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Oral function and cumulative long-term care costs among older Japanese adults: A prospective six-year follow-up study of long care receipt data

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4 **Oral function and cumulative long-term care costs among older Japanese adults: A**
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6 **prospective six-year follow-up study of long care receipt data**
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ABSTRACT

Objectives: This study evaluated the relationship between oral function and long-term care service costs.

Design: This was a prospective six-year follow-up study of survey data

Setting: These data were obtained from the Japan Gerontological Evaluation Study conducted from 2010 to 2011.

Participants: The participants were functionally independent older adults in 12 municipalities across Japan.

Interventions: Care service benefit costs were tracked over six years using publicly available claims records (n = 46,616) to monitor respondents' cumulative care costs.

Primary and secondary outcome measures: The primary outcome variable was the cumulative cost of long-term care insurance services during the follow-up period. We adjusted for the presence or absence of oral function problems, age, sex, physical function, and socioeconomic and lifestyle background.

Results: Tobit analysis revealed that, compared to those with no oral function problems, cumulative long-term care service benefit costs for those with one, two, or three oral function problems were approximately 4000, 47000, and 82000 USD respectively over six years. Compared to those with maintained oral function, there was a maximum difference of approximately 82000 USD in long-term care service costs for those with oral function

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4 problems. As oral problems intensified, the cost of long-term care was increased..
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7 Conclusions: Oral function in older people was associated with cumulative long-term care
8 insurance costs. The oral function of older people should be maintained to reduce future
9 accumulated long-term care insurance costs. Compared to those with maintained oral function,
10 there was a maximum difference of approximately 82000 USD in long-term care service costs
11 for those with oral function problems. The cost of long-term care was amplified as oral
12 problems increased.
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21 **Strengths and limitations**

- 22 • The strength of this study is that it used a large-scale dataset involving data from
23 numerous municipalities
- 24 • Because this was a questionnaire survey, it did not capture the entire population of older
25 people living at home
- 26 • Selection bias may exist due to a valid response rate of 64.7%
- 27 • The follow-up period of 6 years was too short to reflect the lifetime cost of care
- 28 • The data were not adjusted for diseases and did not consider the type of healthcare
29 service used
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42 **Keywords:** oral function, older adults, care cost, long-term care insurance
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INTRODUCTION

Globally, life expectancy is increasing. In Japan, the need for long-term care services is pressing, with the increase in the number of older people requiring long-term care and the lengthening of the period during which care is needed.[1] Of the 35.55 million insured people aged 65 and over, the number of those certified as requiring nursing care or support was 6.69 million in 2019 and is growing.[2] One in four to five persons aged 65 and over requires long-term care. The medical expenses in the fiscal year 2019 for those aged 65 and over amounted to 270.629 billion USD. Additionally, the total number of long-term care insurance (LTCI) benefits in 2019 were reported to be 160.63 million, and the cost was 104.567 billion USD.[3] The number of people insured by LTCI increased by 0.8% compared to that in the previous year. However, according to population estimates, 35.88 million of the 78.2 million people over the age of 40 as of 2019 will be aged 65 or older, and the amount of delinquent LTCI premiums is increasing.[4] The insured's LTCI premiums were raised from USD 58.69 to 60.14 in 2021. This is a predicament that will lead to a tightening of finances and household budgets.[5]

An association between chewing function and oral function in older adults and overall health, physical fitness, and mortality risk has been reported.[6] Additionally, overall muscle strength declines with age. Among other organs associated with the oral cavity, muscle fibers in the tongue decrease with age.[7] Furthermore, a decrease in overall body muscle mass affects mastication.[6] The decline in physical function due to muscle weakness resulting from a decrease in skeletal muscle mass is referred to as sarcopenia.[8] Poor oral function is associated with physical frailty and sarcopenia. Moreover, sarcopenia is also associated with dysphagia.[9] The decline in eating function in old age is a cause of serious diseases, such as malnutrition, and is closely related to life expectancy.[10]

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7 It is presumed that older people with oral function decline may incur higher nursing care costs
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9 due to the greater use of services. Care-need prevention is important to reduce the cost of
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11 government LTCI benefits. Particularly, it is necessary to shift the emphasis to prevention for
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13 those who require light nursing care. Oral frailty[11] has been investigated recently and
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15 evidence suggests that maintaining function from an early stage will help maintain oral
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17 function and, in the long run, prevent a decline in feeding and swallowing function.
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21 The association between oral function and health care costs has been reported.[12–14]
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23 However, there are currently no reports on the cumulative cost of LTCI. This study aimed to
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25 clarify the association between oral function and LTCI costs among older people based on
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27 claim records through a questionnaire survey conducted among Japanese older people in
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29 several municipalities.
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36 **METHODS**

37 38 **Study sample**

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41 The baseline population data were acquired from a self-report questionnaire survey of
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43 community-dwelling people aged 65 years or older, with no physical or cognitive disabilities,
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45 and not receiving long-term care. Our data were derived from the Japan Gerontological
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47 Evaluation Study (JAGES).[15] The survey was sent by mail to residents of 12 municipalities
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49 between August 2010 and January 2012 and included sex. In total, 51302 responses were
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51 received (valid response rate: 64.7%) and unknown age was excluded. We obtained claim
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53 records from a governmental database regarding public LTCI benefits over a period of six years
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55 every month from the baseline survey.
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4 To ascertain the respondents' subsequent use of LTCIs, data on the certification of long-term
5 care needs and information on the imposition of LTCI premiums held by the insurers were
6 collected in encrypted form. The data were combined on an individual basis based on the
7 encrypted IDs to create a cohort data set. A total of 46616 individuals (90.9% follow-up rate),
8 excluding untraceable cases, were included in the analysis.
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15 **Outcome variables**

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18 The outcome variable was the cumulative cost of LTCI services during the follow-up period.
19 Information regarding LTCI costs or deaths was collected from the municipalities. Information
20 regarding long-term care costs was ascertained based on the number-of-use points in the LTCI
21 costs performance information, which was incorporated from the month the questionnaire
22 survey was administered through November 2016. LTCI costs were ascertained for long-term
23 care services used similar to the follow-up period from August 2010 to November 2016.
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33 Since the use of long-term care services is expected to be seasonally skewed, the analysis used
34 a cumulative total of all service costs used during the follow-up period. The long-term care
35 costs handled in this analysis are LTCI costs. The public LTCI do not include the cost of self-
36 paid long-term care services not listed in the information on actual long-term care insurance
37 services. Costs for the purchase of welfare equipment and home modification were also not
38 included. The independent variable was the cumulative cost of LTCI benefits over six years.
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The respondents were divided into three groups based on cumulative costs: 0 USD, less than
1–5 million USD (JPY 1–500 million), and more than 5 million USD (JPY 500 million). We
used a currency exchange rate of JPY 100 to USD 1.

