


BMJ Open Oral function and cumulative long-term care costs among older Japanese adults: a prospective 6-year follow-up study of long care receipt data

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ABSTRACT

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

Design This was a prospective 6-year follow-up study of previous survey data.

Setting The data were obtained from the Japan Gerontological Evaluation Study conducted between 2010 and 2011.

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

Interventions Care service benefit costs were tracked over 6 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 at the time of the baseline survey. **Results** Tobit analysis revealed that, compared with 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 US\$4020, US\$4775 and US\$8292, respectively, over 6 years. Compared with those with maintained oral function, there was a maximum difference of approximately US\$8292 in long-term care service costs for those with oral function problems. With increase in number of oral function problems, there was a concomitant elevation in the cost of long-term care.

Conclusions Oral function in older people was associated with cumulative long-term care insurance costs. The oral function of older people should be maintained to reduce future accumulated long-term care insurance costs. Compared with those with maintained oral function, there was a maximum difference of approximately US\$8292 in long-term care service costs for those with oral function problems. The cost of long-term care was amplified as oral problems increased.

INTRODUCTION

Globally, life expectancy is increasing. In Japan, the need for long-term care services is unrelenting, with constant increase in

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The strength of this study is that it used a large-scale dataset involving data from numerous municipalities.
- ⇒ Because this was a questionnaire survey, it did not capture the entire population of older people living at home.
- ⇒ Selection bias may exist due to a valid response rate of 64.7%.
- ⇒ The follow-up period of 6 years was too short to reflect the lifetime cost of care.
- ⇒ The data were not adjusted for diseases and did not consider the type of healthcare service used.

the number of older people requiring long-term care, together with lengthening of the period during which care is needed.¹ Of the 35.55 million insured people aged ≥65 years, the number of those certified as requiring nursing care or support was 6.69 million in 2019 with the number continually growing.² One in four to five persons aged ≥65 years requires long-term care, and the related medical expenses in the fiscal year 2019 amounted to US\$270.629 billion. Additionally, the total number of long-term care insurance (LTCI) benefits in 2019 were reported to be 160.63 million, and the cost was US\$104.567 billion.³

Japan's LTCI system was established in 2000 as a system in which, the society as a whole supports the care of older adults. This insurance system provides benefits to those who need nursing care, and supports them by making appropriate services available to them. It aims to support physical independence, and reduce the burden on family members who provide care. The LTCI system consists of three parties: the insured, the insurer and the long-term care service provider. Municipalities act as insurers who administer the system, and all citizens aged



≥40 years are eligible to be insured. An insured person is one who subscribes to LTCI, and is eligible to receive long-term care services when he/she is certified as requiring it. If they are using the LTCI system, and are receiving long-term care services, they pay 10% of the cost at the counter (depending on income, the copayment can be up to 30%). The long-term care service provider company that provides the care services to the insured person, bills the insurer for the service cost, which the insured person receives from the insurer (municipality), except for the share to be paid by the insured person at the counter. This LTCI system is financed by public funds, and LTCI premiums. In total, the municipality and the insured person pay 50% each, for the LTCI premiums.⁴ The number of people insured by LTCI increased by 0.8% compared with 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.⁵ The insured's LTCI premiums were raised from US\$58.69 to 60.14 in 2021. This is a predicament that will lead to tightening of finances and household budgets.⁶

In older adults, an association between chewing and oral functions, overall health, physical fitness and mortality risk has been reported.⁷ Additionally, overall muscle strength declines with age. Along with other organs associated with the oral cavity, muscle fibre atrophy occur in the tongue with age.⁸ Furthermore, a decrease in overall body muscle mass affects mastication.⁷ The decline in physical function due to muscle weakness resulting from a decrease in skeletal muscle mass is referred to as sarcopenia.⁹ Poor oral function is associated with physical frailty and sarcopenia. Moreover, sarcopenia is also associated with dysphagia.¹⁰ The decline in eating function in old age is a cause of serious diseases, such as malnutrition, and is closely related to life expectancy.¹¹

It is presumed that older adults with decline in oral functions are likely to incur higher nursing care costs due to the greater use of services. Care-need prevention is important to reduce the cost of government LTCI benefits. Particularly, it is necessary to shift the emphasis to prevention for those who require light nursing care. Oral frailty¹² has been investigated recently, and evidence suggests that maintaining function from an early stage will help maintain oral function and, in the long run, prevent a decline in feeding and swallowing function.¹³

The association between oral function and healthcare costs has been reported.¹⁴⁻¹⁶ However, there are currently no reports on the cumulative cost of LTCI. This study aimed to elucidate the association between oral function and LTCI costs among older people based on claim records, through a questionnaire survey conducted among Japanese older adults living in several municipalities.

