status in occupational classification [11,12]. However, little is known about the association between occupational classification and oral health status and oral health behavior in older people. Particularly, no studies have been conducted to investigate the association between agriculture/forestry/fishery workers and oral health in older people.

It is useful for public health decision making and formulating a public health program to identify a target population from the viewpoint of occupational classification. The purpose of this study was to examine the association of the longest job (the job being done for the longest time) with oral health status and oral health behavior using cross-sectional data from community-dwelling older Japanese people. As a life-course study showed that low childhood socioeconomic status has a long-lasting negative influence on adult health including oral health [13], educational attainment and current economic status were taken into consideration in the analyses.

Methods

Study population

Data from a cross-sectional study, collected as part of the Japan Gerontological Evaluation Study (JAGES) Project, an on-going Japanese prospective cohort study, were used for this study. JAGES aims to conduct empirical studies from gerontological and social epidemiological perspectives. The sample was restricted to those who did not already have a physical or cognitive disability, defined by not receiving public long-term care insurance benefits, at baseline. From July 2010 to January 2012, a mail survey, exceptionally collected by visit in one prefecture, was conducted in a random sample of 169,215 community-dwelling individuals aged 65 years or over residing in 31 municipalities in 12 prefectures in Japan.

The questionnaire on oral health status and oral health behavior was sent to a random sample of 46,009 subjects, of which 27,732 (60.3%) responded. All subjects in one municipality were excluded because the questions used in the present study were not included in the questionnaire. After excluding 4,541 subjects who did not answer about the longest job held, a total of 23,191 subjects (11,310 males and 11,881 females) aged 65 or older in 30 municipalities were included in the present study.

Outcome variables

Number of teeth, denture/bridge use and subjective oral health status were evaluated for oral health status, based on a self-administered questionnaire [14]. Respondents were asked to indicate the number of teeth as 20 or more, 10-19, 1-9 or 0. Denture/bridge use was ascertained by asking, "Do you use a denture or bridge?" with possible answers dichotomized into yes and no. Subjective oral health status was ascertained by asking, "How do you rate your oral health (teeth, gum and denture)?" with possible 4 grade answers dichotomized into good and poor.

Oral health behavior was evaluated based on dental visit for treatment and use of an interdental brush or a dental floss. Dental visit for treatment was ascertained by asking, "Did you visit a dentist for treatment (including adjustment of a denture) within 6 months?" with possible answers dichotomized into yes and no. Use of an interdental brush or a dental floss was ascertained by asking, "Do you use an interdental brush or dental floss?" with possible answers dichotomized into yes and no.

Explanatory variable

Information on the longest job held was used as an explanatory variable and ascertained by asking, "What was the job that you had done for most of your working life?" with possible answers of professional/technical, administrative, clerical, sales/service, skilled/labor, and agriculture/forestry/fishery workers, others and no occupation.

Covariates

Data on socio-demographics (sex, age, educational attainment, equivalent income) were obtained using a self-administered questionnaire and used as covariates. To adjust household income for household size, equivalent income was calculated by dividing the household income by the square root of the number of household members, and placed into one of seven categories (less than US$5,000, US$5,000-9,999, US$10,000-14,999, US$15,000-19,999, US$20,000-29,999, US$30,000-39,999, and US$4,000,000 or higher) (US$1 = 100 Japanese yen) [15].

Data on the number of dentists working in hospitals or clinics were obtained from the Survey of Physicians, Dentists and Pharmacists conducted by the Ministry of Health, Labour and Welfare, Japan in 2010. Data on population in 2010 and area of inhabitable land of each municipality (city, town or village) were obtained from the National Population Census Survey conducted by the Ministry of Internal Affairs and Communications, Japan. The number of dentists working in hospitals or clinics per 100,000 people (density of dentists) and population density were calculated for each municipality. The density of dentists was categorized into four groups (lowest, low middle, high middle, or highest) based on 25th, 50th, and 75th percentiles. Population density was categorized into four groups (metropolitan, urban, semi-urban, or rural-agricultural).

Analysis

The percentage of respondents with poor oral health status and poor oral health behavior were calculated for each longest job in each sex. Two-level (first level: individual, second level: municipality) multilevel Poisson regression models with random intercepts and fixed slopes

were used separately for males and females to calculate multilevel prevalence ratios (PRs) for the longest job after adjusting for age, educational attainment and equivalent income as individual-level variables and densities of dentists and population as municipality-level variables, with each variable of oral health status or oral health behavior as the outcome. In each model, subjects lacking a outcome variable were excluded from the analysis. However, covariates that included missing data were recorded by reassigning missing values to separate missing categories in order to maximize the number of subjects included in the statistical analysis and thereby maximize statistical power: data lacking information of educational attainment and equivalent income were included as "others or data missing" (the category of missing was combined with that of others) and "data missing" categories, respectively. Moreover, subjects with 20 or more teeth and those with 9 or less teeth were excluded in the models in which denture/bridge use and use of interdental brush/dental floss were used as outcome variables, respectively, because some subjects with 20 or more teeth and those with 9 or less teeth might not need to use denture/bridge and interdental brush/dental floss, respectively. All statistical analyses were performed using IBM SPSS Statistics 21 (International Business Machines Co., New York, NY, USA) and MLwiN 2.28 (Centre for Multilevel Modelling, University of Bristol, Bristol, UK).

Ethical considerations

A detailed explanation of the objectives of the JAGES was sent by mail along with the self-administered questionnaire. People who were willing to participate in the study voluntarily completed and mailed back the questionnaire. The JAGES protocol and its informed consent procedure were reviewed and approved by the Ethics Committee on Research of Human Subjects at Nihon Fukushi University.

Results

Distributions of the subjects in accordance with the longest job, age, educational attainment and equivalent income are shown in Table 1. In males, professional/technical workers (23.0%) followed by skilled/labor workers (20.9%) were most predominant; whereas, clerical workers (19.3%) followed by sales/service workers (18.9%) were most predominant among females. The percentage of female subjects having no occupation was 12.8%; however, that in males was 1.1%.

Percentages of subjects with poor oral health status and poor oral health behavior are shown in Table 2. The percentage of males having no occupation and agriculture/forestry/fishery job was the highest in poor oral health status and poor oral health behavior; whereas, those with administrative and clerical job were the lowest. Percentages of females having sales/service, agriculture/forestry/fishery job and no occupation were the highest in poor oral health status and poor oral health behavior; whereas, those having professional/technical, administrative and clerical job were the lowest.

Table 1 Distributions of the longest job, age, educational attainment and equivalent income in each sex

	Male		Female	
	N	%	N	%
Longest job				
Professional/technical	2,606	23.0	1,255	10.6
Administrative	1,305	11.5	142	1.2
Clerical	1,102	9.7	2,293	19.3
Sales/service	1,338	11.8	2,244	18.9
Skilled/labor	2,366	20.9	1,076	9.1
Agriculture/forestry/fishery	1,186	10.5	1,204	10.1
Others	1,280	11.3	2,152	18.1
No occupation	127	1.1	1,515	12.8
Age group (year old)				
65-69	3,148	27.8	3,249	27.3
70-74	3,407	30.1	3,496	29.4
75-79	2,562	22.7	2,596	21.9
80-84	1,498	13.2	1,582	13.3
85 or older	695	6.1	958	8.1
Educational attainment (year)				
Less than 6	279	2.5	519	4.4
6-9	4,739	41.9	5,462	46.0
10-12	3,625	32.1	4,041	34.0
13 or longer	2,483	22.0	1,590	13.4
Others or data missing	184	1.6	269	2.3
Equivalent income (US$)				
Less than 5,000	386	3.4	778	6.5
5,000-9,999	1,038	9.2	1,424	12.0
10,000-14,999	1,350	11.9	1,295	10.9
15,000-19,999	2,240	19.8	1,776	14.9
20,000-29,999	2,459	21.7	2,056	17.3
30,000-39,999	1,452	12.8	1,274	10.7
40,000 or higher	1,035	9.2	941	7.9
Data missing	1,350	11.9	2,337	19.7

