (such as dental check-ups and scaling)" as an
8 exposure (see online supplementary table S2). Compared with participants who had 20 or more teeth,
9 only the HR for participants who had 10-19 teeth and visited a dentist was not significant. No such
10 relationship was observed for "dental visits for treatment" as an exposure.

11 Additionally, we compared HRs for participants who did and did not practice oral self-care
12 in each of the "10-19 teeth" and "0-9 teeth" subgroups (Table 3). Compared with participants who
13 brushed their teeth < 2 times per day, HRs for participants who brushed their teeth ≥ 2 times per day
14 were significantly lower [multivariate HRs (95% CI) 0.80 (0.66-0.96) for participants with 10-19
15 teeth (P -value $< .001$), and 0.81 (0.73-0.91) for participants with 0-9 teeth (P -value $< .05$)]. However,
16 there was no significant difference in either of these subgroups, irrespective of whether or not
17 participants undertook dental visits or used dentures. When we conducted reanalysis after excluding
18 the participants with "0 teeth", the results did not change substantially: 0.80 (0.69-0.94) for
19 participants with 1-9 teeth.

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1 Discussion

2 This cohort study investigated the association between oral self-care and incident functional
3 disability. First, we found that tooth loss was significantly associated with an increased risk of
4 incident functional disability, in agreement with previous studies.^{7,8} However, even among
5 participants who had fewer remaining teeth, the risk for those who brushed their teeth frequently was
6 not significantly higher. Among participants who had 10-19 teeth, we also observed a similar result
7 for those who made dental visits for other reasons (such as dental check-ups and scaling). Our study
8 suggested that if individuals with fewer than 20 teeth practiced good oral self-care habits such as
9 regular tooth-brushing and preventive dental visits, they might partially negate the expected increase
10 in incident functional disability. The present study had a number of strengths: 1) it was a large
11 population-based cohort study involving 12,370 individuals, 2) it had a follow-up rate of almost
12 100%, 3) it took into account considerable confounding factors, and 4) it is the first reported study to
13 have demonstrated an impact of tooth brushing on the increased risk of incident functional disability
14 resulting from having fewer remaining teeth.

15 There are several possible pathways linking oral self-care to incident functional disability.
16 First, periodontal disease is related to systemic inflammation through oral inflammation.²⁴ Second, a
17 recent report has suggested that swallowing of oral bacteria affects the gut microbiota, causing
18 systemic inflammation.¹² Chronic inflammation is known to be a risk factor for atherosclerotic
19 diseases including stroke²⁵ and dementia,²⁶ and may cause autoimmune disease, particularly

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4 1 rheumatoid arthritis.²⁷ These diseases and their symptoms are common causes of functional disability
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7 2 in the Japanese elderly population.²⁸ Indeed, a previous study has suggested that tooth brushing
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10 3 ameliorates the risk of cardiovascular disease.¹¹ Therefore, better oral hygiene through
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13 4 tooth-brushing may reduce the risk of functional disability in the elderly.

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16 5 The present study had several limitations. First, misclassification of the number of teeth and
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19 6 practicing oral self-care as a result of self-reporting might have occurred. However, the validity of
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22 7 the self-reported number of teeth has been confirmed by previous studies,²⁹ and similarly the validity
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25 8 of self-reported dental visits has also been confirmed.³⁰ Second, among the source population of
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28 9 31,694, the rate of valid responses (72.9%, n =23,091) for this study was not high. In addition, the
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31 10 valid responses would have shown a bias toward healthier people living in the community. However,
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34 11 this bias would not have affected the internal validity of the association between oral self-care and
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37 12 incident functional disability. Third, we did not consider causes of incident functional disability.
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40 13 Thus, the mechanisms responsible for the reduction of incident functional disability risk resulting
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43 14 from oral self-care remained unidentified. Fourth, although we observed the preventive association
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46 15 even after adjusting for major characteristics/behaviour, not all potential confounding factors were
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49 16 considered. For example, although cognitive function and income might be possible confounders, we
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52 17 did not include them as adjustment items.