METHODS

Study sample

The baseline population data were acquired from a self-reported questionnaire survey of community-dwelling people aged ≥65 years, with no physical or cognitive disabilities, and not receiving long-term care. Our data were derived from the Japan Gerontological Evaluation Study (JAGES).^{17,18} At the time of the baseline survey, respondents were not certified as needing long-term care. As such, respondents resided in the community. The JAGES survey was done by collecting self-administered questionnaires, which were mailed to a random sample of functionally independent individuals aged ≥65 years, from 12 participating municipalities between August 2010 and January 2012. In total, 51 302 responses were received (valid response rate: 64.7%) and unknown sex and age was excluded. The study population was limited to older adults who were not certified as needing long-term care at the time of the survey; it was combined with the actual LTCI benefits held by the government 6 years later. We obtained claim records from a governmental database regarding public LTCI benefits over a period of 6 years for every month from the baseline survey. To ascertain the respondents' subsequent use of LTCIs, information on the actual insurance benefits provided by insurers, data on the certification of long-term care needs held by insurers, deaths and information on the imposition of LTCI premiums were collected in encrypted forms by the insurers. The provided data and questionnaire survey data were matched on an individual basis by the researcher based on the encrypted IDs to create a cohort data set for analysis. A total of 46 616 individuals (90.9% follow-up rate), excluding untraceable cases including in-migrants and out-migrants, were included in the analysis.

Outcome variables

The outcome variable was the cumulative cost of LTCI services during the follow-up period. Information regarding LTCI costs, or deaths was collected from the municipalities. In this analysis, we used the cumulative total of all service costs used during the follow-up period and all the costs for those who never received certification of need for assistance or care during the follow-up period, and those who died without using LTCI services were zero. Information regarding long-term care costs was ascertained based on the number-of-use points in the LTCI costs performance information, which was incorporated from the month the questionnaire survey was administered through November 2016. LTCI costs were ascertained for long-term care services using a similar follow-up period from August 2010 to November 2016.

Since the use of long-term care services is expected to be seasonally skewed, the analysis used a cumulative total of all service costs used during the follow-up period. The long-term care costs handled in this analysis are LTCI costs. The public LTCI do not include the cost of self-paid long-term care services not listed in the information on actual LTCI services. Costs for the purchase of

welfare equipment and home modification were also not included. The independent variable was the cumulative cost of LTCI benefits over 6 years. The respondents were divided into two groups based on cumulative costs: US\$0 and more USD. We used a currency exchange rate of JPY 100 to US\$1.

Explanatory variables

Explanatory variables were those related to oral function at the time of the baseline survey. In Japan, to assess whether a person is eligible for nursing care prevention services or LTCI services, use of the Kihon Checklist (KCL) has been recommended by the Ministry of Health, Labour and Welfare.¹⁹ The KCL was created by the Ministry of Health, Labour and Welfare in Japan to help people aged ≥ 65 years reflect on their lives and health status and check for any decline in their physical or mental functions.²⁰ It is used by the local governments, and in community consultations to screen for persons eligible for long-term care prevention programmes, and to assess the effectiveness of interventions. The KCL was automatically sent to all individuals ≥ 65 years on an annual basis up until 2014, but is now administered at the discretion of each local administration.²¹ The self-administered questionnaire consists of 25 questions on daily living, physical and mental functions which are answered with ‘yes’ or ‘no’ responses: five items each to evaluate activities related to daily living motor functions, and physical and mental functions; three items each to evaluate oral functions and cognitive functions; and two items each to evaluate low nutritional status and seclusion. The questionnaire group consists of questions in seven areas of depressive mood assessment. For each question, one point is added when a problem in daily functioning is considered to exist, and the higher the score, the more problems in daily functioning get recorded.²² The following three items related to oral function were used in this survey: ‘Do you find chewing hard food more difficult compared with half a year earlier?; Have you ever choked on tea or soup?; Are you bothered by a feeling of thirst?’. A response of yes to two or more of these was considered poor oral function and one yes or none was considered normal.^{23 24}