Multilevel PRs of the longest job in each sex after adjusting for individual-level age, educational attainment and equivalent income, and municipality-level densities of dentists and population are shown in Table 3. Significantly high PRs for some kinds of longest jobs were observed in all variables of oral health status and all variables of oral health behavior except denture/bridge use and dental visit for treatment in females. Especially, agriculture/forestry/fishery workers showed significantly

Table 2 Total number of subjects for analyses and percentages of subjects with poor oral health status and poor oral health behavior according to the longest job in each sex

Longest job in each sex	Poor oral health status						Poor oral health behavior			
	Having 19 or less teeth		Denture/bridge non-user in subjects with 19 or less teeth		Subjective poor oral health		No dental visit for treatment		Interdental brush/ dental floss non-user in subjects with 10 or more teeth	
	N for analyses	%	N for analyses	%	N for analyses	%	N for analyses	%	N for analyses	%
Male										
Professional/technical	2,555	60.2	1,453	29.2	2,506	31.0	2,514	46.7	1,402	44.9
Administrative	1,281	57.5	701	25.8	1,256	24.5	1,269	40.7	755	43.8
Clerical	1,089	60.7	635	23.9	1,071	27.6	1,083	43.2	645	46.0
Sales/service	1,318	68.5	837	33.3	1,282	31.0	1,290	45.5	705	49.5
Skilled/labor	2,313	69.6	1,487	35.8	2,251	34.4	2,263	54.0	1,057	51.0
Agriculture/forestry/fishery	1,154	84.1	854	39.9	1,122	34.0	1,114	55.7	354	56.2
Others	1,238	71.1	787	40.2	1,200	33.2	1,201	51.9	536	53.7
No occupation	123	80.5	89	44.9	118	45.8	116	67.2	46	63.0
Total	11,071	66.8	6,843	33.1	10,806	31.3	10,850	48.7	5,500	48.4
Female										
Professional/technical	1,224	57.2	648	31.0	1,203	24.0	1,204	47.6	770	31.9
Administrative	132	68.9	82	29.3	132	22.0	132	50.8	57	28.1
Clerical	2,244	56.6	1,169	29.6	2,209	25.3	2,217	47.9	1,363	30.9
Sales/service	2,155	69.1	1,331	32.3	2,131	32.1	2,132	52.8	1,046	38.8
Skilled/labor	1,045	69.7	654	33.3	1,027	28.8	1,033	56.4	496	42.1
Agriculture/forestry/fishery	1,156	85.8	848	31.8	1,165	29.3	1,149	60.0	344	48.5
Others	2,084	74.5	1,366	34.8	2,042	29.8	2,036	55.0	865	44.3
No occupation	1,465	76.0	997	35.9	1,448	29.3	1,426	57.8	569	40.4
Total	11,505	69.0	7,095	32.7	11,357	28.4	11,329	53.3	5,510	37.7

higher PRs in having 19 or less teeth (1.15, 95% confidence interval (CI): 1.06 - 1.26), denture/bridge non-users in subjects with 19 or less teeth (1.18, 1.01 - 1.36) and interdental brush/dental floss non-user in subjects with 10 or more teeth (1.21, 1.03 - 1.43) in males, and having 19 or less teeth (1.21, 1.09 - 1.34) and interdental brush/dental floss non-user in subjects with 10 or more teeth (1.25, 1.02 - 1.53) in females.

The municipality-level density of dentists was significantly associated with subjective oral health and dental visit for treatment in females in the fully adjusted models. Subjects in municipalities with a lower density of dentists were less likely to have subjective poor oral health and visit dentists. Municipality-level population density was significantly associated with the number of teeth and dental visit for treatment in females. Subjects in municipalities with lower population density were less likely to have 20 or more teeth and visit dentists.

Discussion

The results of the present study showed that the longest job held was significantly associated with oral health status and oral health behavior in older Japanese people even after adjusting for individual-level age, educational attainment (childhood socioeconomic status) and equivalent income (current socioeconomic status) and municipality-level differences in densities of dentists and population (environment related to access to dental care). Especially, older people whose longest jobs were sales/service, skilled/labor, agriculture/forestry/fishery or others, or who had no occupation were more likely to have poor oral health status and poor oral health behavior compared to those whose longest jobs were professional/technical.

The results of present study agree with those of previous studies [11,12,16]. Studies in Japanese male workers aged 20-69 years showed that professional and office workers had better oral health including periodontal status and number of teeth than salespersons and service occupations [11,12]. A study from Denmark among 75-year-olds, in which the longest job held was categorized into unskilled workers, skilled workers, low managerials, high managerials and others, showed that unskilled workers had significantly higher odds ratios for having no or few teeth than high managerials and others after adjusting for

Table 3 Fully adjusted multilevel prevalence ratios for the longest job in each sex

Longest job in each sex	Poor oral health status						Poor oral health behavior			
	Having 19 or less teeth		Denture/bridge non-user in subjects with 19 or less teeth		Subjective poor oral health		No dental visit for treatment		Interdental brush/dental floss non-user in subjects with 10 or more teeth	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Male										
Administrative	1.01	(0.92-1.10)	1.00	(0.84-1.20)	0.85	(0.74-0.97)*	0.91	(0.82-1.01)	1.02	(0.89-1.17)
Clerical	1.02	(0.93-1.12)	0.88	(0.73-1.06)	0.92	(0.80-1.05)	0.94	(0.84-1.05)	1.04	(0.91-1.20)
Sales/service	1.11	(1.02-1.21)*	1.08	(0.93-1.26)	0.98	(0.86-1.10)	0.97	(0.88-1.07)	1.08	(0.95-1.24)
Skilled/labor	1.07	(1.00-1.15)	1.11	(0.98-1.27)	1.08	(0.98-1.20)	1.13	(1.04-1.23)**	1.08	(0.96-1.22)
Agriculture/forestry/fishery	1.15	(1.06-1.26)**	1.18	(1.01-1.36)*	1.10	(0.96-1.25)	1.10	(1.00-1.22)	1.21	(1.03-1.43)*
Others	1.07	(0.98-1.16)	1.23	(1.06-1.42)**	1.05	(0.93-1.18)	1.08	(0.97-1.19)	1.15	(0.99-1.32)
No occupation	1.09	(0.89-1.34)	1.31	(0.94-1.82)	1.41	(1.06-1.87)*	1.30	(1.03-1.64)*	1.32	(0.91-1.93)
Female										
Administrative	1.16	(0.93-1.45)	1.00	(0.66-1.54)	0.94	(0.64-1.38)	1.07	(0.83-1.39)	0.87	(0.53-1.45)
Clerical	1.01	(0.92-1.11)	0.99	(0.83-1.18)	1.06	(0.92-1.23)	1.04	(0.94-1.16)	0.97	(0.83-1.14)
Sales/service	1.15	(1.05-1.26)**	0.99	(0.84-1.18)	1.29	(1.12-1.48)***	1.06	(0.96-1.17)	1.15	(0.97-1.35)
Skilled/labor	1.10	(0.99-1.22)	1.00	(0.82-1.22)	1.13	(0.96-1.33)	1.10	(0.98-1.24)	1.14	(0.94-1.38)
Agriculture/forestry/fishery	1.21	(1.09-1.34)***	0.95	(0.79-1.15)	1.16	(0.99-1.37)	1.04	(0.93-1.17)	1.25	(1.02-1.53)*
Others	1.15	(1.05-1.26)**	1.03	(0.87-1.22)	1.18	(1.02-1.36)*	1.06	(0.96-1.18)	1.23	(1.05-1.46)*
No occupation	1.13	(1.03-1.25)*	1.11	(0.93-1.33)	1.19	(1.02-1.39)*	1.10	(0.99-1.23)	1.14	(0.94-1.37)

PR, prevalence ratio; CI, confidence interval.
Reference: professional/technical.
Adjusted for individual-level age, educational attainment and equivalent income, and municipality-level densities of dentists and population.
*:$P < 0.05$, **:$P < 0.01$, ***:$P < 0.001$.

income and education [16]. In addition to support the results of the previous studies, the present study added new findings including that agriculture/forestry/fishery job was one of the occupational classes associated with poor oral health status and poor oral health behavior.