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54 18 In conclusion, this study has shown that tooth-brushing may partially negate the increased
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57 19 risk of incident functional disability resulting from having fewer remaining teeth. Further studies will

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4 1 need to confirm the effects of oral self-care on incident functional disability in individuals with
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1 Acknowledgments

2 We would like to thank Yoshiko Nakata, Mami Takahashi, and Shu Zhang for their technical
3 assistance.

4
5 **Contributions:** Study concept and design: YT, IT. Acquisition of data: YT, KS, IT. Analysis and
6 interpretation of data: SB, YT, JA, YS, IT. Drafting of the manuscript: SB, YT, IT. Critical revision
7 of the manuscript for important intellectual content: SB, YT, JA, KS, YS, IT. All authors read and
8 approved final manuscript.

9
10 **Funding:** This study was supported by grants from the Foundation for Total Health Promotion
11 (H27-General Research grants), and Health Sciences Research grants (nos. H26-Junkankitou
12 [Seisaku]-Ippan-001 and H29-Junkankitou-Ippan-003) from the Ministry of Health, Labour and
13 Welfare of Japan. The authors declare no potential conflicts of interest with respect to the authorship
14 and/or publication of this article.

15
16 **Competing interests:** None declared.

17
18 **Ethics approval:** The Ethics Committee of Tohoku University Graduate School of Medicine
19 reviewed and approved the study protocol.

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7 2 **Provenance and peer review:** Not commissioned; externally peer reviewed.
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10 3 **Data sharing statement:** No additional data are available.
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2 TABLES

Table 1. Relationship Between Number of Teeth and Participant Characteristic (n=12,370)

Characteristic	Number of Teeth		
	≥20, n = 4,047	10-19, n = 3,108	0-9, n = 5,215
Women, %	50.0	53.4	58.2
Age, mean ± SD	71.3 ± 4.8	72.8 ± 5.2	75.6 ± 6.2
Body mass index, kg/m ² , %			
<18.5	3.2	4.9	6.2
18.5-24.9	63.8	64.0	65.3
≥25.0	32.9	31.1	28.5
Current smoking, %	11.0	14.5	14.6
Current alcohol drinking, %	46.1	41.3	31.7
Education < 16 years, %	22.9	27.2	33.7
Daily walking time ≥ 1 hour, %	29.3	29.1	26.0
Medical history, %			
Stroke	2.2	2.9	3.1
Hypertension	43.5	43.5	43.5
Myocardial infarction	3.8	4.4	5.9
Diabetes mellitus	10.5	11.5	12.6
Psychological distress, % ^a	3.4	4.2	5.6
Energy intake, kcal/d, mean ± SD ^b	1463.5 ± 406.9	1451.9 ± 401.7	1413.8 ± 393.7
Protein intake, g/d, mean ± SD	54.7 ± 14.0	53.6 ± 14.3	52.5 ± 14.4
Use of dentures, %	27.3	75.1	93.0
Tooth brushing (times/d)	2.0 ± 0.9	1.9 ± 1.1	1.8 ± 0.9
≥ 1 dental visits per year, %			
For treatment	57.3	63.5	43.8
For other reasons	39.5	34.3	19.7

^a Kessler six-item psychological distress scale score ≥ 13.

^b Excluding alcohol.

SD = standard deviation.

Table 2. Relationship Between Oral Self-Care and Incident Functional Disability Stratified According to Number of Teeth (n=12,370).