54 **Explanatory variables**

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57 Explanatory variables were those related to oral function. The Kihon Checklist was created by
58 the Ministry of Health, Labour and Welfare in Japan to help people aged 65 or older reflect on
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4 their lives and health status and check for any decline in their physical or mental functions. The
5 self-administered questionnaire consists of 25 questions on daily living and physical and
6 mental functions which are answered with "yes" or "no" responses: five items to evaluate
7 activities related to daily living, five items evaluate motor functions, two items evaluate low
8 nutritional status, three items evaluate oral functions, two items evaluate seclusion, three items
9 evaluate cognitive functions, and five items evaluate physical and mental functions. The
10 questionnaire group consists of questions in seven areas of depressive mood assessment. For
11 each question, one point is added when a problem in daily functioning is considered to exist,
12 and the higher the score, the more problems in daily functioning are evaluated.[16] The
13 following three items related to oral function were used in this survey: "Do you find chewing
14 hard food more difficult compared to half a year earlier? Have you ever choked on tea or soup?
15 Are you bothered by a feeling of thirst?" A response of yes to two or more of these was
16 considered poor oral function and one yes or none was considered normal.[17,18]

33 **Covariates**

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36 Sex, age, educational attainment, household equivalized income, and marital status were used
37 as basic attributes to be considered when examining the association with the use of long-term
38 care services. Regarding demographic attributes, age was divided into five groups: 65–69, 70–
39 74, 75–79, 80–84, and 85 years and older, socioeconomic background was categorized per
40 household equivalized income (USD <2 million, 2–4 million, \geq 4 million). Household
41 equivalized income was calculated by dividing the total income of the entire household by the
42 square root of the number of household members. Educational attainment was surveyed: <9,
43 9–12, >13 years of schooling). Life background including marital status was categorized as
44 currently married, other as not married. Health self-assessment, Geriatric Depression Rating
45 Scale (GDS),[19] activities of daily living (ADL), and smoking status were used as indicators
46 of health status. Subjective health was classified as good (very good, fair) or poor (not so good,
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4 poor), and the 15-item Geriatric Depression Scale (0–4 no depression, 5–10 mild depression,
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6 and 11–15 severe depression) was used to evaluate depression. Smoking status was classified
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8 as no (never smoked, <4 years) and yes (\leq 4 years not smoking, still smoking). Missing values
9
10 in the covariates were dummy coded and included as the “Missing” category in the analysis.
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13 **Statistical analyses**

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16 Descriptive statistics were reviewed on the percentages of LTCI costs over six years, divided
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18 into three groups: zero, less than 1–5 million, and more than 5 million. Results are expressed
19
20 as the number of applicable cases (%). Percentage comparisons were analyzed using the chi-
21
22 square test. Next, the six-year cumulative LTCI costs were used as the independent variable to
23
24 evaluate the association with oral function. The analysis was conducted using the tobit
25
26 model,[20,21] taking into account that the independent variable was not normally distributed
27
28 with a concentration in the zero circles. In the analysis, after initially analyzing with the crude
29
30 model, the adjustment variables were put in the following order. Age and sex were added to
31
32 model 1, while physical factors (ADL, GDS, smoking) and socioeconomic background (years
33
34 of education, marital status, equivalent income) were added to model 2. Standard errors were
35
36 used to estimate regression coefficients. Statistical analyses were conducted using STATA
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38 15.1. The statistical significance level was set at $p < 0.05$.
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47 **Patient and public involvement**

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50 No patient or the public was involved in the development of research question and design of
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52 this study. The results of this research will be disseminated to stakeholders such as local and
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54 central health government after being published in a scientific journal.
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Results

Table 1. Characteristics of the surveyed participants

Variables	Categories	1 to 4.99 million						Total	p-value
		No cost		USD		Over 5 million USD			
		n	%	n	%	n	%		
		39268	84.23%	6257	13.40%	1091	2.37%	46616	
Sex	male	18502	85.70%	2715	12.60%	368	1.70%	21585	<0.01
	female	20766	83.00%	3542	14.20%	723	2.90%	25031	
Age	65-69	12712	95.90%	490	3.70%	54	0.40%	13256	<0.01
	70-74	12582	91.50%	1039	7.60%	123	0.90%	13744	
	75-79	8584	81.50%	1705	16.20%	247	2.30%	10536	
	80-84	4005	65.20%	1799	29.30%	335	5.50%	6139	
	85 and older	1385	47.10%	1224	41.60%	332	11.30%	2941	
Oral function	normal	30660	86.40%	4098	11.60%	718	2.00%	35476	<0.01
	poor	5147	76.80%	1340	20.00%	219	3.30%	6706	
Choked	no	31160	85.70%	4399	12.10%	790	2.20%	36349	<0.01
	yes	5728	78.90%	1325	18.30%	206	2.80%	7259	
	missing	16	66.70%	8	33.30%	0	0.00%	24	
Difficulty eating	no	27496	86.80%	3565	11.30%	609	1.90%	31670	<0.01
	yes	9566	78.70%	2193	18.00%	397	3.30%	12156	
	missing	9	81.80%	1	9.10%	1	9.10%	11	

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4		Dry								
5	Mouth	no	28898	86.30%	3911	11.70%	673	2.00%	33482	<0.01
6										
7		yes	7401	79.00%	1674	17.90%	299	3.20%	9374	
8										
9										
10		missing	1	25.00%	2	50.00%	1	25.00%	4	
11										
12		Activities								
13										
14		of Daily								
15	Living	independent	37784	85.10%	5677	12.80%	918	2.10%	44379	<0.01
16										
17		minimum								
18		assist	367	47.70%	294	38.20%	108	14.00%	769	
19										
20		assist	96	67.60%	32	22.50%	14	9.90%	142	
21										
22		missing	1014	77.70%	246	18.90%	45	3.40%	1305	
23										
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25										
26		Depressive								
27										
28	symptoms	no depression	24093	87.70%	2953	10.70%	428	1.60%	27474	<0.01
29										
30		mild								
31		depression	6589	80.40%	1347	16.40%	260	3.20%	8196	
32										
33		depression	2052	75.40%	549	20.20%	120	4.40%	2721	
34										
35		missing	6534	79.40%	1408	17.10%	283	3.40%	8225	
36										
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39	Smoking	no	29410	84.50%	4574	13.10%	804	2.30%	34788	0.02
40										
41		yes	5948	85.60%	872	12.50%	132	1.90%	6952	
42										
43		missing	3910	80.20%	811	16.60%	155	3.20%	4876	
44										
45										
46		Marital								
47										
48	status	married	28632	87.40%	3615	11.00%	517	1.60%	32764	<0.01
49										
50		others	9741	76.80%	2413	19.00%	530	4.20%	12684	
51										
52		missing	895	76.60%	229	19.60%	44	3.80%	1168	
53										
54		Equivalent								
55										
56	income	low	16151	84.20%	2562	13.40%	463	2.40%	19176	<0.01
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	middle	12585	87.00%	1617	11.20%	260	1.80%	14462	
	high	3625	88.00%	432	10.50%	60	1.50%	4117	
	missing	6907	77.90%	1646	18.60%	308	3.50%	8861	
Education	6-9 years	18271	82.20%	3349	15.10%	615	2.80%	22235	<0.01
	10-12 years	13147	86.60%	1758	11.60%	277	1.80%	15182	
	>13 years	6917	87.70%	854	10.80%	118	1.50%	7889	
	missing	933	71.20%	296	22.60%	81	6.20%	1310	

The total number of participants is shown as a percentage.

Comparisons were made using the chi-square test.

For missing values, missing categories were created and included in the analysis.

Table 1 shows the six-year cumulative LTCI and the list of covered persons. The chi-square test indicated significant differences for all variables. Next, to investigate the relationship between oral function and the costs associated with the use of LTCI, we conducted a tobit analysis using the data on cumulative LTCI costs over 6 years as the independent variable and oral function as the explanatory variable (Table 2). Compared to persons with normal oral function, the model in which age, sex, social environment, and physical factors were all inputted showed that costs for people with one oral function problem were (B=404,000), two oral function problems (B=477,000), and three oral function problems (B=828,000) more than those with normal oral function.