Sex differences were observed in the association between the longest job held and some variables of oral health status and oral health behavior. However, no statistically significant differences in the longest job held were observed in denture/bridge use in females after adjusting for individual-level age, education and income, and municipality-level densities of dentists and population. A significant association was observed between low income and not using denture/bridge (data not shown). These results suggest that the difference in denture/bridge use was ascribed to differences in the present economic status but not the longest job in females. Denture/bridge treatment is covered by insurance in Japan; however, 10-30% of the treatment fee is out-of-pocket. Therefore, the financial aspect of dental treatment should be considered in order to reduce oral health inequalities especially in females.

There are several possible pathways between the longest job held and oral health status and oral health behavior. One possibility is that temporal accessibility to dental health care varies according to occupational classification. For example, professional workers could manage their schedule by themselves and could easily gain access to dental health care. However, sales/service and skilled/labor workers may have a lesser degree of time flexibility than professional workers. In addition to the time flexibility according to the longest job, present working situation according to the longest job may affect denture/bridge use and dental visit. The percentage of subjects who still work was highest in agriculture/forestry/fishery workers (47% for males, 36% for females). Because agriculture/forestry/fishery workers still work, they might have less chance to visit dentists and receive denture treatment.

A second possibility is that spatial accessibility differs among the job type. Agriculture/forestry/fishery workers live in rural areas. On the other hand, professional/technical workers live in urban areas. The density of dental clinics is higher in urban areas than rural areas in Japan, especially in the period when the study subjects were engaged in their longest job [17]. A study showed that the density of dentists was associated with having a regular dentist in Japan even where universal healthcare insurance covered dental care [18]. Fully adjusted models in the present study showed that densities of dentists and

population were significantly associated with some variables of oral health status and oral health behavior. As even after adjusting for densities of dentists and population, the longest job held was associated with oral health status, the longest job itself might be a significant determinant of oral health status.

The third possibility is that the perceived need of dental health varies according to job type. For example, professional/technical, administrative or clerical workers are more likely to pay attention to their appearance and speech, which are affected by the front teeth, than agriculture/forestry/fishery workers and people without an occupation. The fourth possibility is that the chance to participate in an oral health program and to obtain information of oral health varies among the longest jobs. Oral health programs including dental check-up are not mandated by law in Japan. Large companies have their own oral health program; however, small companies and small municipalities where agriculture/forestry/fishery workers live do not [19].

The strengths of the present study include large sample size, population-based sampling, and control for potential confounding factors. However, the present study also has a number of limitations. First, measurement of oral health status was based on self-report, not based on clinical examination. However, the validity and reliability of the self-reported number of teeth and denture-bridge use has been established by multiple studies and widely used in epidemiological surveys [20]. We have confirmed the validity of our questionnaire for oral health status [14]. Second, data on the longest job held were also obtained using a self-administered questionnaire. However, the validity of the measure was reported [21]. Third, duration spent in the longest job was unknown. For example, housewives who worked in a technical field for a year before marriage were counted as "technical workers" rather than no occupation even if the non-working period was longer than the working period. A further study considering the duration is needed to confirm the results of the present study. Fourth, the characteristics of the analyzed population might not represent that of the target population. Because demographic data on the target population were not obtained, we could not evaluate representativeness of the analyzed population. Our previous study, which was done in 2003 in one municipality using the same survey method (response rate: 55.5%), showed that people under the age of 80 and with middle to high levels of household income were more likely to respond to a questionnaire survey [22].

Conclusions

The longest job held was significantly associated with oral health status and oral health behavior in older Japanese people even after adjusting for individual-level age, educational attainment and equivalent income, and municipality-level densities of dentists and population. Especially, older people whose longest jobs were sales/service, skilled/labor, agriculture/forestry/fishery or others, or who had no occupation were more likely to have poor oral health status and poor oral health behavior compared to those whose longest jobs were professional/technical. These results suggest that intervention in people whose jobs were sales/service, skilled/labor, agriculture/forestry/fishery or others, or who had no occupation may help reduce inequality in oral health due to job classification.

Abbreviations

JAGES: Japan Gerontological Evaluation Study; PR: Prevalence ratio; CI: Confidence interval.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

TY conceived the idea for the study, participated in its design, performed the statistical analysis and drafted the manuscript as the principal author. KK is the principal investigator of the JAGES project, helped to develop the idea of the study, participated in acquiring the data and the study design, and edited the manuscript. JA participated in data acquisition and study design and critically revised the manuscript. SF helped with data analysis and critically revised the manuscript. YH helped to develop the idea of the study, participated in the study design, and edited the manuscript. All authors read and approved the final manuscript.

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References

1. Tsakos G: **Inequalities in oral health of the elderly: rising to the public health challenge?** *J Dent Res* 2011, **90**:689–690.
2. Tsakos G, Sheiham A, Iliffe S, Kharicha K, Harari D, Swift CG, Gillman G, Stuck AE: **The impact of educational level on oral health-related quality of life in older people in London.** *Eur J Oral Sci* 2009, **117**:286–292.
3. Tsakos G, Demakakos P, Breeze E, Watt RG: **Social gradients in oral health in older adults: findings from the English longitudinal survey of aging.** *Am J Public Health* 2011, **101**:1892–1899.
4. Listl S: **Income-related inequalities in dental service utilization by Europeans aged 50+.** *J Dent Res* 2011, **90**:717–723.
5. Ben-Shlomo Y, Kuh D: **A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives.** *Int J Epidemiol* 2002, **31**:285–293.
6. Aoyama H, Ando Y, Hanada N: **The receiving rate of oral examination for periodontitis based on the health law for elderly.** *Health Sci Health Care* 2004, **4**:42–43 (in Japanese).

7. Kimura H, Goda K, Takeda N, Hirao T, Fukunaga I, Kageyama H, Jitsunari F: **Oral health promotion in the workplace and relative factors.** *J Dent Hlth* 2001, **51**:37–47 (in Japanese).
8. Miravitlles M, Naberan K, Cantoni J, Azpeitia A: **Socioeconomic status and health-related quality of life of patients with chronic obstructive pulmonary disease.** *Respiration* 2011, **82**:402–408.
9. Nash SD, Cruickshanks KJ, Klein R, Klein BE, Nieto FJ, Ryff CD, Krantz EM, Shubert CR, Nondahl DM, Acher CW: **Socioeconomic status and subclinical atherosclerosis in older adults.** *Prev Med* 2011, **52**:208–212.
10. Lacey RJ, Belcher J, Croft PR: **Does life course socio-economic position influence chronic disabling pain in older adults? A general population study.** *Eur J Public Health* 2013, **23**:534–540.
11. Morita I, Nakagaki H, Yoshii S, Tsuboi S, Hayashizaki J, Mizuno K, Sheiham A: **Is there a gradient by job classification in dental status in Japanese men?** *Eur J Oral Sci* 2007, **115**:275–279.
12. Morita I, Nakagaki H, Yoshii S, Tsuboi S, Hayashizaki J, Igo J, Mizuno K, Sheiham A: **Gradients in periodontal status in Japanese employed males.** *J Clin Periodontol* 2007, **34**:952–956.
13. Poulton R, Caspi A, Milne BJ, Thomson WM, Taylor A, Sears MR, Moffitt TE: **Association between children's experience of socioeconomic disadvantage and adult health: a life-course study.** *Lancet* 2002, **360**:1640–1645.
14. Yamamoto T, Kondo K, Fuchida S, Aida J, Nakade M, Hirata Y: **Validity of self-reported oral health variables: Aichi Gerontological Evaluation Study (AGES) project.** *Health Sci Health Care* 2012, **12**:4–12 (in Japanese).
15. Matsuyama Y, Aida J, Takeuchi K, Tsakos G, Watt RG, Kondo K, Osaka K: **Inequalities of dental prosthesis use under universal healthcare insurance.** *Community Dent Oral Epidemiol* 2014, **42**:122–128.
16. Avlund K, Holstein BE, Osler M, Damsgaard MT, Holm-Pedersen P, Rasmussen NK: **Social position and health in old age: the relevance of different indicators of social position.** *Scand J Public Health* 2003, **31**:126–136.
17. Okawa Y, Hirata S, Okada M, Ishii T: **Geographic distribution of dentists in Japan: 1980-2000.** *J Public Health Dent* 2011, **71**:236–240.
18. Hanibuchi T, Aida J, Nakade M, Hirai H, Kondo K: **Geographical accessibility to dental care in the Japanese elderly.** *Community Dent Health* 2011, **28**:128–135.
19. Ishii M, Komatsuzaki A, Suetaka T, Iida H: **Relations between dental care expenses and dental health services carried out by health insurance associations.** *Jpn J Dent Pract Admin* 1999, **34**:58–66 (in Japanese).
20. Pitiphat W, Garcia RI, Douglass CW, Joshipura KJ: **Validation of self reported oral health measures.** *J Public Health Dent* 2002, **62**:122–128.
21. Lacey RJ, Belcher J, Croft PR: **Validity of two simple measures for estimating life-course socio-economic position in cross-sectional postal survey data in an older population: results from the North Staffordshire Osteoarthritis Project (NorStOP).** *BMC Med Res Methodol* 2012, **12**:88.
22. Suemori K: **Tendency to non-response.** In *Health Inequalities in Japan: An Empirical Study of Older People.* Edited by Kondo K. Melbourne, Australia: Trans Pacific Press; 2010:222.