Covariates

Sex, age, educational attainment, household equivalised income and marital status at the time of the baseline survey were used as basic attributes to be considered when examining the association with the use of long-term care services. Regarding demographic attributes, age was divided into five groups: 65–69, 70–74, 75–79, 80–84 and ≥ 85 years, socioeconomic background was categorised per household equivalised income (<US\$20 thousand, US\$20–40 thousand, \geq US\$40 thousand). Household equivalised income was calculated by dividing the total income of the entire household by the square root of the number of household members. Educational attainment was assessed by <9, 9–12, >13 years of schooling. Life background, including marital status, was categorised

as currently married, or as not married. Household composition was classified as, yes or no with or without a cohabitant. Geriatric Depression Rating Scale (GDS),²⁵ activities of daily living (ADL) and smoking status were used as indicators of health status. The 15-item Geriatric Depression Scale (0–4 no depression, 5–10 mild depression and 11–15 severe depression) was used to evaluate depression.^{26–28} Smoking status was classified as no (never smoked, <4 years) and yes (≤ 4 years not smoking, still smoking). Missing values in the covariates were dummy coded and included as ‘Missing’ category in the analysis.

Statistical analyses

Descriptive statistics were sociodemographic variables and mean and percentages of LTCI costs over 6 years were stratified according to the two stratified groups: zero and more typology. Percentage comparisons were analysed using the χ^2 test. Next, the 6-year cumulative LTCI costs were used as the independent variable to evaluate the association with oral function. The analysis was conducted using the tobit model,^{29 30} taking into account that the independent variable was not normally distributed with a concentration in the zero circles. In the analysis, after initially analysing with the crude model, the adjustment variables were put in the following order. Age and sex were added to model 1, while physical factors (ADL, GDS, smoking), and socioeconomic background (years of education, marital status, household structure, equivalent income) were added to model 2. SEs were used to estimate regression coefficients. Statistical analyses were conducted using STATA SE V.15.1 (Stata Corp). The statistical significance level was set at $p < 0.05$. Accumulated care costs depend on the length of time care was needed. Therefore, the rates of those who were certified as needing care and those who died, and the number of days to get there, were calculated for each group in terms of the number of oral problems. Information such as the certification of the need for nursing care and the moving out of the country was provided by the insurer.

Patient and public involvement

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

RESULTS

The analysis showed that with zero expenses had an average age of 73.0 years, while those using care expenses had an average age of 79.2 years. The minimum cost was US\$5.00, the maximum cost was US\$235 536.90. **Table 1** shows the baseline characteristics of the respondents and the average cumulative LTCI cost. **Table 2** shows the Tobit regression differences in cumulative cost of LTCI services by number of



Table 1 Baseline characteristics of the participants and cumulative long-term care insurance costs. (n=46616)