Table 2. Tobit regression differences in cumulative cost of long-term care insurance services by number of

oral problems

Explanatory	Categories	Crude Model	Model 1	Model 2
		B (95% CI)	B (95% CI)	B (95% CI)
Oral function	normal	reference	reference	reference
	one problem	10414.23	6532.43	4040.88
		(8712.39 to 12116.06)	(4909.64 to 8155.22)	(2369.44 to 5712.33)
	two problem	18217.95	10028.46	4770.79
		(15986.76 to 20449.15)	(7922.02 to 12134.91)	(2564.31 to 6977.28)
	three problem	28416.51	17793.12	8282.54
(25114.68 to 31718.34)		(14699.14 to 20887.10)	(4989.13 to 11575.96)	

Unit: USD 1 \equiv 100 JPY

Model 1: adjusting for age, sex

Model 2: further adjusting for activity of daily living, current smoking, depressive symptoms, equivalent income, education, marital status

B: partial regression coefficient, CI: confidence interval

Additionally, according to oral function, the percentages of certification for the need for long-term care and death or displacement are as follows: among those with three problems, 36.8%

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4 were certified as needing long-term care, compared to 16.7% for those with preserved oral
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6 function. Death and displacement also occurred in 20.6% of those with three problems
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8 compared to 9.1% of those with preserved oral function. The number of days to certification
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10 for the need for long-term care and death or relocation also decreased with the number of oral
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12 function problems.
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22 **Discussion**

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24 This study is the first to examine the differences between the degree of oral function and
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26 subsequent cumulative LTCI costs. In examining cumulative LTCI costs over six years, our
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28 results indicated that cumulative LTCI costs were higher for those with oral function problems
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30 compared to those with maintained oral function. A difference of 4000 to 8200 USD in
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32 cumulative LTCI costs over six years was observed between those with maintained oral
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34 function and those with oral function problems. Further, more oral function problems were
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36 associated with higher future LTCI costs.
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44 Table 1 shows that physical factors such as a decline in ADL and depression, as well as
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46 socioeconomic background such as equivalent income and years of education, were also
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48 associated with the cost of care. In terms of environmental factors, costs were higher in marital
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50 status for those who were not married. Further, women were more likely to be in the higher
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52 cost group than men. This is consistent with the report that 34.0% of caregivers were male,[1]
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54 indicating that women use more services when they require care, which also indicates a
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56 problem in the caregiving environment.
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7 An analysis of the degree of oral function and 6-year cumulative LTCI costs in Table 2 shows
8 a difference in cumulative LTCI costs for those with declining oral function compared with
9 maintained oral function. As a mechanism for this, an association between physical function
10 and oral health has been reported in older people with impaired oral function. The number of
11 chewable foods and bite strength has been associated with leg extension power and time spent
12 standing on one leg,[22,23] and the risk of falling is 2.5 times higher among those with 19 or
13 fewer teeth compared to those with 20 or more teeth.[24]
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26 Oral function is also associated with mental function and dementia. Poor quality of life related
27 to oral hygiene increases the risk of depressive symptoms among older people.[25] In terms of
28 cognitive function, those with few teeth and no dentures have a 1.9 times higher likelihood of
29 having dementia than those with 20 or more teeth.[26] Severe periodontitis, a possible cause
30 of tooth loss, is associated with MCI.[27] As retained teeth decrease, the number of occlusal
31 surfaces decreases. Low occlusal contact and consumption of soft foods are risk factors for
32 Alzheimer's disease.[28] Regarding the association between frailty and oral function, older
33 patients with frailty have significantly reduced oral function, which is associated with lower
34 occlusal force, masseter muscle thickness, and oral diadochokinesis rate.[29] A study on older
35 people in Japan demonstrated that the risk of requiring long-term care is frail.[30] From these
36 findings, it can be inferred that a decline in oral function is closely related to physical, mental,
37 and cognitive function and is a factor in the development of the need for long-term care. The
38 risk of needing long-term care and certification as requiring long-term care are assumed to be
39 associated with the use of long-term care services and thus, with the cumulative cost of LTCI
40 costs.
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4 However, in a previous study similarly examining the association with cumulative LTCI costs,
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6 cumulative LTCI costs were 600 USD higher over 6 years (100 USD per year) for those who
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8 were less physically active than for those who were less physically active.[31] In addition,
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10 caregiving costs were 1200 USD lower over 6 years (200 USD per year) for those who
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12 participated in social activities such as hobbies and sports groups compared to those who did
13
14 not.[32] These are certainly reasonable explanations for the results indicating an association of
15
16 high cost with oral function decline, which is a risk of needing care, and high cost with oral
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18 function decline, which was 4000 to 8200 USD over 6 years (670 to 1360 USD per year) for
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20 those whose function declined compared to those whose oral function was maintained in the
21
22 present study.
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30 In Table 2, the analysis was based on the number of oral function problems. For each increase
31
32 in oral function problems, there was an increase in cost. The cost per beneficiary per year in
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34 2020 for the elderly in Japan was 2.09 million USD.[33] For those with one oral function
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36 problem, it was equivalent to 19.3% of the total, 22.7% for those with two, and 39.5% for those
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38 with three. However, oral function affected the cost of long-term care services, when the
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40 cumulative long-term care costs during the follow-up period were analyzed. People with good
41
42 oral function may have a shorter duration of need for long-term care during the follow-up
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44 period (Table 3).
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48 Table 3. Rate of those certified as requiring long-term care and mortality and days by the oral problem
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Oral function	Requiring long-term care			Mortality		
	n	(%)	First time days to certification	n	(%)	Days to death or displacement
Normal	3081	(16.70%)	1928.77	1674	(9.10%)	2024.14

One problem	2167(22.40%)	1874.07	1214(12.60%)	1987.63
Two problems	1148(29.30%)	1814.63	636 (16.20%)	1945.89
Three problems	484 (36.80%)	1725.16	271 (20.60%)	1891.41
total	6880(20.70%)	1799.69	3795(11.40%)	1943.58

The percentage of the number of problems for each oral function.

Previous studies related to eating difficulties have also reported that fewer teeth and denture use are associated with mortality[34,35] and fewer foods can be chewed by those who require nursing care.[22] Self-reported surveys have reported that mastication disorders are associated with an increased risk of mortality among older persons.[36] In a study related to oral dryness, it was reported that lip strength and lip dexterity are decreased in persons requiring nursing care,[37] and weak lip strength is also associated with oral dryness as is the length of time spent opening the mouth. Dysphagia is associated with frailty.[38,39] Increased problems with oral function increase the need for nursing care and the risk of death, which can have a serious impact on the health status of older adults with poor oral function, consistent with previous research on the need to provide effective oral health care and reduce the burden of oral disease, as well as its impact on general health.[40]

In this study, chewing hard food, choking, and thirst were evaluated. It is desirable to maintain these functions to reduce the future cost of care. It has been reported that bite and chewing strength related to difficulty in chewing hard foods, hyoid muscle related to swallowing, and xerostomia can be improved by functional training.[41-46] For patients with oral problems, early professional care and efforts to maintain oral function may help control future LTCI costs. Since oral function deterioration can also lead to dysphagia, it is hoped that in the future this will lead to a reduction in deaths from aspiration pneumonia, the leading cause of death in Japan.[24]

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4 Based on these results, we attempted to estimate the total cost savings in Japanese LTCI if this
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6 goal were achieved; 18.9% of all people in Table 1 had two or more oral problems. The
7
8 difference in cumulative LTCI costs would be 477,000 for two functional declines or 795,000
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10 per year. Applying the results of this study, in a community of 10,000 seniors, 1,890 seniors
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12 would have oral function impairment. If oral function improves, the cumulative cost of long-
13
14 term care will be reduced by 150.25 million USD per year. In addition, 76.8% of those with
15
16 oral dysfunction did not use long-term care services, even though they had oral dysfunction.
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18 Preventive intervention for those with oral function loss who are not using services will prevent
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20 the risk of further functional decline and serious illness in the future.
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25 **Strengths**