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手段的日常生活活動低下者割合の市町村格差は存在するのか−JAGES プロジェクト−

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要旨

地域づくりによる介謎予防戦略の開発に向け，地域在住高齢者の IADL 低下者割合などの市町村間格差とその関連要因を検討した. 日本老年学的評価研究データを用い, 88,370 名（53 市区町村）を対象に，老研式活動能力指標 IADL 5 項目いずれかの非自立者割合と関連要因の地域相関分析を行った．前期高齢者の IADL 低下者割合は市区町村問で 7.9〜23.2%の差があり，関連しうる心理社会的指標など多指標でも 2〜17 倍の差があった．特に女性でスポーツや趣味の会への参加者割合が高い市町村は IADL 低下者割合が低いという負の関連を認めた．今後多面的な検証は必要だが，作業療法が重視する趣味や集団活動を促す地域づくりが，介護予防に寄与すると考えられた.

キーワード ： 介護予防，IADL,（地域在住高齢者）

高齢者の外出行動と社会的・余暇的活動における性差と地域差　JAGES プロジェクトから

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［目的］ 生きがいや社会的活動参加の促進を通じた高齢者の健康づくりには性差や地域差への考慮が重要とされる。しかしこれらの活動における性差や地域差の現状は十分明らかとはいえない。本研究では高齢者の外出行動と社会的・余暇的活動の性差と地域差を検討した。

［方法］ Japan Gerontological Evaluation Study (JAGES) プロジェクトが 2010 年～ 2012 年に実施した，全国 31 自治体の要介護認定非該当 65 歳以上男女への郵送自記式質問紙調査データから 103,621 人を分析対象とした。分析項目は，週 1 日以上の外出有無，就労有無，団体・会への参加有無および月 1 回以上の参加者無，友人・知人との交流有無および月 1 回以上の交流有無，趣味の有無を測定した。性，年齢階級（65 歳以上 75 歳未満，75 歳以上），および地域特性として都市度（大都市地域，都市的地域，郡部的地域）を用いた。年齢階級別の性差および地域差の分析にはカイ二乗検定を実施した。さらに実年齢や就学年数，抑うつ傾向等の影響を調整するロジスティック回帰分析を行った（有意水準 1%）。また趣味や参加する団体・会についてはその具体的内容を記述的に示した。

［結果］ 年齢階級別の多変量解析の結果，男性は有意に週 1 回以上の外出や就労，趣味活動が多く，関体・会への参加や友人・知人との交流は少なかった。ほとんどの活動項目で都市度間に有意差が認められ，郡部的地域と比較して大都市地域では週 1 回以上外出のオッズ比が約 2.3 と高い一方，友人との交流のオッズ比は後期高齢者で約 0.4，後期高齢者で約 0.5 であった。性や都市度に共通して趣味の会の加入は多い一方，前期高齢者では町内会，後期高齢者では老人クラブの都市度差が大きく，実施割合に 30%程度の差がみられた。趣味についても同様に散歩・ジョギングや園芸は性や都市度によらず実施割合が高いが，パソコンや体操・太極拳は性差が大きく，作物の栽培は地域差が大きかった。

［結論］ 本研究から，①外出行動や社会的・余暇的活動のほとんどに性差や都市度差が観察され，それらのパターンが活動の種類によって異なること，②参加する団体・会や趣味の内容には男女や都市度に共通するものと，性差や都市度差の大きいものがあることが明らかになった。以上の特徴を踏まえた高齢者の活動推進のための具体的手法開発が重要であることが示唆された。

キーワード： 高齢者，性差，地域差，社会的活動，余暇的活動，外出行動

OPEN

Laughter and Subjective Health Among Community-Dwelling Older People in Japan

Cross-Sectional Analysis of the Japan Gerontological Evaluation Study Cohort Data

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Abstract: The aim of this study was to evaluate the association of laughter with subjective health independent of socioeconomic status and social participation among older people in Japan. We used the data of 26,368 individuals (men, 12,174; women, 14,194) 65 years or older who participated in the Japan Gerontological Evaluation Study (JAGES) in 2013. Participants provided information on laughter and self-rated health, depression, socioeconomic, and psychosocial factors. We evaluated laughter from three perspectives: frequency, opportunities, and interpersonal interactions. Even after adjustment for depression, sociodemographic factors, and social participation, the prevalence ratio for poor subjective health among women who never or almost never laugh was 1.78 (95% confidence interval, 1.48–2.15) compared with those who reported laughing every day. Similar associations were observed among men. Laughter may be an important factor for the promotion of general and mental health of older adults. The mechanisms linking laughter and health warrant further study.

Key Words: Laughter, subjective health, depression, social participation, Japan

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Previous studies have suggested that laughter has various health benefits, such as boosting immunity (Sakai et al., 2013), reducing depressive symptom (Hirsch et al., 2010), lowering blood pressure (Dolgoff-Kaspar et al., 2012), and preventing cognitive decline (Takeda et al., 2010). Laughter has been incorporated in complimentary medicine. Laughter yoga has been shown to be feasible in the hemodialysis context, and patients reported decreased fatigue, pain relief and improved communication (Bennett et al., 2014). The Smile-Sun technique, a set of positive verbal and nonverbal communication techniques using positive humor, has been applied in cancer patients to boost immunity (Sakai et al., 2013). Laughter also improves glycemic control among diabetes patients (Bennett et al., 2014). However, most of the previous studies did not generalize beyond the boundaries of the hospital and clinic, and very few were able to examine the impact of laughter on health in daily life or in the social context.

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Laughter has been found to occur most frequently during casual conversation (Provine, 1993), and laughter usually occurs when one encounters a meaningful interpretation of some stimulus or event that is different from which was initially assumed (Ramachandran, 1998). The frequency of laughter likely varies according to one's character and social background. That is, the frequency and opportunities for laughter can vary according to one's life situation, especially socioeconomic status and degree of social participation, and these factors could confound the effect of laughter on health, but this theory has yet to be examined.

Hasan and Hasan (2009) conducted a study among patients from India and Canada to characterize the frequency of laughter that was beneficial or detrimental to health. Among participants in India, a moderate level of laughter was found to be beneficial, whereas both low and high levels had no effect. Laughter was associated with emotional well-being and life satisfaction. In other words, frequency of laughing and the way of laughter influence health differently from environments.

To our knowledge, no studies have been conducted on the relationship between laughter and health, taking account of people's socioeconomic background and degree of social participation. Socioeconomic status and social participation can be considered common previous causes (*i.e.*, confounders) of the association between laughter and health. We therefore set out to examine the relationship between laughter and subjective health adjusting for socioeconomic factors and social participation, evaluating laughter from three perspectives: frequency, number of opportunities, and laughing in interpersonal interactions.