Variables	Categories	Total		US\$0		US\$1 or more		mean	SE	95% CI of the mean	SD
		n	n	n	%	n	%				
Sex	Male	21585	18502	85.72	14.28	3083	14.28	18952.33	533.65	17905.92 to 19998.74	27590.35
	Female	25031	20766	82.96	17.04	4265	17.04	24819.77	542.73	23755.68 to 25883.86	32977.54
Age	65-69	13256	12712	95.90	4.10	544	4.10	18183.74	1333.29	15564.05 to 20803.44	29483.42
	70-74	13744	12582	91.55	8.45	1162	8.45	16788.02	853.48	15113.25 to 18462.78	27404.61
	75-79	10536	8584	81.47	18.53	1952	18.53	19843.02	690.84	18488.04 to 21198.01	28584.58
	80-84	6139	4005	65.24	34.76	2134	34.76	23925.24	735.67	22482.39 to 25368.10	31393.58
Oral function	85 and older	2941	1385	47.09	52.91	1556	52.91	29386.23	961.85	27499.29 to 31273.17	34839.83
	0.00	23298	20523	88.09	11.91	2775	11.91	22038.89	573.24	20914.88 to 23162.91	30180.78
	1.00	12178	10137	83.24	16.76	2041	16.76	22642.72	698.77	21272.34 to 24013.10	31560.89
Choked	2.00	4986	3902	78.26	21.74	1084	21.74	21148.40	885.64	19410.62 to 22886.19	29091.78
	3.00	1720	1245	72.38	27.62	475	27.62	25721.67	1671.76	22436.66 to 29006.67	36396.87
	No	36349	31160	85.72	14.28	5189	14.28	22501.65	434.98	21648.89 to 23354.41	30714.88
Difficulty in eating	Yes	7259	5728	78.91	21.09	1531	21.09	22103.65	862.06	20412.57 to 23794.73	32174.66
	Missing	24	16	66.67	33.33	8	33.33	7911.47	4794.59	-12717.99 to 28540.92	8304.47
Dry mouth	No	31670	27496	86.82	13.18	4174	13.18	21942.01	477.92	21005.02 to 22878.99	30245.05
	Yes	12156	9566	78.69	21.31	2590	21.31	23190.94	663.02	21890.78 to 24491.10	32311.67
Activities of daily living	Missing	11	9	81.82	18.18	2	18.18	25555.10	24512.30	-285903.20 to 337013.40	34665.63
	No	33482	28898	86.31	13.69	4584	13.69	22103.32	458.44	21204.56 to 23002.09	30783.74
Depressive symptoms	Yes	9374	7401	78.95	21.05	1973	21.05	23117.57	730.29	21685.29 to 24549.85	31580.48
	Missing	4	1	25.00	75.00	3	75.00	37865.47	33626.18	-106816.30 to 182547.23	58242.25
Smoking	Independent	44379	37784	85.14	14.86	6595	14.86	21497.68	394.90	20723.53 to 22271.82	30009.55
	Minimum assist	769	367	47.72	52.28	402	52.28	33386.73	2107.73	29241.06 to 37532.40	39149.44
Depressive symptoms	Assist	142	96	67.61	32.39	46	32.39	52744.22	10428.07	31633.68 to 73854.75	65123.31
	Missing	1305	1014	77.70	22.30	291	22.30	22182.71	1760.23	18712.23 to 25653.18	25264.02
Depressive symptoms	No depression	27474	24093	87.69	12.31	3381	12.31	20689.68	524.96	19660.37 to 21718.98	29067.64
	Mild depression	8196	6589	80.39	19.61	1607	19.61	23907.93	875.49	22190.53 to 25625.32	32932.83
Smoking	Depression	2721	2052	75.41	24.59	669	24.59	24857.99	1422.94	22063.24 to 27652.75	34268.90
	Missing	8225	6534	79.44	20.56	1691	20.56	23475.66	868.28	21772.27 to 25179.04	31354.46
Smoking	No	34788	29410	84.54	15.46	5378	15.46	22621.56	444.19	21750.74 to 23492.37	31258.05
	Yes	6952	5948	85.56	14.44	1004	14.44	20498.76	986.93	18561.88 to 22435.64	30032.53
Smoking	Missing	4876	3910	80.19	19.81	966	19.81	23183.46	1341.24	20548.12 to 25818.81	29598.54

Continued

Table 1 Continued

Variables	Total		US\$0		US\$1 or more		mean	SE	95% CI of the mean	SD
	n	%	n	%	n	%				
Marital status										
Married	32764	28632	87.39	4132	12.61	19436.49	473.92	18507.31 to 20365.68	28506.40	
Others	12684	9741	76.80	2943	23.20	26439.03	669.37	25126.47 to 27751.60	33761.73	
Missing	1168	895	76.63	273	23.37	23211.96	2153.29	18966.15 to 27457.77	30679.67	
Living arrangement										
Living with others	39644	33827	85.33	5817	14.67	21730.41	426.36	20894.56 to 22566.27	30397.54	
Living alone	6163	5441	88.28	1531	24.84	24835.00	921.89	23026.41 to 26643.58	33008.39	
Equivalent income										
Low	19176	16151	84.23	3025	15.77	22321.17	605.88	21133.14 to 23509.21	31318.70	
Middle	14462	12585	87.02	1877	12.98	21747.74	758.07	20260.87 to 23234.61	31062.52	
High	4117	3625	88.05	492	11.95	20363.70	1361.97	17687.00 to 23040.39	28763.09	
Missing	8861	6907	77.95	1954	22.05	23632.21	778.56	22105.09 to 25159.34	30829.37	
Education										
6–9 years	22235	18271	82.17	3964	17.83	23266.45	545.68	22196.56 to 24336.34	32037.63	
10–12 years	15182	13147	86.60	2035	13.40	20946.62	689.82	19593.68 to 22299.56	29217.84	
>13 years	7889	6917	87.68	972	12.32	19434.13	977.85	17514.89 to 21353.37	28726.15	
Missing	1310	933	71.22	377	28.78	29673.63	2083.82	25570.31 to 33776.94	33665.16	

oral problems. Table 3 shows the rate of those certified as requiring long-term care, mortality and days by the oral problem.

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 with persons with normal oral function, the model in which age, sex, social environment and physical factors were inputted, showed that costs for people with one oral function problem were (B=4020.35), two oral function problems (B=4775.48) and three oral function problems (B=8292.83), to be more than those with normal oral function.