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27 The strength of this study is that we analyzed merged individual data from questionnaires on
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29 social life and public claim records as they pertain to long-term care services. More
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31 specifically, we used a large-scale dataset involving data from numerous municipalities.
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34

35 **Limitations**

36
37 There are five limitations of this study. First, because this is a questionnaire survey, it does not
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39 capture the entire population of older people living at home. In addition, those who were able
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41 to respond to both the baseline and follow-up surveys may have consisted of healthy
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43 individuals. Measurement bias may have occurred. Second, the data in this study consisted of
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45 surveys conducted at the municipal level, where cooperation was obtained, and selection bias
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47 may exist. The data are biased due to a valid response rate of 64.7%. Third, the follow-up
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49 period was only 6 years, which is too short to reflect the lifetime cost of care. Future studies
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51 should incorporate a longer follow-up period. Fourth, the data are not adjusted for diseases.
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53 There may be confounding factors that were not taken into account in the analyses in this study.
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59 Fifth, our data did not take into account the type of health care services used. Depending on
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4 the services used, the patient may already be receiving professional care related to oral organ
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6 function. Future surveys should also analyze by type of service.
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8 9 **Conclusions**

10
11 The degree of oral function in older people was associated with cumulative LTCI costs. There
12
13 was a difference in cumulative LTCI costs between those with preserved oral function and
14
15 those with declining oral function. Compared to those whose oral function was maintained,
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17 those with oral function problems had approximately 4000 to 8000 USD lower cumulative
18
19 LTCI costs over six years. The more oral function problems, the larger the difference.
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21 Maintaining the oral functions of older people may lead to a reduction in future accumulated
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23 LTCI costs.
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31 **Acknowledgments**

32
33 This study used data from the Japan Gerontological Evaluation Study (JAGES), conducted by
34
35 the Center for Well-being and Society, Nihon Fukushi University, as one of their research
36
37 projects. Editorial support in the form of medical writing was obtained from Editage.
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45 **Author contribution**

46
47 All authors contributed to the conception and design of this study. Data collection was
48
49 primarily conducted by MS, YM, EO, and TO. Analyses were performed by KK and supported
50
51 by MS, YM, EO, and TO. KK prepared the initial manuscript and MS, YM, EO, and TO
52
53 significantly contributed to revising it. All authors read and approved the final manuscript.
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Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the respective funding organisations.

Conflicts of interest

The authors have no competing interests to declare.

Patient consent for publication

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4 Not required.
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7 **Institutional review board statement**
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9
10 This study was approved by the Ethics Committee on the Research of Human Subjects at Nihon
11
12 Fukushima University (no. 10-05). This study was conducted through a collaborative research
13
14 agreement with the associated municipalities. JAGES participants were informed that
15
16 participation in the study was voluntary and that completing and returning the questionnaire
17
18 via mail indicated their consent to participate in the study. We obtained written informed
19
20 consent from the participants.
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24 **Provenance and peer review**
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26
27 Not commissioned; externally peer reviewed. Data availability statement Data are available
28
29 upon reasonable request.
30
31

32 **Data availability statement**
33

34
35 Data are not open for public due to ethical concerns. Data are from the JAGES study whose
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37 authors may be contacted at data management committee: dataadmin@jages.net. The data set
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39 has ethical or legal restrictions because it includes human participants.
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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
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 <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6,7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
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	7,8
Bias	9	Describe any efforts to address potential sources of bias	6,7
Study size	10	Explain how the study size was arrived at	6,7

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Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7,8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	9
		(b) Describe any methods used to examine subgroups and interactions	9
		(c) Explain how missing data were addressed	9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	9
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy			
		(e) Describe any sensitivity analyses	

Continued on next page

For peer review only

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60**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	10
		(b) Give reasons for non-participation at each stage	
		(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	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	17
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	13
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
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	13,14
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	17

Discussion

Key results	18	Summarise key results with reference to study objectives	14
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	15,16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16,17
Generalisability	21	Discuss the generalisability (external validity) of the study results	18

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	20
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2 *Give information separately for cases and controls in case-control studies and, if applicable, for exposed and
3 unexposed groups in cohort and cross-sectional studies.
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7 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and
8 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely
9 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at
10 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is
11 available at www.strobe-statement.org.
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Oral function and cumulative long-term care costs among older Japanese adults: A prospective six-year follow-up study of long care receipt data

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4 1 **Oral function and cumulative long-term care costs among older Japanese adults: A**
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6 2 **prospective six-year follow-up study of long care receipt data**
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4 41 **ABSTRACT**

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7 42 **Objectives:** This study evaluated the relationship between status of oral function and related
8
9 43 long-term care service costs.

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12 44 **Design:** This was a prospective six-year follow-up study of a previous survey data.

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15 45 **Setting:** The data were obtained from the Japan Gerontological Evaluation Study conducted
16
17 46 between 2010 and 2011.

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20 47 **Participants:** The participants were functionally independent older adults in 12 municipalities
21
22 48 across Japan.

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25 49 **Interventions:** Care service benefit costs were tracked over six years using publicly available
26
27 50 claims records (n = 46,616) to monitor respondents' cumulative care costs.

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30 51 **Primary and secondary outcome measures:** The primary outcome variable was the
31
32 52 cumulative cost of long-term care insurance services during the follow-up period. We adjusted
33
34 53 for the presence or absence of oral function problems, age, sex, physical function, and
35
36 54 socioeconomic and lifestyle background at the time of the baseline survey.

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40 55 **Results:** Tobit analysis revealed that, compared to those with no oral function problems,
41
42 56 cumulative long-term care service benefit costs for those with one, two, or three oral function
43
44 57 problems were approximately 4,000, 47,000, and 82,000 USD respectively, over six years.
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46 58 Compared to those with maintained oral function, there was a maximum difference of
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48 59 approximately 82,000 USD in long-term care service costs for those with oral function
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50 60 problems. With increase in number of oral function problems, there was a concomitant
51
52 61 elevation in the cost of long-term care.

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56 62 **Conclusions:** Oral function in older people was associated with cumulative long-term care

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4 63 insurance costs. The oral function of older people should be maintained to reduce future
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6 64 accumulated long-term care insurance costs. Compared to those with maintained oral function,
7
8 65 there was a maximum difference of approximately 82,000 USD in long-term care service costs
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10 66 for those with oral function problems. The cost of long-term care was amplified as oral
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12
13 67 problems increased.

68 **Strengths and limitations**

- 69 • The strength of this study is that it used a large-scale dataset involving data from
70 numerous municipalities
- 71 • Because this was a questionnaire survey, it did not capture the entire population of older
72 people living at home
- 73 • Selection bias may exist due to a valid response rate of 64.7%
- 74 • The follow-up period of six years was too short to reflect the lifetime cost of care
- 75 • The data were not adjusted for diseases and did not consider the type of healthcare
76 service used

77 **Keywords:** oral function, older adults, care cost, long-term care insurance, Japan

79 INTRODUCTION

80 Globally, life expectancy is increasing. In Japan, the need for long-term care services is
81 unrelenting, with constant increase in the number of older people requiring long-term care,
82 together with lengthening of the period during which care is needed.[1] Of the 35.55 million
83 insured people aged ≥ 65 years, the number of those certified as requiring nursing care or
84 support was 6.69 million in 2019 with the number continually growing.[2] One in four to five
85 persons aged ≥ 65 years requires long-term care, and the related medical expenses in the fiscal
86 year 2019 amounted to 270.629 billion USD. Additionally, the total number of long-term care
87 insurance (LTCI) benefits in 2019 were reported to be 160.63 million, and the cost was 104.567
88 billion USD.[3]