METHODS

Study Sample

The present study is based on the Japan Gerontological Evaluation Study (JAGES). The JAGES cohort was established in 2010 to investigate factors associated with subjective and objective health among noninstitutionalized individuals 65 years or older. The cohort covers 30 municipalities in Japan. We used the 2013 wave of JAGES, where self-reported questionnaires were mailed to 195,290 community-dwelling individuals 65 years or older. Of those, 138,294 individuals responded to the survey (response rate, 70.8%). Aside from basic questions, there were five modules of the survey covering different topics—module A: nursing care, medical care, and lifestyles; module B: oral hygiene, optimism, subjective health; module C: social capital, history of abuse; module D: subjective quality of life, sleep, cognitive function; module E: physical activity. We used module B, which includes questions about laughter. Respondents to module B were composed of 12,174 men and 14,194 women. We excluded 5968 subjects (men, 2202; women, 3766) with missing information on subjective health status, frequency

TABLE 1. Characteristics of the Subjects by Sex

	Men	Women
Poor subjective health	1892 (19.0)	1627 (15.6)
GDS score ≥ 5	1513 (15.2)	1623 (15.6)
Frequency of laughing in 4 wks (days)		
Almost every day	3762 (37.7)	5070 (48.6)
1–5 days per week	3754 (37.6)	3877 (37.2)
1–3 days per month	1463 (14.7)	935 (9.0)
Never or almost never	993 (10.0)	546 (5.2)
Number of opportunities of laughing		
Median [25%, 75%]	2 [1, 3]	3 [2, 4]
4+	2088 (20.9)	2892 (27.7)
2–3	5122 (51.4)	5508 (52.8)
0–1	2762 (27.7)	2028 (19.4)
Number of opportunities for laughing in interpersonal interactions (times)		
3	1734 (17.4)	1813 (17.4)
2	2825 (28.3)	3750 (36.0)
1	3610 (36.2)	3742 (35.9)
0	1803 (18.1)	1123 (10.8)
Frequency of social participation per 48 wks (times)		
Median [25%, 75%]	24 [0, 102]	24 [0, 138]
First quartile (men: 0 times, women: 0 times)	2270 (22.8)	2238 (21.5)
Second quartile (men: 1–24 times, women: 1–24 times)	2041 (20.5)	1581 (15.2)
Third quartile (men: 25–102 times, women: 24–138 times)	1739 (17.4)	1906 (18.3)
Fourth quartile (men: >102 times, women: >138 times)	2010 (20.2)	1859 (17.8)
Missing data	1912 (19.2)	2844 (27.3)
Age, yrs		
65–69	3124 (31.3)	3095 (29.7)
70–74	3024 (30.3)	3252 (31.2)
75–79	2137 (21.4)	2199 (21.1)
80+	1687 (16.9)	1882 (18.0)
Mean (SD)	73.36 (6.00)	73.62 (6.14)
Educational attainment		
≥10 yrs	6339 (63.6)	5979 (57.3)
<10 yrs	3633 (36.4)	4449 (42.7)
Missing data	55 (0.6)	94 (0.9)
Longest jobs		
Professionals, managers	3665 (36.8)	1091 (10.5)
Clerks, services, engineers	4103 (41.1)	5117 (49.1)
Agricultures, forestries, fisheries, self-employed, other	1623 (16.3)	2153 (20.6)
No jobs	50 (0.5)	935 (9.0)
Missing data	531 (5.3)	1132 (10.9)
Marital status		
Married	8586 (86.1)	6261 (60.0)
Bereaved	732 (7.3)	3275 (31.4)
Divorced	254 (2.5)	416 (4.0)
Never married	201 (2.0)	215 (2.1)
Other	95 (1.0)	74 (0.7)
Missing data	104 (1.0)	187 (1.8)
Equivalent family income (10,000 yen)		
Continuous (yen, log transformed), mean (SD)	14.54 (0.65)	14.41 (0.76)
First quintile (men: 8.84–129.90, women: 8.84–123.74)	1771 (17.8)	1666 (16.0)
Second quintile (men: 129.90–194.45, women: 123.74–175.00)	1687 (16.9)	1695 (16.3)
Third quintile (men: 194.45–247.49, women: 175.00–245.97)	1544 (15.5)	1746 (16.7)

(Continued on next page)

TABLE 1. *(Continued)*

	Men	Women
Fourth quintile (men: 247.49–318.20, women: 245.97–318.20)	1769 (17.7)	1476 (14.2)
Fifth quintile (men: >318.20, women: >318.20)	2229 (22.4)	1961 (18.8)
Missing data	972 (9.7)	1884 (18.1)

Data are presented as *n* (%), unless otherwise indicated.

Poor subjective health: measured by the question "How about your present health status? (responses: very good, good, bad, very bad). "Very bad" and "bad" were categorized as bad subjective health.

Number of opportunities of laughing: the number of opportunities when participants often laugh. Participants chose from eight opportunities (conversations with friends, conversations with your partner, conversations with your children and grandchildren, watching TV and videos, listening to radios, watching comic storytellings and plays, reading comics and magazines, other), and multiple answers were allowed.

Number of opportunities for laughing in interpersonal interactions: conversations with friends, conversations with you partner and conversations with children and grandchildren.

of laughing, depression (the short form of Geriatric Depression Scale [GDS]), number of opportunities of laughing, sex, or age.

Poor Subjective Health

Our outcome variable was poor self-rated health, assessed by the standard single-item question "How would you rate your present health status? (responses: very good, good, bad, very bad)"; "very bad" and "bad" were categorized as poor subjective health.

Laughter

We analyzed three types of variables related to laughter: frequency of laughing, number of opportunities for laughter, and laughing during interpersonal interactions. Respondents were asked to check up to eight different opportunities for laughing: during conversations with friends, conversations with a partner, conversations with children and grandchildren, watching TV and videos, listening to the radio, watching comic storytellings and plays, reading comics and magazines, and other. Three possible responses were given for laughing during interpersonal interactions: conversations with friends, conversations with a partner, and conversations with children and grandchildren.

Covariates

We controlled for age, sex, marital status, education, occupation, equivalized household income, depressive symptoms, and social participation. For the evaluation of depressive moods, the 15-item GDS (GDS-15) was used. The GDS-15 is a 15-item questionnaire, with a score range from 1 to 15. Higher scores indicate more depressive symptomatology. Following previous studies, we used 5 as the cutoff score for indicating moderate to severe psychological distress (Wongpakaran et al., 2013). For the evaluation of depressive moods, we measured frequency of social participations by summing up the number of opportunities per year one participated in social activities and groups. We divided them into four quartiles and used the first quartile as the reference category.

Statistical Analysis

Poisson regression model was used to calculate the prevalence ratio (PR) for poor subjective health by frequency of laughing. In model 1, we controlled for the number of opportunities for laughter. In model 2, depressive symptoms was added as a potential confounder. In model 3, demographic variables (age, sex, marital status) were added to the variables in model 2. In model 4, socioeconomic variables (education, occupation, and equivalized household income) were added to the variables in model 3. In the final model 5, social participation (frequency of social participation per year) was added to the variables in model 4. In models 6 to 10, we repeated the same sequence of analyses as models 1 to 5, except we switched "number of opportunities for laughter" with "number of opportunities for laughter during interpersonal interactions" as a covariate. R 3.1.0 was used for statistical analysis, with a two-tailed significance level set at 5%.

RESULTS

Baseline characteristics are shown in Table 1. Women tend to laugh more frequently as well as to report a higher number of opportunities for laughter, compared with men. The prevalence of poor subjective health and depression according to participants' characteristics are shown in Table 2. We paid particular attention to statistically controlling for depressive symptoms, given the possibility that absence of laughter could be a symptom of depression.

The results of Poisson regression models linking laughter and poor subjective health are shown in Tables 3 and 4. Subjective health was associated with occupation, marital status, and household income in men. For women, in model 1, we found an association between frequency of laughter and poor self-rated health. The PR comparing the bottom to top category of frequency was 3.80 (95% confidence interval [CI], 3.24–4.46). With the successive addition of covariates (across models 2–5, as well as from models 6–10), the PR became more attenuated. Nonetheless, even in the fully adjusted models (models 5 and 10), we found significant associations between frequency of laughter and self-rated health. For women, in model 5, the PRs of poor self-rated health were 1.78 (1.48–2.15) for laughing never or almost never and 1.39 (1.17–1.66) for none to one opportunity of laughing. We found similar tendencies, albeit somewhat weaker associations, among men.