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

DISCUSSION

This study is the first to examine the differences between the degree of oral function and associated cumulative LTCI costs. In examining cumulative LTCI costs over 6 years, our results indicated that cumulative LTCI costs were higher for those with oral function problems compared with those with maintained oral function. A difference of US\$4000–8200 in cumulative LTCI costs over 6 years was observed between those with maintained oral function and those with oral function problems. Further, higher number of oral function problems were associated with higher future LTCI costs.

The cost of care was found to be related to physical function, socioeconomic background and the care environment. Decline in ADL together with depression, as well as equivalent income, and years of education were also associated with the cost of care. In terms of marital status, costs were higher for those who were not married. Further, women were more likely to be in the higher cost group than men. This is consistent with another report that showed 34.0% of caregivers were male,¹ indicating that women use care services more when they required, which also indicates a problem in the caregiving environment.

**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	4020.35
		(8712.39 to 12 116.06)	(4909.64 to 8155.22)	(2348.95 to 5691.75)
	Two problems	18217.95	10 028.46	4775.48
		(15 986.76 to 20 449.15)	(7922.02 to 12 134.91)	(2569.12 to 6981.85)
	Three problems	28416.51	17 793.12	8292.83
(25 114.68 to 31 718.34)		(14 699.14 to 20 887.10)	(4999.92 to 11 585.74)	

US\$1=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, household structure.
 B, partial regression coefficient.

An analysis of the degree of oral function and 6-year cumulative LTCI costs in [table 2](#) shows a difference in cumulative LTCI costs for those with declining oral function compared with maintained oral function. As an explanation for this, an association between physical function and oral health has been reported in older people with impaired oral function. The number of chewable foods and bite strength has been associated with leg extension power and time spent standing on one leg,^{31 32} and the risk of falling is 2.5 times higher among those with 19 or fewer teeth compared with those with 20 or more teeth.³³

Oral function is also associated with mental function and dementia. Poor quality of life related to oral hygiene increases the risk of depressive symptoms among older people.³⁴ In terms of cognitive function, those with few teeth and no dentures have a 1.9 times higher likelihood of having dementia than those with 20 or more teeth.³⁵ Severe periodontitis, a possible cause of tooth loss, is associated with mild cognitive impairment.³⁶ As retained teeth decrease, the number of occlusal surfaces decreases. Low occlusal contact and consumption of soft foods are risk factors for Alzheimer's disease.³⁷ Regarding the association between frailty and oral function, older patients with frailty have significantly reduced oral function, which is associated with lower occlusal force, masseter muscle thickness and oral diadochokinesis rate.³⁸ A study on

older people in Japan demonstrated that one of the risk of requiring long-term care is frailty.³⁹ From these findings, it can be inferred that a decline in oral function is closely related to physical, mental and cognitive function and is a factor in the development of the need for long-term care. The risk of needing long-term care, and certification for requirement of long-term care are assumed to be associated with the use of long-term care services and thus, with the cumulative cost of LTCI costs.

However, in a similar study examining the association with cumulative LTCI costs, cumulative LTCI costs were US\$600 higher over 6 years (US\$100 per year) for those who were less physically active than for those who had normal physical active.²⁸ In addition, caregiving costs were US\$1200 lower over 6 years (US\$200 per year) for those who participated in social activities such as hobbies and sports groups, compared with those who did not.⁴⁰ These are certainly reasonable explanations for the results indicating an association of high cost with oral function decline, which is a risk of needing care, and high cost with oral function decline, which was US\$4000–8200 over 6 years (US\$670–1360 per year) for those whose function declined compared with those in whom oral function was maintained in the present study.

The cost per beneficiary per year in 2020 for the elderly in Japan was US\$2.09 million.⁴¹ There was a concomitant

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

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

increase in cost, with each increase in oral function problems. For those with one oral function problem, the cost increase was 19.3% of the total, it was 22.7% for those with two and 39.5% for those with three. When the cumulative long-term care costs during the follow-up period were analysed by oral function, it was found to affect the cost of long-term care services. People with good oral function may have a shorter duration of need for long-term care during the follow-up period.