89 Japan's long-term care insurance system was established in 2000 as a system in which, the
90 society as a whole supports the care of older adults. This insurance system provides benefits to
91 those who need nursing care, and supports them by making appropriate services available to
92 them. It aims to support physical independence, and reduce the burden on family members who
93 provide care. The long-term care insurance system consists of three parties: the insured, the
94 insurer, and the long-term care service provider. Municipalities act as insurers who administer
95 the system, and all citizens aged ≥ 40 years are eligible to be insured. An insured person is one
96 who subscribes to long-term care insurance, and is eligible to receive long-term care services
97 when he/she is certified as requiring it. If they are using the long-term care insurance system,
98 and are receiving long-term care services, they pay 10% of the cost at the counter (depending
99 on income, the co-payment can be up to 30%). The long-term care service provider company
100 that provides the care services to the insured person, bills the insurer for the service cost, which
101 the insured person receives from the insurer (municipality), except for the share to be paid by
102 the insured person at the counter. This long-term care insurance system is financed by public

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4 103 funds, and long-term care insurance premiums. In total, the municipality and the insured person
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6 104 pay 50% each, for the long-term care insurance premiums.[4] The number of people insured
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8 105 by LTCI increased by 0.8% compared to that in the previous year. However, according to
9
10 106 population estimates, 35.88 million of the 78.2 million people over the age of 40 as of 2019
11
12 107 will be aged 65 or older, and the amount of delinquent LTCI premiums is increasing.[5] The
13
14 108 insured's LTCI premiums were raised from 58.69 to 60.14 USD in 2021. This is a predicament
15
16 109 that will lead to tightening of finances and household budgets.[6]
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20 110 In older adults, an association between chewing and oral functions, overall health, physical
21
22 111 fitness, and mortality risk has been reported.[7] Additionally, overall muscle strength declines
23
24 112 with age. Along with other organs associated with the oral cavity, muscle fiber atrophy occur
25
26 113 in the tongue with age.[8] Furthermore, a decrease in overall body muscle mass affects
27
28 114 mastication.[7] The decline in physical function due to muscle weakness resulting from a
29
30 115 decrease in skeletal muscle mass is referred to as sarcopenia.[9] Poor oral function is associated
31
32 116 with physical frailty and sarcopenia. Moreover, sarcopenia is also associated with
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34 117 dysphagia.[10] The decline in eating function in old age is a cause of serious diseases, such as
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36 118 malnutrition, and is closely related to life expectancy.[11]
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44 120 It is presumed that older adults with decline in oral functions are likely to incur higher nursing
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46 121 care costs due to the greater use of services. Care-need prevention is important to reduce the
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48 122 cost of government LTCI benefits. Particularly, it is necessary to shift the emphasis to
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50 123 prevention for those who require light nursing care. Oral frailty[12] has been investigated
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52 124 recently, and evidence suggests that maintaining function from an early stage will help
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54 125 maintain oral function and, in the long run, prevent a decline in feeding and swallowing
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4 126 function.[13]
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7 127 The association between oral function and health care costs has been reported.[14-16]
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9 128 However, there are currently no reports on the cumulative cost of LTCI. This study aimed to
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11 129 elucidate the association between oral function and LTCI costs among older people based on
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13 130 claim records, through a questionnaire survey conducted among Japanese older adults living
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15 131 in several municipalities.
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20 21 133 **METHODS**

22 23 24 134 **Study sample**

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27 135 The baseline population data were acquired from a self-reported questionnaire survey of
28
29 136 community-dwelling people aged ≥ 65 years, with no physical or cognitive disabilities, and not
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31 137 receiving long-term care. Our data were derived from the Japan Gerontological Evaluation
32
33 138 Study (JAGES).[17,18] At the time of the baseline survey, respondents were not certified as
34
35 139 needing long-term care. As such, respondents resided in the community. The JAGES survey
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37 140 was done by collecting self-administered questionnaires, which were mailed to a random
38
39 141 sample of functionally independent individuals aged ≥ 65 years, from 12 participating
40
41 142 municipalities between August 2010 and January 2012. In total, 51,302 responses were
42
43 143 received (valid response rate: 64.7%) and unknown sex and age was excluded. The study
44
45 144 population was limited to older adults who were not certified as needing long-term care at the
46
47 145 time of the survey; it was combined with the actual long-term care insurance benefits held by
48
49 146 the government six years later. We obtained claim records from a governmental database
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51 147 regarding public LTCI benefits over a period of six years for every month from the baseline
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53 148 survey. To ascertain the respondents' subsequent use of LTCIs, information on the actual
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4 149 insurance benefits provided by insurers, data on the certification of long-term care needs held
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6 150 by insurers, deaths, and information on the imposition of LTCI premiums were collected in
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8 151 encrypted forms by the insurers. The provided data and questionnaire survey data were
9
10 152 matched on an individual basis by the researcher based on the encrypted IDs to create a cohort
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12
13 153 data set for analysis. A total of 46,616 individuals (90.9% follow-up rate), excluding
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15 154 untraceable cases including in-migrants and out-migrants were included in the analysis.
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21 156 **Outcome variables**

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24 157 The outcome variable was the cumulative cost of LTCI services during the follow-up period.
25
26 158 Information regarding LTCI costs, or deaths was collected from the municipalities. In this
27
28 159 analysis, we used the cumulative total of all service costs used during the follow-up period and
29
30 160 all The costs for those who never received certification of need for assistance or care during
31
32 161 the follow-up period, and those who died without using long-term care insurance services were
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34
35 162 zero. Information regarding long-term care costs was ascertained based on the number-of-use
36
37 163 points in the LTCI costs performance information, which was incorporated from the month the
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39 164 questionnaire survey was administered through November 2016. LTCI costs were ascertained
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41 165 for long-term care services using a similar follow-up period from August 2010 to November
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44 166 2016.
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47 167 Since the use of long-term care services is expected to be seasonally skewed, the analysis used
48
49 168 a cumulative total of all service costs used during the follow-up period. The long-term care
50
51 169 costs handled in this analysis are LTCI costs. The public LTCI do not include the cost of self-
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53 170 paid long-term care services not listed in the information on actual long-term care insurance
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56 171 services. Costs for the purchase of welfare equipment and home modification were also not
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4 172 included. The independent variable was the cumulative cost of LTCI benefits over six years.
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6 173 The respondents were divided into two groups based on cumulative costs: 0 USD, and more
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8 174 USD. We used a currency exchange rate of JPY 100 to USD 1.
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14 176 **Explanatory variables**

17 177 Explanatory variables were those related to oral function at the time of the baseline survey. In
18
19 178 Japan, to assess whether a person is eligible for nursing care prevention services or LTCI
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21 179 services, use of the Kihon Checklist (KCL) has been recommended by the Ministry of Health,
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23 180 Labour and Welfare.[19] The KCL was created by the Ministry of Health, Labour and Welfare
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25 181 in Japan to help people aged ≥ 65 years reflect on their lives and health status and check for
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27 182 any decline in their physical or mental functions [20]. It is used by the local governments, and
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29 183 in community consultations to screen for persons eligible for long-term care prevention
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31 184 programs, and to assess the effectiveness of interventions. The KCL was automatically sent to
32
33 185 all individuals ≥ 65 years on an annual basis up until 2014, but is now administered at the
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35 186 discretion of each local administration [21].
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37 187 The self-administered questionnaire consists of 25 questions on daily living, physical, and
38
39 188 mental functions which are answered with "yes" or "no" responses: five items each to evaluate
40
41 189 activities related to daily living motor functions, and physical and mental functions; three items
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43 190 each to evaluate oral functions and cognitive functions; and two items each to evaluate low
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45 191 nutritional status and seclusion. The questionnaire group consists of questions in seven areas
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47 192 of depressive mood assessment. For each question, one point is added when a problem in daily
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49 193 functioning is considered to exist, and the higher the score, the more problems in daily
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51 194 functioning get recorded.[22] The following three items related to oral function were used in
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4 195 this survey: “Do you find chewing hard food more difficult compared to half a year earlier?
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6 196 Have you ever choked on tea or soup? Are you bothered by a feeling of thirst?” A response of
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8 197 yes to two or more of these was considered poor oral function and one yes or none was
9
10 198 considered normal.[23,24]