In a subanalysis, we did the same analysis, except we switched subjective health with depression as the objective variable. There were stronger relationships between laughing and depression in both men and women. For women, in model 4, where we controlled all the covariates, the PRs were 3.61 (3.02–4.31).

DISCUSSION

The purpose of the present study was to investigate the effects of laughter on self-rated health after carefully controlling for potential confounders. The results of the study showed that frequency of laughing is significantly related to subjective health. Although some categories

TABLE 2. Prevalence of Poor Subjective Health and Depression by Participants' Characteristics

	Sum of Each		Poor Subjective Health		Depression	
	Men	Women	Men	Women	Men	Women
Depression						
GDS score ≥ 5	1513	1623	715 (47.3%)	648 (39.9%)		
GDS score < 5	8459	8805	1177 (13.9%)	979 (11.1%)		
Frequency of laughing in 4 wks (days)						
Almost every day	3762	5070	482 (12.8%)	518 (10.2%)	281 (7.5%)	391 (7.7%)
1–5 days per week	3754	3877	679 (18.1%)	658 (17.0%)	494 (13.2%)	665 (17.2%)
1–3 days per month	1463	935	349 (23.9%)	239 (25.6%)	319 (21.8%)	295 (31.6%)
Never or almost never	993	546	382 (38.5%)	212 (38.8%)	419 (42.2%)	272 (49.8%)
Number of opportunities of laughing						
≥4	2088	2892	266 (12.7%)	249 (8.6%)	136 (6.5%)	204 (7.1%)
2–3	5122	5508	856 (16.7%)	877 (15.9%)	672 (13.1%)	810 (14.7%)
0–1	2762	2028	770 (27.9%)	501 (24.7%)	705 (25.5%)	609 (30.0%)
Number of opportunities for laughing in interpersonal interactions						
3	1734	1813	206 (11.9%)	140 (7.7%)	110 (6.3%)	101 (5.6%)
2	2825	3750	440 (15.6%)	455 (12.1%)	274 (9.7%)	413 (11.0%)
1	3610	3742	686 (19.0%)	700 (18.7%)	584 (16.2%)	696 (18.6%)
0	1803	1123	560 (31.1%)	332 (29.6%)	545 (30.2%)	413 (36.8%)
Social participation per year						
First quartile (men: 0 times, women: 0 times)	2270	2238	649 (28.6%)	571 (25.5%)	571 (25.2%)	589 (26.3%)
Second quartile (men: 1–24 times, women: 1–24 times)	2041	1581	386 (18.9%)	257 (16.3%)	327 (16.0%)	280 (17.7%)
Third quartile (men: 25–102 times, women: 24–138 times)	1739	1906	269 (15.5%)	235 (12.3%)	186 (10.7%)	212 (11.1%)
Fourth quartile (men: >102 times, women: >138 times)	2010	1859	228 (11.3%)	150 (8.1%)	154 (7.7%)	153 (8.2%)
Missing data	1912	2844	360 (18.8%)	414 (14.6%)	275 (14.4%)	389 (13.7%)
Age, yrs						
65–69	3124	3095	455 (14.6%)	331 (10.7%)	414 (13.3%)	404 (13.1%)
70–74	3024	3252	493 (16.3%)	438 (13.5%)	420 (13.9%)	458 (14.1%)
75–79	2137	2199	519 (24.3%)	408 (18.6%)	353 (16.5%)	362 (16.5%)
≥80	1687	1882	425 (25.2%)	450 (23.9%)	326 (19.3%)	399 (21.2%)
Educational attainment						
≥10 yrs	6339	5979	1042 (16.4%)	763 (12.8%)	779 (12.3%)	755 (12.6%)
<10 yrs	3633	4449	850 (23.4%)	864 (19.4%)	734 (20.2%)	868 (19.5%)
Missing data	55	94	11 (20.0%)	16 (17.0%)	13 (23.6%)	23 (24.5%)
Longest jobs						
Professionals, managers	3665	1091	579 (15.8%)	138 (12.6%)	440 (12.0%)	129 (11.8%)
Clerks, services, engineers	4103	5117	830 (20.2%)	710 (13.9%)	637 (15.5%)	751 (14.7%)
Agricultures, forestries, fisheries, self-employed, other	1623	2153	345 (21.3%)	417 (19.4%)	314 (19.3%)	393 (18.3%)
No jobs	50	935	15 (30.0%)	175 (18.7%)	17 (34.0%)	151 (16.1%)
Missing data	531	1132	123 (23.2%)	187 (16.5%)	105 (19.8%)	199 (17.6%)
Marital status						
Married	8586	6261	1562 (18.2%)	873 (13.9%)	1161 (13.5%)	780 (12.5%)
Bereaved	732	3275	159 (21.7%)	577 (17.6%)	161 (22.0%)	634 (19.4%)
Divorced	254	416	65 (25.6%)	66 (15.9%)	70 (27.6%)	94 (22.6%)
Never married	201	215	50 (24.9%)	39 (18.1%)	63 (31.3%)	51 (23.7%)
Other	95	74	29 (30.5%)	20 (27.0%)	32 (33.7%)	23 (31.1%)
Missing data	104	187	27 (26.0%)	52 (27.8%)	26 (25.0%)	41 (21.9%)
Equivalent family income (10,000 yen)						
First quintile (men: 8.84–129.90, women: 8.84–123.74)	1771	1666	472 (26.7%)	334 (20.0%)	476 (26.9%)	398 (23.9%)
Second quintile (men: 129.90–194.45, women: 123.74–175.00)	1687	1695	344 (20.4%)	310 (18.3%)	299 (17.7%)	331 (19.5%)
Third quintile (men: 194.45–247.49, women: 175.00–245.97)	1544	1746	264 (17.1%)	227 (13.0%)	212 (13.7%)	254 (14.5%)
Fourth quintile (men: 247.49–318.20, women: 245.97–318.20)	1769	1476	282 (15.9%)	185 (12.5%)	164 (9.3%)	164 (11.1%)
Fifth quintile (men: >318.20, women: >318.20)	2229	1961	322 (14.4%)	248 (12.6%)	167 (7.5%)	161 (8.2%)
Missing data	972	1884	208 (21.4%)	323 (17.1%)	195 (20.1%)	315 (16.7%)