Previous studies related to eating difficulties have also reported that fewer teeth and denture use are associated with mortality,^{42 43} and less foods can be chewed by those who require nursing care.³² Self-reported surveys have reported that mastication disorders are associated with an increased risk of mortality among older persons.⁴⁴ In a study related to oral dryness, it was reported that lip strength and lip dexterity are decreased in persons requiring nursing care,⁴⁵ 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.^{46 47} 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 healthcare and reduce the burden of oral disease, as well as its impact on general health.⁴⁸

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.^{49–54} 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.³⁴

Based on these results, we attempted to estimate the total cost savings in Japanese LTCI if these goals were achieved; 15.9% of all people in [table 1](#) had two or more oral problems. The difference in cumulative LTCI costs would be US\$4775 for two functional declines or US\$795 per year. Applying the results of this study, in a community of 10 000 elderly adults, 1890 of them would have oral function impairment. The preservation of oral function could lower the individual's cost of care. In addition, 76.8% of those with oral dysfunction did not use long-term care services, even though they had oral dysfunction. Preventive intervention for those with oral function loss, who are not using services will prevent the risk of further functional decline and serious illness in the future.

Strengths

The strength of this study is that we analysed merged individual data from questionnaires on social life and public

claim records as they pertain to long-term care services. More specifically, we used a large-scale dataset involving data from numerous municipalities.

Limitations

There are five limitations of this study. First, because this is a questionnaire survey, it does not capture the entire population of older people including those living at home. The study population was limited to older adults who were not certified as needing long-term care at the time of the survey; it was also limited to older adults who could be combined with the actual LTCI benefits held by the government 6 years later. Second, the data in this study consisted of surveys conducted at the municipal level, where cooperation was obtained, and selection bias may exist. The data are biased due to a valid response rate of 64.7%. Third, the follow-up period was only 6 years, which is far too short to reflect the lifetime cost of care. Future studies should incorporate a longer follow-up period. Fourth, the data are not adjusted for diseases. There may be confounding factors that were not taken into account in the analyses in this study. Fifth, our data did not take into account the type of healthcare services used. Depending on the services used, the patient may already be receiving professional care related to oral organ function. Future surveys should also analyse by type of service.

CONCLUSIONS

The degree of oral function in older people was found to be associated with cumulative LTCI costs. The oral function of older people should be maintained to reduce future accumulated LTCI costs. There was a difference in cumulative LTCI costs between those with preserved oral function and those with declining oral function. Compared with those whose oral function was maintained, those with oral function problems had approximately US\$4020–8292 higher cumulative LTCI costs over 6 years. There was a maximum difference of approximately US\$8292 in long-term care service costs for those with oral function problems. The more the oral function problems, larger the difference. Maintaining the oral functions of older people may lead to a reduction in future accumulated LTCI costs.