13 199 **Covariates**

16 200 Sex, age, educational attainment, household equivalized income, and marital status at the time
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18 201 of the baseline survey were used as basic attributes to be considered when examining the
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20 202 association with the use of long-term care services. Regarding demographic attributes, age was
21
22 203 divided into five groups: 65–69, 70–74, 75–79, 80–84, and ≥ 85 years, socioeconomic
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24 204 background was categorized per household equivalized income (<2 million, 2–4 million, ≥ 4
25
26 205 million USD). Household equivalized income was calculated by dividing the total income of
27
28 206 the entire household by the square root of the number of household members. Educational
29
30 207 attainment was assessed by <9, 9–12, >13 years of schooling. Life background, including
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32 208 marital status, was categorized as currently married, or as not married. Household composition
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34 209 was classified as, yes or no with or without a cohabitant. Geriatric Depression Rating Scale
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36 210 (GDS),[25] activities of daily living (ADL), and smoking status were used as indicators of
37
38 211 health status. The 15-item Geriatric Depression Scale (0–4 no depression, 5–10 mild
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40 212 depression, and 11–15 severe depression) was used to evaluate depression. [26–28] Smoking
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42 213 status was classified as no (never smoked, <4 years), and yes (≤ 4 years not smoking, still
43
44 214 smoking). Missing values in the covariates were dummy coded and included as “Missing”
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46 215 category in the analysis.

53 216 **Statistical analyses**

56 217 Descriptive statistics were sociodemographic variables and mean and percentages of LTCI

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4 218 costs over six years were stratified according to the two stratified groups: zero, and more
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6 219 typology. Percentage comparisons were analyzed using the chi-square test. Next, the six-year
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8 220 cumulative LTCI costs were used as the independent variable to evaluate the association with
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10 221 oral function. The analysis was conducted using the tobit model,[29,30] taking into account
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12 222 that the independent variable was not normally distributed with a concentration in the zero
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14 223 circles. In the analysis, after initially analyzing with the crude model, the adjustment variables
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16 224 were put in the following order. Age and sex were added to model 1, while physical factors
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18 225 (ADL, GDS, smoking), and socioeconomic background (years of education, marital status,
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20 226 household structure, equivalent income) were added to model 2. Standard errors were used to
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22 227 estimate regression coefficients. Statistical analyses were conducted using STATA SE 15.1
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24 228 (Stata Corp, College Station, Texas, USA). The statistical significance level was set at $p < 0.05$.
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26 229 Accumulated care costs depend on the length of time care was needed. Therefore, the rates of
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28 230 those who were certified as needing care and those who died, and the number of days to get
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30 231 there, were calculated for each group in terms of the number of oral problems. Information
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32 232 such as the certification of the need for nursing care and the moving out of the country was
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34 233 provided by the insurer.
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236 **Patient and public involvement**

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49 237 No patient or the public were involved in the development of research question and design of
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51 238 this study. The results of this research will be disseminated to stakeholders such as local and
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53 239 central health government after being published in a scientific journal.
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4 241 **Results**

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7 242 The analysis showed that with zero expenses had an average age of 73.0 years, while those
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9 243 using care expenses had an average age of 79.2 years. The minimum cost was 5.00 USD, the
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11 244 maximum cost was 2,35,536.90 USD. Table 1 shows the baseline characteristics of the
12
13 245 respondents and the average cumulative LTCI cost. Table 2 shows the Tobit regression
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15 246 differences in cumulative cost of long-term care insurance services by number of oral
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17 247 problems. Table 3 shows rate of those certified as requiring long-term care, mortality, and days
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20 248 by the oral problem.
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249 Table 1. Baseline characteristics of the participants and cumulative long-term care insurance costs. (n=46616)

Variables	Categories	total	USD 0		USD 1 or more						
		n	n	%	N	%	mean	SE	95% confidence interval of the mean		SD
Sex	Male	21585	18502	85.72	3083	14.28	18952.33	533.65	17905.92	19998.74	27590.35
	Female	25031	20766	82.96	4265	17.04	24819.77	542.73	23755.68	25883.86	32977.54
Age	65–69	13256	544	4.10	12712	95.90	18183.74	1333.29	15564.05	20803.44	29483.42
	70–74	13744	1162	8.45	12582	91.55	16788.02	853.48	15113.25	18462.78	27404.61
	75–79	10536	1952	18.53	8584	81.47	19843.02	690.84	18488.04	21198.01	28584.58
	80–84	6139	2134	34.76	4005	65.24	23925.24	735.67	22482.39	25368.10	31393.58
	85 and older	2941	1556	52.91	1385	47.09	29386.23	961.85	27499.29	31273.17	34839.83
Oral function	0.00	23298	20523	88.09	2775	11.91	22038.89	573.24	20914.88	23162.91	30180.78
	1.00	12178	10137	83.24	2041	16.76	22642.72	698.77	21272.34	24013.10	31560.89
	2.00	4986	3902	78.26	1084	21.74	21148.40	885.64	19410.62	22886.19	29091.78
	3.00	1720	1245	72.38	475	27.62	25721.67	1671.76	22436.66	29006.67	36396.87
Choked	No	36349	31160	85.72	5189	14.28	22501.65	434.98	21648.89	23354.41	30714.88
	Yes	7259	5728	78.91	1531	21.09	22103.65	862.06	20412.57	23794.73	32174.66
	Missing	24	16	66.67	8	33.33	7911.47	4794.59	-12717.99	28540.92	8304.47
Difficulty in eating	No	31670	27496	86.82	4174	13.18	21942.01	477.92	21005.02	22878.99	30245.05
	Yes	12156	9566	78.69	2590	21.31	23190.94	663.02	21890.78	24491.10	32311.67
	Missing	11	9	81.82	2	18.18	25555.10	24512.30	-285903.20	337013.40	34665.63
Dry mouth	No	33482	28898	86.31	4584	13.69	22103.32	458.44	21204.56	23002.09	30783.74