TABLE 3. PR and CI for Poor Subjective Health in Men

	Crude		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8		Model 9		Model 10	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Frequency of laughing																						
Almost every day	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–
1–5 days per week	1.41	1.26–1.59	1.34	1.19–1.51	1.24	1.10–1.40	1.25	1.11–1.40	1.24	1.10–1.40	1.25	1.11–1.40	1.32	1.17–1.49	1.24	1.10–1.39	1.24	1.10–1.39	1.24	1.10–1.39	1.24	1.10–1.40
1–3 days per month	1.86	1.62–2.14	1.65	1.43–1.91	1.39	1.20–1.61	1.38	1.20–1.60	1.38	1.19–1.59	1.37	1.19–1.59	1.62	1.40–1.87	1.38	1.19–1.60	1.37	1.19–1.59	1.37	1.18–1.59	1.37	1.19–1.59
Never or almost never	3.00	2.63–3.43	2.39	2.05–2.79	1.63	1.39–1.91	1.62	1.38–1.90	1.60	1.36–1.87	1.54	1.31–1.80	2.30	1.97–2.69	1.62	1.38–1.90	1.59	1.36–1.87	1.58	1.35–1.86	1.54	1.31–1.81
Number of opportunities of laughing																						
≥4	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–										
2–3	1.31	1.14–1.51	1.16	1.01–1.33	1.08	0.94–1.25	1.09	0.95–1.26	1.09	0.95–1.26	1.06	0.92–1.22										
0–1	2.19	1.90–2.52	1.53	1.31–1.78	1.34	1.15–1.57	1.33	1.13–1.55	1.32	1.13–1.54	1.25	1.07–1.46										
Number of opportunities for laughing in interpersonal interactions (times)																						
3	Ref	–											Ref	–	Ref	–	Ref	–	Ref	–	Ref	–
2	1.31	1.11–1.55											1.22	1.03–1.44	1.18	1.00–1.40	1.19	1.01–1.40	1.20	1.01–1.42	1.17	0.99–1.38
1	1.60	1.37–1.87											1.35	1.15–1.59	1.23	1.05–1.44	1.23	1.04–1.44	1.23	1.04–1.44	1.16	0.99–1.37
0	2.61	2.23–3.07											1.76	1.47–2.10	1.48	1.24–1.77	1.48	1.23–1.77	1.45	1.21–1.74	1.35	1.12–1.61
Depression																						
GDS ≥ 5	3.40	3.09–3.73			2.84	2.57–3.14	2.79	2.52–3.08	2.69	2.43–2.98	2.56	2.31–2.84			2.82	2.55–3.12	2.77	2.50–3.06	2.67	2.41–2.96	2.55	2.30–2.83
GDS < 5	Ref	–			Ref	–	Ref	–	Ref	–	Ref	–			Ref	–	Ref	–	Ref	–	Ref	–
Age, yrs																						
65–69	Ref	–					Ref	–	Ref	–	Ref	–					Ref	–	Ref	–	Ref	–
70–74	1.12	0.99–1.27					1.13	0.99–1.28	1.11	0.98–1.26	1.13	0.99–1.29					1.13	0.99–1.28	1.11	0.97–1.26	1.13	0.99–1.28
75–79	1.67	1.47–1.89					1.57	1.38–1.78	1.53	1.35–1.74	1.56	1.37–1.77					1.56	1.38–1.78	1.53	1.35–1.74	1.55	1.37–1.77
≥80	1.73	1.52–1.97					1.55	1.35–1.78	1.51	1.32–1.74	1.51	1.31–1.73					1.56	1.36–1.79	1.52	1.33–1.75	1.52	1.32–1.74
Marital status																						
Married	Ref	–					Ref	–	Ref	–	Ref	–					Ref	–	Ref	–	Ref	–
Bereaved	1.19	1.01–1.41					0.84	0.71–0.99	0.84	0.71–0.99	0.84	0.71–1.00					0.83	0.70–0.99	0.83	0.70–0.98	0.84	0.71–0.99
Divorced	1.41	1.10–1.80					1.05	0.81–1.35	1.03	0.80–1.32	1.00	0.78–1.29					1.04	0.81–1.34	1.02	0.79–1.32	1.00	0.78–1.29
Never married	1.37	1.03–1.81					1.00	0.75–1.34	0.95	0.71–1.27	0.92	0.69–1.23					0.98	0.73–1.31	0.93	0.70–1.25	0.91	0.68–1.21
Other	1.68	1.16–2.42					1.14	0.79–1.65	1.09	0.75–1.58	1.08	0.74–1.56					1.13	0.78–1.64	1.09	0.75–1.57	1.08	0.74–1.56
Missing data	1.43	0.98–2.09					1.02	0.70–1.50	0.97	0.66–1.43	1.00	0.67–1.47					1.01	0.69–1.48	0.95	0.65–1.41	0.98	0.67–1.45
Educational attainment																						
≥10 yrs	Ref	–							Ref	–	Ref	–							Ref	–	Ref	–
<10 yrs	1.43	1.30–1.56							1.15	1.04–1.27	1.12	1.02–1.24							1.14	1.04–1.26	1.12	1.01–1.23
Missing data	1.22	0.67–2.21							0.93	0.51–1.68	0.93	0.51–1.68							0.91	0.50–1.66	0.91	0.50–1.66
Longest jobs																						
Professionals, managers	Ref	–							Ref	–	Ref	–							Ref	–	Ref	–
Clerks, services, engineers	1.28	1.15–1.42							1.13	1.02–1.26	1.11	0.99–1.24							1.13	1.01–1.26	1.11	0.99–1.23
Agricultures, forestries, fisheries, self-employed, other	1.35	1.18–1.54							1.06	0.92–1.22	1.03	0.90–1.19							1.06	0.93–1.22	1.04	0.90–1.19
No jobs	1.90	1.14–3.17							1.06	0.63–1.78	1.03	0.61–1.73							1.07	0.64–1.80	1.04	0.62–1.75
Missing data	1.47	1.21–1.78							1.14	0.93–1.39	1.13	0.93–1.38							1.15	0.94–1.40	1.14	0.93–1.39
Equivalent family income (10,000 yen)																						
First quintile (men: 8.84–129.90, women: 8.84–123.74)	1.84	1.60–2.13							1.13	0.97–1.31	1.12	0.96–1.30							1.13	0.97–1.31	1.12	0.96–1.30
Second quintile (men: 129.90–194.45, women: 123.74–175.00)	1.41	1.21–1.64							1.07	0.92–1.25	1.07	0.91–1.25							1.07	0.91–1.25	1.06	0.91–1.24

Third quintile (men: 194.45–247.49, women: 175.00–245.97)	1.18	1.01–1.39	1.01	0.86–1.19	1.00	0.85–1.18			1.00	0.85–1.18	0.99	0.84–1.17
Fourth quintile (men: 247.49–318.20, women: 245.97–318.20)	1.10	0.94–1.29	1.02	0.87–1.20	1.03	0.87–1.21			1.02	0.87–1.19	1.02	0.87–1.20
Fifth quintile (men: >318.20, women: >318.20)	Ref	–	Ref	–	Ref	–			Ref	–	Ref	–
Missing data	1.48	1.24–1.76	0.96	0.80–1.15	0.95	0.79–1.14			0.96	0.80–1.16	0.95	0.80–1.15
Frequency of social participation per year (times)												
First quartile (men: 0 times, women: 0 times)	Ref	–			Ref	–					Ref	–
Second quartile (men: 1–24 times, women: 1–24 times)	0.66	0.58–0.75			0.82	0.72–0.94					0.82	0.72–0.93
Third quartile (men: 25–102 times, women: 24–138 times)	0.54	0.47–0.62			0.75	0.65–0.87					0.76	0.66–0.88
Fourth quartile (men: >102 times, women: >138 times)	0.40	0.34–0.46			0.59	0.50–0.69					0.59	0.51–0.70
Missing data	0.66	0.58–0.75			0.78	0.69–0.90					0.79	0.69–0.90

of laughter were not significant in men, the results still suggested a protective effect of laughter, both in terms of frequency as well as number of different occasions for laughter. Statistical adjustment for depression, sociodemographic factors, and social participation resulted in an attenuation of the relation. Depression and social participation were especially important confounders to consider. Nonetheless, our findings suggest that encouraging laughter may be a potential avenue for health promotion.

The relationship between laughter and subjective health may be underpinned by at least four distinct mechanisms (Martin, 2002). First, laughter may have direct psycho-neuro-immunological benefits such as lowering markers of inflammation. Second, laughter may be a marker of positive emotions, which can promote resilience against disease (Kubzansky, 2011). Third, laughing can buffer the effects of stress (Berk et al., 1989). Finally, people who laugh often can make a good impression on others and make others more likely to help them, for example, by providing them with social support.

The simple frequency of laughter seems to be more predictive of subjective health than the number of different occasions/contexts for laughter. This finding is consistent with previous studies that have found that laughing frequently is related to emotional well-being and life satisfaction (Hasan and Hasan, 2009). According to Schimmack et al. (2002), life satisfaction is correlated with emotional well-being, and the association is stronger in individualistic societies. The current study shows that there are stronger relationships between laughter and subjective health in older people. Alpass and Neville (2003) reported in their study that the most significant predictor of depression in older men was loneliness and that age-related losses (such as decline in mobility) may weaken their ability to maintain relationships with others. The current study also shows that women laugh more frequently than men do and laughter is more strongly related to subjective health among women. LaFrance et al. (2003) reported that women smile and laugh more than men do. These findings suggest that laughter is especially important for old people and women.