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REFERENCES

- Cabinet Office, Government of Japan. Chapter 1. Aging situation. In: *White paper on aging Society*, 2018. https://www8.cao.go.jp/kourei/whitepaper/w-2018/html/zenbun/s1_2_2.html.
- Ministry of Health, Labour and Welfare. Long-Term care insurance business status report. Available: <https://www.mhlw.go.jp/topics/kaigo/osirase/jigyo/19/> [Accessed 25 Nov 2022].
- Ministry of Health, Labour and Welfare. Overview of national medical expenses. n.d. Available: <https://www.mhlw.go.jp/toukei/saikin/hw/k-iryohi/19/index.html>
- Ministry of Health. Labour and welfare outline of long-term care insurance system. Available: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/kaigo_koureisha/gaiyo/index.html [Accessed 8 Nov 2022].
- Statistics Bureau of Japan. Population estimation. Available: <https://www.stat.go.jp/english/data/jinsui/tsuki/index.html2022>
- Ministry of Health, Labour and Welfare. About the first long-term care insurance premium and expected service amount, etc. during the 8th long-term care insurance business plan period. overview of 2020 statistics on actual conditions of long-term care costs. Available: <https://www.mhlw.go.jp/toukei/saikin/hw/kaigo/kyufu/20/index.html>
- Murakami M, Hirano H, Watanabe Y, *et al.* Relationship between chewing ability and sarcopenia in Japanese community-dwelling older adults. *Geriatr Gerontol Int* 2015;15:1007–12.
- Bässler R. Histopathology of different types of atrophy of the human tongue. *Pathol Res Pract* 1987;182:87–97.
- Chen L-K, Liu L-K, Woo J, *et al.* Sarcopenia in Asia: consensus report of the Asian Working group for sarcopenia. *J Am Med Dir Assoc* 2014;15:95–101.
- Fujishima I, Fujiu-Kurachi M, Arai H, *et al.* Sarcopenia and dysphagia: position paper by four professional organizations. *Geriatr Gerontol Int* 2019;19:91–7.
- Serra-Prat M, Palomera M, Gomez C, *et al.* Oropharyngeal dysphagia as a risk factor for malnutrition and lower respiratory tract infection in independently living older persons: a population-based prospective study. *Age Ageing* 2012;41:376–81.
- Tanaka T, Takahashi K, Hirano H, *et al.* Oral frailty as a risk factor for physical frailty and mortality in community-dwelling elderly. *J Gerontol A Biol Sci Med Sci* 2018;73:1661–7.
- Neelamana SK, Janakiram C. Characterizing the literature on validity and assessment tool of oral frailty: a systematic scoping review. *J Contemp Dent Pract* 2022;23:659–68.
- Thompson B, Cooney P, Lawrence H, *et al.* The potential oral health impact of cost barriers to dental care: findings from a Canadian population-based study. *BMC Oral Health* 2014;14:78.
- Nomura Y, Sato T, Kamoshida Y, *et al.* Prediction of health care costs by dental health care costs and periodontal status. *Appl Sci* 2020;10:3140.
- Münzenmayer MA, Mariño R, Hsueh A. Cost-Effectiveness of professional oral health care in Australian residential aged care facilities. *Gerodontology* 2019;36:107–17.
- World Health Organization Centre for Health development. Knowledge translation for healthy ageing: the Japan Gerontological evaluation study (JAGES). Available: https://extranet.who.int/kobe_centre/en/project-details/knowledge-translation-healthy-ageing-japan-gerontological-evaluation-study-jages. [Accessed 19 Nov 2022].
- Kondo K, Rosenberg M, World Health Organization.. Advancing universal health coverage through knowledge translation for healthy ageing: lessons learnt from the Japan gerontological evaluation study. World Health organization. License: CC BY-NC-SA 3.0 IGO, 2018. Available: <https://apps.who.int/iris/handle/10665/279010>
- Japanese Ministry of Health, Labour and Welfare. The basic checklist; Apr 2016. Available: <http://www.mhlw.go.jp/topics/kaigo/kaigi/051219/dl/2.pdf>
- Ministry of Health, Labour and Welfare. Guidelines for comprehensive projects for care Prevention and daily life support. Ministry of Health, Labour and Welfare; 2022. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj [cited Nov 6 2022]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.mhlw.go.jp/file/06-Seisakujouhou-12300000-Roukenkyoku/0000088276.pdf
- Arai H, Satake S. English translation of the Kihon checklist. *Geriatr Gerontol Int* 2015;15:518–9.
- Sewo Sampaio PY, Sampaio RAC, Yamada M, *et al.* Validation and translation of the Kihon checklist (frailty index) into Brazilian Portuguese. *Geriatr Gerontol Int* 2014;14:561–9.
- Kamegaya T, Yamaguchi H, Hayashi K. Evaluation by the Basic Checklist and the risk of 3 years incident long-term care insurance certification. *J Gen Fam Med* 2017;18:230–6.
- Fukutomi E, Okumiya K, Wada T, *et al.* Importance of cognitive assessment as part of the "Kihon Checklist" developed by the Japanese Ministry of Health, Labor and Welfare for prediction of frailty at a 2-year follow up. *Geriatr Gerontol Int* 2013;13:654–62.
- Yesavage JA, Brink TL, Rose TL, *et al.* Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res* 1982-1983;17:37–49.
- Hoyl MT, Alessi CA, Harker JO, *et al.* Development and testing of a five-item version of the geriatric depression scale. *J Am Geriatr Soc* 1999;47:873–8.
- Rinaldi P, Mecocci P, Benedetti C, *et al.* Validation of the five-item geriatric depression scale in elderly subjects in three different settings. *J Am Geriatr Soc* 2003;51:694–8.
- Hirai H, Saito M, Kondo N, *et al.* Physical activity and cumulative long-term care cost among older Japanese adults: a prospective study in JAGES. *Int J Environ Res Public Health* 2021;18:5004.
- Tobin J. Estimation of relationships for limited dependent variables. *Econometrica* 1958;26:24–36.
- Amemiya Y. Instrumental variable estimator for the nonlinear errors-in-variables model. *J Econom* 1985;28:273–89.
- Ansai T, Takata Y, Soh I, *et al.* Relationship between chewing ability and 4-year mortality in a cohort of 80-year-old Japanese people. *Oral Dis* 2007;13:214–9.
- Yamaga T, Yoshihara A, Ando Y, *et al.* Relationship between dental occlusion and physical fitness in an elderly population. *J Gerontol A Biol Sci Med Sci* 2002;57:M616–20.
- Yamamoto T, Kondo K, Misawa J, *et al.* Dental status and incident falls among older Japanese: a prospective cohort study. *BMJ Open* 2012;2:e001262.
- Rouxel P, Tsakos G, Chandola T, *et al.* Oral Health-A neglected aspect of subjective well-being in later life. *J Gerontol B Psychol Sci* 2018;73:382–6.
- Aida J, Kondo K, Hirai H, *et al.* Association between dental status and incident disability in an older Japanese population. *J Am Geriatr Soc* 2012;60:338–43.