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3												
4		Yes	9374	7401	78.95	1973	21.05	23117.57	730.29	21685.29	24549.85	31580.48
5		Missing	4	1	25.00	3	75.00	37865.47	33626.18	-106816.30	182547.23	58242.25
6	Activities of daily	Independent	44379	37784	85.14	6595	14.86	21497.68	394.90	20723.53	22271.82	30009.55
7	living	Minimum assist	769	367	47.72	402	52.28	33386.73	2107.73	29241.06	37532.40	39149.44
8		Assist	142	96	67.61	46	32.39	52744.22	10428.07	31633.68	73854.75	65123.31
9		Missing	1305	1014	77.70	291	22.30	22182.71	1760.23	18712.23	25653.18	25264.02
10	Depressive	No depression	27474	24093	87.69	3381	12.31	20689.68	524.96	19660.37	21718.98	29067.64
11	symptoms	Mild depression	8196	6589	80.39	1607	19.61	23907.93	875.49	22190.53	25625.32	32932.83
12		Depression	2721	2052	75.41	669	24.59	24857.99	1422.94	22063.24	27652.75	34268.90
13		Missing	8225	6534	79.44	1691	20.56	23475.66	868.28	21772.27	25179.04	31354.46
14	Smoking	No	34788	29410	84.54	5378	15.46	22621.56	444.19	21750.74	23492.37	31258.05
15		Yes	6952	5948	85.56	1004	14.44	20498.76	986.93	18561.88	22435.64	30032.53
16		Missing	4876	3910	80.19	966	19.81	23183.46	1341.24	20548.12	25818.81	29598.54
17	Marital status	Married	32764	28632	87.39	4132	12.61	19436.49	473.92	18507.31	20365.68	28506.40
18		Others	12684	9741	76.80	2943	23.20	26439.03	669.37	25126.47	27751.60	33761.73
19		Missing	1168	895	76.63	273	23.37	23211.96	2153.29	18966.15	27457.77	30679.67
20	Living arrangement	Living with others	39644	33827	85.33	5817	14.67	21730.41	426.36	20894.56	22566.27	30397.54
21		Living alone	6163	5441	88.28	1531	24.84	24835.00	921.89	23026.41	26643.58	33008.39
22	Equivalent income	Low	19176	16151	84.23	3025	15.77	22321.17	605.88	21133.14	23509.21	31318.70
23		Middle	14462	12585	87.02	1877	12.98	21747.74	758.07	20260.87	23234.61	31062.52
24		High	4117	3625	88.05	492	11.95	20363.70	1361.97	17687.00	23040.39	28763.09
25		Missing	8861	6907	77.95	1954	22.05	23632.21	778.56	22105.09	25159.34	30829.37
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Education	6–9 years	22235	18271	82.17	3964	17.83	23266.45	545.68	22196.56	24336.34	32037.63
	10–12 years	15182	13147	86.60	2035	13.40	20946.62	689.82	19593.68	22299.56	29217.84
	>13 years	7889	6917	87.68	972	12.32	19434.13	977.85	17514.89	21353.37	28726.15
	Missing	1310	933	71.22	377	28.78	29673.63	2083.82	25570.31	33776.94	33665.16

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252 Next, to investigate the relationship between oral function and the costs associated with the use
 253 of LTCI, we conducted a tobit analysis using the data on cumulative LTCI costs over six years
 254 as the independent variable, and oral function as the explanatory variable (Table 2). Compared
 255 to persons with normal oral function, the model in which age, sex, social environment, and
 256 physical factors were inputted, showed that costs for people with one oral function problem
 257 were (B=4020,35), two oral function problems (B=4775,48), and three oral function problems
 258 (B=8292,83), to be more than those with normal oral function.

259

260 Table 2. Tobit regression differences in cumulative cost of long-term care insurance services by number of
 261 oral problems

Explanatory	Categories	Crude Model	Model 1	Model 2
		B (95% CI)	B (95% CI)	B (95% CI)
Oral function	normal	reference	reference	reference
	One problem	10414.23 (8712.39 to 12116.06)	6532.43 (4909.64 to 8155.22)	4020.35 (2348.95 to 5691.75)
	Two problems	18217.95 (15986.76 to 20449.15)	10028.46 (7922.02 to 12134.91)	4775.48 (2569.12 to 6981.85)
	Three problems	28416.51	17793.12	8292.83

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(25114.68 to 31718.34) (14699.14 to 20887.10) (4999.92 to 11585.74)

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263 Unit: USD 1 \doteq 100 JPY

264 Model 1: adjusting for age, sex

265 Model 2: further adjusting for activity of daily living, current smoking, depressive symptoms, equivalent

266 income, education, marital status, household structure

267 B: partial regression coefficient, CI: confidence interval

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269 The impact of oral function on the cost of long-term care services was examined. The analysis
 270 was based on the cumulative cost of care during the follow-up period. According to oral
 271 function, the percentages of persons requiring certification for the need for long-term care, and
 272 death or displacement are as follows: among those with three problems, 36.8% were certified
 273 as needing long-term care, compared to 16.7% for those with preserved oral function. Death
 274 and displacement also occurred in 20.6% of those with three problems compared to 9.1% of
 275 those with preserved oral function. The number of days to certification for the need for long-
 276 term care and death or relocation also decreased with decrease in the number of oral function
 277 problems. Oral function affected the cost of long-term care services, when the cumulative long-
 278 term care costs during the follow-up period were analyzed.(Table 3)

279

280 Table 3. Rate of those certified as requiring long-term care and mortality and days by the oral problem

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Oral function	Requiring long-term care			Mortality		
	n	(%)	First time days to certification	n	(%)	Days to death or displacement
Normal	3081	(16.70%)	1928.77	1674	(9.10%)	2024.14
One problem	2167	(22.40%)	1874.07	1214	(12.60%)	1987.63
Two problems	1148	(29.30%)	1814.63	636	(16.20%)	1945.89
Three problems	484	(36.80%)	1725.16	271	(20.60%)	1891.41
total	6880	(20.70%)	1799.69	3795	(11.40%)	1943.58

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284 Discussion

285 This study is the first to examine the differences between the degree of oral function and
 286 associated cumulative LTCI costs. In examining cumulative LTCI costs over six years, our
 287 results indicated that cumulative LTCI costs were higher for those with oral function problems
 288 compared to those with maintained oral function. A difference of 4,000 to 8,200 USD in
 289 cumulative LTCI costs over six years was observed between those with maintained oral
 290 function and those with oral function problems. Further, higher number of oral function
 291 problems were associated with higher future LTCI costs.

292

293 The cost of care was found to be related to physical function, socioeconomic background, and
 294 the care environment. Decline in ADL together with depression, as well as equivalent income,
 295 and years of education were also associated with the cost of care. In terms of marital status,

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4 296 costs were higher for those who were not married. Further, women were more likely to be in
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6 297 the higher cost group than men. This is consistent with another report that showed 34.0% of
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8 298 caregivers were male,[1] indicating that women use care services more when they required,
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10 299 which also indicates a problem in the caregiving environment.
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16 301 An analysis of the degree of oral function and 6-year cumulative LTCI costs in Table 2 shows
17
18 302 a difference in cumulative LTCI costs for those with declining oral function compared with
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20 303 maintained oral function. As an explanation for this, an association between physical function
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22 304 and oral health has been reported in older people with impaired oral function. The number of
23
24 305 chewable foods and bite strength has been associated with leg extension power and time spent
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26 306 standing on one leg,[31,32] and the risk of falling is 2.5 times higher among those with 19 or
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28 307 fewer teeth compared to those with 20 or more teeth.[33]
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35 309 Oral function is also associated with mental function and dementia. Poor quality of life related
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37 310 to oral hygiene increases the risk of depressive symptoms among older people.[34] In terms of
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39 311 cognitive function, those with few teeth and no dentures have a 1.9 times higher likelihood of
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41 312 having dementia than those with 20 or more teeth.[35] Severe periodontitis, a possible cause
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43 313 of tooth loss, is associated with Mild Cognitive Impairment(MCI).[36] As retained teeth
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45 314 decrease, the number of occlusal surfaces decreases. Low occlusal contact and consumption of
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47 315 soft foods are risk factors for Alzheimer's disease.[37] Regarding the association between
48
49 316 frailty and oral function, older patients with frailty have significantly reduced oral function,
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51 317 which is associated with lower occlusal force, masseter muscle thickness, and oral
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53 318 diadochokinesis rate.[38] A study on older people in Japan demonstrated that one of the risk
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4 319 of requiring long-term care is frailty.[39] From these findings, it can be inferred that a decline
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6 320 in oral function is closely related to physical, mental, and cognitive function and is a factor in
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8 321 the development of the need for long-term care. The risk of needing long-term care, and
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10 322 certification for requirement of long-term care are assumed to be associated with the use of
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13 323 long-term care services and thus, with the cumulative cost of LTCI costs.