Oral Self-care and Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ^{*1}	Model 2 ^{*2}
Tooth brushing					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with brushing teeth ≥2 per day	1,977	10,200	300 (15.2)	1.05 (0.91-1.22)	1.05 (0.91-1.21)
10-19 with brushing teeth <2 per day	1,131	5,529	230 (20.3)	1.44 (1.23-1.69)	1.32 (1.12-1.55)
0-9 with brushing teeth ≥2 per day	2,840	13,888	634 (22.3)	1.15 (1.01-1.30)	1.09 (0.96-1.23)
0-9 with brushing teeth <2 per day	2,375	10,812	689 (29.0)	1.52 (1.35-1.72)	1.33 (1.17-1.51)
≥1 dental visits per year					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with dental visits	2,010	10,208	335 (16.7)	1.17 (1.02-1.35)	1.14 (0.99-1.32)
10-19 with no dental visits	1,098	5,521	195 (17.8)	1.23 (1.04-1.46)	1.16 (0.98-1.38)
0-9 with dental visits	2,343	11,502	528 (22.5)	1.26 (1.11-1.42)	1.15 (1.01-1.31)
0-9 with no dental visits	2,872	13,198	795 (27.7)	1.36 (1.21-1.54)	1.23 (1.09-1.39)
Use of dentures					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with use of dentures	2,333	11,770	411 (17.6)	1.18 (1.04-1.35)	1.15 (1.01-1.32)
10-19 with no use of dentures	775	3,958	119 (15.4)	1.22 (1.00-1.49)	1.13 (0.92-1.38)
0-9 with use of dentures	4,850	23,087	1220 (25.2)	1.29 (1.15-1.44)	1.19 (1.06-1.33)
0-9 with no use of dentures	365	1,613	103 (28.2)	1.66 (1.34-2.06)	1.35 (1.09-1.68)

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

Table 3. Sensitivity Analysis of the Relationship Between Oral Self-Care and Incident Functional Disability According to Number of Teeth (n=8,323).

Oral Self-care and Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ¹	Model 2 ²
10-19 teeth (n=3,108)					
Brushing teeth <2 per day	1,131	5,529	230 (20.3)	1.00 (reference)	1.00 (reference)
Brushing teeth ≥2 per day	1,977	10,200	300 (15.2)	0.73 (0.61-0.87)	0.80 (0.66-0.96)
No dental visits	1,098	5,521	195 (17.8)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2,010	10,208	335 (16.7)	0.95 (0.79-1.13)	0.98 (0.82-1.17)
No use of dentures	775	3,958	119 (15.4)	1.00 (reference)	1.00 (reference)
Use of dentures	2,333	11,770	411 (17.6)	0.97 (0.79-1.19)	1.00 (0.81-1.23)
0-9 teeth (n=5,215)					
Brushing teeth <2 per day	2,375	10,812	689 (29.0)	1.00 (reference)	1.00 (reference)
Brushing teeth ≥2 per day	2,840	13,888	634 (22.3)	0.75 (0.67-0.84)	0.81 (0.73-0.91)
No dental visits	2,872	13,198	795 (27.7)	1.00 (reference)	1.00 (reference)
≥1 dental visits per year	2,343	11,502	528 (22.5)	0.92 (0.82-1.03)	0.94 (0.84-1.05)
No use of dentures	365	1,613	103 (28.2)	1.00 (reference)	1.00 (reference)
Use of dentures	4,850	23,087	1220 (25.2)	0.78 (0.64-0.96)	0.88 (0.71-1.07)

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

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Supplementary table S1. Number of Teeth in Relation to Incident Functional Disability (n=12,370).

Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ^{*1}	Model 2 ^{*2}
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19	3,108	15,729	530 (17.1)	1.19 (1.05-1.35)	1.15 (1.01-1.30)
0-9	5,215	24,700	1,323 (25.4)	1.31 (1.18-1.47)	1.20 (1.07-1.34)
P-trend	-	-	-	<.001	.002

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

Title: Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese: The Ohsaki Cohort 2006 Study

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Supplementary Table S2. The Relationship Between the Reason for the Dental Visits and Incident Functional Disability According to Number of Teeth (n=12,370).