- 36 Iwasaki M, Kimura Y, Ogawa H, *et al.* Periodontitis, periodontal inflammation, and mild cognitive impairment: a 5-year cohort study. *J Periodontol Res* 2019;54:233–40.
- 37 Popovac A, Čelebić A, Peršić S, *et al.* Oral health status and nutritional habits as predictors for developing Alzheimer's disease. *Med Princ Pract* 2021;30:448–54.
- 38 Watanabe Y, Hirano H, Arai H, *et al.* Relationship between frailty and oral function in community-dwelling elderly adults. *J Am Geriatr Soc* 2017;65:66–76.
- 39 Kitamura A, Seino S, Taniguchi Y, *et al.* Impact of lifestyle-related diseases and frailty on the incidence of loss of independence in Japanese community-dwelling older adults: a longitudinal study on aging and health in Kusatsu. *Nihon Kosho Eisei Zasshi* 2020;67:134–45.
- 40 Saito M, Kondo N, Aida J, *et al.* Differences in cumulative long-term care costs by community activities and employment: a prospective follow-up study of older Japanese adults. *Int J Environ Res Public Health* 2021;18:5414.
- 41 Ministry of Health, Labour and Welfare. Long-Term care, health and welfare services for the elderly, statistics on care costs at 2020. Available: <https://www.mhlw.go.jp/wp/hakusyo/kousei/20-2/kousei-data/siryou/sh1000.html>
- 42 Fukai K, Takiguchi T, Ando Y, *et al.* Mortality rates of community-residing adults with and without dentures. *Geriatr Gerontol Int* 2008;8:152–9.
- 43 Yoshida M, Morikawa H, Yoshikawa M, *et al.* Eight-Year mortality associated with dental occlusion and denture use in community-dwelling elderly persons. *Gerodontology* 2005;22:234–7.
- 44 Nakanishi N, Fukuda H, Takatorige T, *et al.* Relationship between self-assessed masticatory disability and 9-year mortality in a cohort of community-residing elderly people. *J Am Geriatr Soc* 2005;53:54–8.
- 45 Tamura F, Fukui T, Kikutani T, *et al.* Lip-closing function of elderly people during ingestion: comparison with young adults. *Int J Orofacial Myology* 2009;35:33–43.
- 46 Yang R-Y, Yang A-Y, Chen Y-C, *et al.* Association between dysphagia and frailty in older adults: a systematic review and meta-analysis. *Nutrients*. 2022;14:1812.
- 47 Baijens LWJ, Clavé P, Cras P, *et al.* European Society for Swallowing Disorders - European Union Geriatric Medicine Society white paper: oropharyngeal dysphagia as a geriatric syndrome. *Clin Interv Aging* 2016;11:1403–28.
- 48 Badewy R, Singh H, Quiñonez C, *et al.* Impact of poor oral health on community-dwelling seniors: a scoping review. *Health Serv Insights* 2021;14:1178632921989734.
- 49 Ibayashi H, Fujino Y, Pham T-M, *et al.* Intervention study of exercise program for oral function in healthy elderly people. *Tohoku J Exp Med* 2008;215:237–45.
- 50 Sakayori T, Maki Y, Ohkubo M, *et al.* Longitudinal evaluation of community support project to improve oral function in Japanese elderly. *Bull Tokyo Dent Coll* 2016;57:75–82.
- 51 Sakayori T, Maki Y, Hirata S, *et al.* Evaluation of a Japanese “Prevention of Long-term Care” project for the improvement in oral function in the high-risk elderly. *Geriatr Gerontol Int* 2013;13:451–7.
- 52 Hakuta C, Mori C, Ueno M, *et al.* Evaluation of an oral function promotion programme for the independent elderly in Japan. *Gerodontology* 2009;26:250–8.
- 53 Ohara Y, Yoshida N, Kono Y, *et al.* Effectiveness of an oral health educational program on community-dwelling older people with xerostomia. *Geriatr Gerontol Int* 2015;15:481–9.
- 54 Easterling C. Does an exercise aimed at improving swallow function have an effect on vocal function in the healthy elderly? *Dysphagia* 2008;23:317–26.