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15 324 However, in a similar study examining the association with cumulative LTCI costs, cumulative
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17 325 LTCI costs were 600 USD higher over six years (100 USD per year) for those who were less
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19 326 physically active than for those who had normal physical active.[28] In addition, caregiving
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21 327 costs were 1,200 USD lower over six years (200 USD per year) for those who participated in
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23 328 social activities such as hobbies and sports groups, compared to those who did not.[40] These
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25 329 are certainly reasonable explanations for the results indicating an association of high cost with
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27 330 oral function decline, which is a risk of needing care, and high cost with oral function decline,
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29 331 which was 4,000 to 8,200 USD over six years (670 to 1,360 USD per year) for those whose
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31 332 function declined compared to those in whom oral function was maintained in the present
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34 333 study.

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41 335 The cost per beneficiary per year in 2020 for the elderly in Japan was 2.09 million USD.[41]
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43 336 There was a concomitant increase in cost, with each increase in oral function problems. For
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45 337 those with one oral function problem, the cost increase was 19.3% of the total, it was 22.7%
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47 338 for those with two, and 39.5% for those with three. When the cumulative long-term care costs
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49 339 during the follow-up period were analyzed by oral function, it was found to affect the cost of
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51 340 long-term care services. People with good oral function may have a shorter duration of need
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54 341 for long-term care during the follow-up period.

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4 342 Previous studies related to eating difficulties have also reported that fewer teeth and denture
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6 343 use are associated with mortality[42,43], and less foods can be chewed by those who require
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8 344 nursing care.[32] Self-reported surveys have reported that mastication disorders are associated
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10 345 with an increased risk of mortality among older persons.[44] In a study related to oral dryness,
11
12 346 it was reported that lip strength and lip dexterity are decreased in persons requiring nursing
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14 347 care,[45] and weak lip strength is also associated with oral dryness as is the length of time spent
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16 348 opening the mouth. Dysphagia is associated with frailty.[46,47] Increased problems with oral
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18 349 function increase the need for nursing care and the risk of death, which can have a serious
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20 350 impact on the health status of older adults with poor oral function, consistent with previous
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22 351 research on the need to provide effective oral health care and reduce the burden of oral disease,
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24 352 as well as its impact on general health.[48]

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29 353 In this study, chewing hard food, choking, and thirst were evaluated. It is desirable to maintain
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31 354 these functions to reduce the future cost of care. It has been reported that bite and chewing
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33 355 strength related to difficulty in chewing hard foods, hyoid muscle related to swallowing, and
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35 356 xerostomia can be improved by functional training.[49-54] For patients with oral problems,
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37 357 early professional care and efforts to maintain oral function may help control future LTCI costs.
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39 358 Since oral function deterioration can also lead to dysphagia, it is hoped that in the future this
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41 359 will lead to a reduction in deaths from aspiration pneumonia, the leading cause of death in
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43 360 Japan.[34]

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48 361 Based on these results, we attempted to estimate the total cost savings in Japanese LTCI if
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50 362 these goals were achieved; 18.9% of all people in Table 1 had two or more oral problems. The
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52 363 difference in cumulative LTCI costs would be 477,000 USD for two functional declines or
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54 364 795,000 USD per year. Applying the results of this study, in a community of 10,000 elderly
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56 365 adults, 1,890 of them would have oral function impairment. The preservation of oral function

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4 366 could lower the individuals cost of care. In addition, 76.8% of those with oral dysfunction did
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6 367 not use long-term care services, even though they had oral dysfunction. Preventive intervention
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8 368 for those with oral function loss, who are not using services will prevent the risk of further
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10 369 functional decline and serious illness in the future.

13 370 **Strengths**

16 371 The strength of this study is that we analyzed merged individual data from questionnaires on
17
18 372 social life and public claim records as they pertain to long-term care services. More
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20 373 specifically, we used a large-scale dataset involving data from numerous municipalities.

23 374 **Limitations**

26 375 There are five limitations of this study. First, because this is a questionnaire survey, it does not
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28 376 capture the entire population of older people including those living at home. The study
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30 377 population was limited to older adults who were not certified as needing long-term care at the
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32 378 time of the survey; it was also limited to older adults who could be combined with the actual
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34 379 long-term care insurance benefits held by the government six years later. Second, the data in
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36 380 this study consisted of surveys conducted at the municipal level, where cooperation was
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38 381 obtained, and selection bias may exist. The data are biased due to a valid response rate of
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40 382 64.7%. Third, the follow-up period was only six years, which is far too short to reflect the
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42 383 lifetime cost of care. Future studies should incorporate a longer follow-up period. Fourth, the
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44 384 data are not adjusted for diseases. There may be confounding factors that were not taken into
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46 385 account in the analyses in this study. Fifth, our data did not take into account the type of health
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48 386 care services used. Depending on the services used, the patient may already be receiving
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50 387 professional care related to oral organ function. Future surveys should also analyze by type of
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52 388 service.

389 **Conclusions**

390 The degree of oral function in older people was found to be associated with cumulative LTCI
391 costs. The oral function of older people should be maintained to reduce future accumulated
392 LTCI costs. There was a difference in cumulative LTCI costs between those with preserved
393 oral function and those with declining oral function. Compared to those whose oral function
394 was maintained, those with oral function problems had approximately 4,000 to 8,000 USD
395 higher cumulative LTCI costs over six years. There was a maximum difference of
396 approximately 82,000 USD in long-term care service costs for those with oral function
397 problems. The more the oral function problems, larger the difference. Maintaining the oral
398 functions of older people may lead to a reduction in future accumulated LTCI costs.

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405 **Author contribution**

406 All authors contributed to the conception and design of this study. Data collection was
407 primarily conducted by MS, YM, EO, and TO. Analyses were performed by KK and supported
408 by MS, YM, EO, and TO. KK prepared the initial manuscript and MS, YM, EO, and TO
409 significantly contributed to revising it. All authors read and approved the final manuscript.

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Disclaimer

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Conflicts of interest

The authors have no competing interests to declare.

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4 433 **Patient consent for publication**

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7 434 Not required.

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10 435 **Institutional review board statement**

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12 436 This study was approved by the Ethics Committee on the Research of Human Subjects at Nihon
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14 437 Fukushima University (no. 10-05). This study was conducted through a collaborative research
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16 438 agreement with the associated municipalities. JAGES participants were informed that
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18 439 participation in the study was voluntary, and that completing and returning the questionnaire
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20 440 via mail indicated their consent to participate in the study. We obtained written informed
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22 441 consent from the participants.
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27 442 **Provenance and peer review**

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29 443 Not commissioned; externally peer reviewed.
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33 444 **Data availability statement**

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35 445 Data are not open for public due to ethical concerns. Data are from the JAGES study whose
36
37 446 authors may be contacted at data management committee: dataadmin@jages.net. The data set
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39 447 has ethical or legal restrictions because it includes human participants.
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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
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 <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	6,7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
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	7,8
Bias	9	Describe any efforts to address potential sources of bias	6,7
Study size	10	Explain how the study size was arrived at	6,7

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2	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
3			6,7,8
4			
5	Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
6			9
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9			(b) Describe any methods used to examine subgroups and interactions
10			9
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12			(c) Explain how missing data were addressed
13			9
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15			(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed
16			
17			<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed
18			
19			<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy
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23			(e) Describe any sensitivity analyses
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60**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	10
		(b) Give reasons for non-participation at each stage	
		(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	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	17
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	13
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
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	13,14
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	17

Discussion

Key results	18	Summarise key results with reference to study objectives	14
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	15,16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16,17
Generalisability	21	Discuss the generalisability (external validity) of the study results	18

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	20
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2 *Give information separately for cases and controls in case-control studies and, if applicable, for exposed and
3 unexposed groups in cohort and cross-sectional studies.
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7 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and
8 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely
9 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at
10 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is
11 available at www.strobe-statement.org.
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