Dental visits and Number of Teeth	Participants, n	Person-years	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
				Model 1 ^{*1}	Model 2 ^{*2}
≥1 dental visits for treatment per year					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with dental visits	1,972	10,015	330 (16.7)	1.17 (1.02-1.35)	1.15 (0.99-1.32)
10-19 with no dental visits	1,136	5,713	200 (17.6)	1.23 (1.04-1.45)	1.15 (0.98-1.36)
0-9 with dental visits	2,284	11,214	513 (22.5)	1.25 (1.10-1.42)	1.14 (1.00-1.30)
0-9 with no dental visits	2,931	13,484	810 (27.6)	1.36 (1.21-1.54)	1.24 (1.10-1.40)
≥1 dental visits for other reasons per year					
≥20	4,047	21,152	476 (11.8)	1.00 (reference)	1.00 (reference)
10-19 with dental visits	1,065	5,464	169 (15.9)	1.11 (0.93-1.33)	1.07 (0.90-1.28)
10-19 with no dental visits	2,043	2,043	361 (17.7)	1.23 (1.07-1.41)	1.19 (1.03-1.36)
0-9 with dental visits	1,026	4,983	240 (23.4)	1.35 (1.15-1.58)	1.21 (1.03-1.42)
0-9 with no dental visits	4,189	19,716	1083 (25.9)	1.30 (1.17-1.46)	1.19 (1.06-1.34)

*¹Model 1: Adjusted for age (65-69, 70-74, 75-79, 80-84, and ≥85 y) and sex.

*²Model 2: Adjusted for model 1 + education level (age upon final graduation from school <16, 16-18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m²; <18.5, 18.5-24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d-1h/d, >1h/d, missing), history of disease (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (sex-specific tertile, missing), and protein intake (sex-specific tertile, missing).

*³Other reason is getting dental checkup and scaling, for example.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page or line numbers where the checklist items are located in this paper*
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Line 2-3, Page 1 Line 4, Page 3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Line 1-18, Page 3
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	Line 2-18, Page 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Line 13, Page 5 Line 19, Page 5 - Line 1-2, Page 6
Methods			
Study design	4	Present key elements of study design early in the paper	Line 2, Page 7 – Line 1, Page 8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Line 4-13 page 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Line 10, Page 7 – Line 1, Page 8 Line 10-17, page 10
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	(This is not a matched studies)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Line 7, Page 8 - Line 17, Page 10
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Line 7, Page 8 - Line 8, Page 10
Bias	9	Describe any efforts to address potential sources of bias	Line 16, Page 11 - Line 4, Page 12
Study size	10	Explain how the study size was arrived at	Line 4-6, 10-15, Page 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Line 18, Page 8 – Line 2, Page 9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Line 8, page 11-Line 16, page 12
		(b) Describe any methods used to examine subgroups and interactions	Line 7-8, Page 14 Line 11-12, Page 14
		(c) Explain how missing data were addressed	Line 16, Page 11 - Line 4, Page 12
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	Line 2-5, Page 8
		(e) Describe any sensitivity analyses	Line 11-12, page 14

*Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study

Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Line 13, Page 7 – Line 1, Page 8
		(b) Give reasons for non-participation at each stage	Line 13, Page 7 – Line 1, Page 8
		(c) Consider use of a flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Line 2-7, Page 13 Table 1, Page 25
		(b) Indicate number of participants with missing data for each variable of interest	Line 15, Page 7 – Line 1, Page 8
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	Line 4-5, Page 8 Table 2, Page 26
Outcome data	15	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	Line 4-5, Page 8 Table 2, Page 26
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2, Page 26 Line 16, Page 13-Line 6, Page 14
		(b) Report category boundaries when continuous variables were categorized	Line 16, Page 11 - Line 4, Page 12
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Line 7-19, Page 14 Table 3, Page 27 Supplementary Table S2, Page 29
Discussion			
Key results	18	Summarise key results with reference to study objectives	Line 3-7, Page 16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Line 5-17, Page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Line 3-10, Page 16 Line 15, Page 16-Line 4, Page 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Line 10-13, Page 19

*Impact of Oral Self-care on Incident Functional Disability in Elderly Japanese : The Ohsaki Cohort 2006 Study