However, the present study had limitations. First and foremost, we are unable to establish a causal relationship between laughter and poor subjective health owing to the cross-sectional nature of the data. Longitudinal analyses of our cohort data will clarify how laughing can prevent poor subjective health. In addition, we cannot completely exclude the possibility of reverse causation, even though the study controlled for depression and other covariates. The third limitation is that all the answers to questionnaire were self-reported. The perceived frequency of laughter may be at variance from the actual frequency, but we lacked objective data on laughing frequency. Moreover, we did not consider the types of laughter. There are many types of laughing, for example, smiling is an indication of fondness and appeasement, whereas laughter expresses playfulness (Hooff, 1972), and Duchenne laughter is coming from positive emotion, whereas non-Duchenne laughter is fake laughter (Gervais and Wilson, 2005). Further studies are needed to examine these differences among various types of laughter. There is missing information for 882 subjects with missing in subjective health status, 1306 in laughter, and 4692 in depression. It may be plausible that less healthy people are more likely not to report their health status, possibly making the association between laughter and health underestimated. Finally, it is unclear whether laughter can prevent disease onset. Although previous research has indicated that laughter can improve the biomarkers of immune function (Bennett and Lengacher, 2009; Donkor et al., 2014), there were very few studies that examined actual disease outcomes. Martin (2002) even reported that many studies regarding the health benefits of humor and laughter are less conclusive than commonly believed. However, Donkor et al. (2014) showed that health-related quality of life among stroke survivors was significantly related to laughter, and this is consistent with our subanalysis. Future study needs to investigate further this point.

TABLE 4. PR and CI for Poor Subjective Health in Women

	Crude		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8		Model 9		Model 10	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Frequency of laughing																						
Almost every day	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–
1–5 days per week	1.66	1.48–1.86	1.51	1.34–1.70	1.33	1.18–1.50	1.33	1.18–1.49	1.33	1.18–1.50	1.33	1.18–1.50	1.48	1.31–1.66	1.32	1.17–1.48	1.31	1.16–1.48	1.31	1.17–1.48	1.32	1.17–1.49
1–3 days per month	2.50	2.15–2.92	2.09	1.78–2.45	1.59	1.35–1.87	1.59	1.35–1.87	1.58	1.34–1.86	1.55	1.32–1.83	1.97	1.68–2.32	1.53	1.30–1.80	1.53	1.30–1.80	1.52	1.29–1.80	1.50	1.28–1.77
Never or almost never	3.80	3.24–4.46	2.90	2.42–3.47	1.89	1.57–2.28	1.86	1.54–2.25	1.85	1.54–2.24	1.78	1.48–2.15	2.61	2.17–3.14	1.76	1.46–2.13	1.74	1.44–2.10	1.73	1.43–2.10	1.68	1.39–2.04
Number of opportunities of laughing																						
≥4	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–	Ref	–										
2–3	1.85	1.61–2.13	1.60	1.38–1.84	1.48	1.28–1.71	1.46	1.26–1.69	1.44	1.25–1.67	1.39	1.20–1.61										
0–1	2.87	2.46–3.34	1.89	1.59–2.24	1.60	1.35–1.89	1.51	1.27–1.80	1.47	1.24–1.75	1.39	1.17–1.66										
Number of opportunities for laughing in interpersonal interactions (times)																						
3	Ref	–											Ref	–	Ref	–	Ref	–	Ref	–	Ref	–
2	1.57	1.30–1.90											1.42	1.17–1.71	1.34	1.11–1.62	1.35	1.11–1.65	1.34	1.10–1.63	1.33	1.09–1.61
1	2.42	2.02–2.90											1.94	1.61–2.34	1.71	1.42–2.07	1.70	1.40–2.07	1.67	1.37–2.03	1.60	1.32–1.95
0	3.83	3.14–4.66											2.37	1.91–2.95	1.89	1.51–2.35	1.83	1.46–2.30	1.78	1.41–2.23	1.66	1.32–2.08
Depression																						
GDS ≥ 5	3.59	3.25–3.97			2.84	2.55–3.17	2.79	2.50–3.10	2.72	2.44–3.04	2.58	2.31–2.88			2.79	2.51–3.11	2.75	2.46–3.06	2.69	2.41–3.00	2.56	2.29–2.86
GDS < 5	Ref	–			Ref	–	Ref	–	Ref	–	Ref	–			Ref	–	Ref	–	Ref	–	Ref	–
Age, yrs																						
65–69	Ref	–					Ref	–	Ref	–	Ref	–					Ref	–	Ref	–	Ref	–
70–74	1.26	1.09–1.45					1.24	1.07–1.43	1.21	1.04–1.39	1.21	1.05–1.40					1.23	1.06–1.42	1.20	1.04–1.38	1.20	1.04–1.39
75–79	1.73	1.50–2.01					1.61	1.39–1.87	1.55	1.33–1.80	1.53	1.31–1.78					1.58	1.37–1.83	1.53	1.31–1.77	1.51	1.30–1.75
≥80	2.24	1.94–2.58					1.91	1.64–2.23	1.82	1.55–2.13	1.72	1.47–2.01					1.88	1.62–2.20	1.80	1.54–2.10	1.70	1.45–1.99
Marital status																						
Married	Ref	–					Ref	–	Ref	–	Ref	–					Ref	–	Ref	–	Ref	–
Bereaved	1.26	1.14–1.40					0.84	0.75–0.94	0.83	0.74–0.94	0.84	0.75–0.95					0.80	0.71–0.90	0.80	0.71–0.90	0.81	0.72–0.91
Divorced	1.14	0.89–1.46					0.85	0.66–1.10	0.86	0.67–1.10	0.83	0.64–1.06					0.80	0.62–1.03	0.81	0.63–1.04	0.78	0.61–1.01
Never married	1.30	0.94–1.79					0.86	0.62–1.19	0.90	0.65–1.25	0.87	0.63–1.20					0.79	0.57–1.10	0.84	0.60–1.16	0.81	0.59–1.13
Other	1.94	1.24–3.02					1.09	0.70–1.71	1.06	0.68–1.66	1.01	0.64–1.58					1.05	0.67–1.64	1.02	0.65–1.60	0.98	0.62–1.53
Missing data	1.99	1.51–2.64					1.32	0.99–1.75	1.32	0.99–1.76	1.32	0.98–1.76					1.27	0.96–1.68	1.27	0.95–1.70	1.28	0.95–1.71
Educational attainment																						
≥10 yrs	Ref	–							Ref	–	Ref	–							Ref	–	Ref	–
<10 yrs	1.53	1.39–1.69							1.17	1.05–1.30	1.13	1.02–1.26							1.17	1.05–1.29	1.13	1.02–1.25
Missing data	1.34	0.82–2.20							0.90	0.55–1.49	0.87	0.53–1.44							0.89	0.54–1.47	0.87	0.52–1.43
Longest jobs																						
Professionals, managers	Ref	–							Ref	–	Ref	–							Ref	–	Ref	–
Clerks, services, engineers	1.10	0.91–1.32							1.02	0.84–1.22	0.99	0.83–1.19							1.01	0.84–1.22	0.99	0.82–1.19
Agricultures, forestries, fisheries, self-employed, other	1.53	1.26–1.86							1.18	0.96–1.43	1.12	0.92–1.36							1.17	0.96–1.43	1.11	0.91–1.36
No jobs	1.48	1.18–1.85							1.13	0.90–1.42	1.07	0.86–1.35							1.13	0.90–1.41	1.07	0.85–1.34
Missing data	1.31	1.05–1.63							0.93	0.74–1.17	0.91	0.73–1.15							0.93	0.74–1.17	0.91	0.72–1.15
Equivalent family income (10,000 yen)																						
First quintile (men: 8.84–129.90, women: 8.84–123.74)	1.59	1.35–1.87							1.00	0.84–1.19	0.99	0.84–1.18							0.99	0.83–1.17	0.98	0.83–1.17
Second quintile (men: 129.90–194.45, women: 123.74–175.00)	1.45	1.22–1.71							1.07	0.90–1.27	1.05	0.89–1.25							1.06	0.89–1.25	1.04	0.88–1.24
Third quintile (men: 194.45–247.49, women: 175.00–245.97)	1.03	0.86–1.23							0.86	0.71–1.03	0.87	0.72–1.04							0.85	0.71–1.02	0.86	0.72–1.03

Fourth quintile (men: 247.49–318.20, women: 245.97–318.20)	0.99	0.82–1.20							0.92	0.76–1.11	0.91	0.75–1.11
Fifth quintile (men: >318.20, women: >318.20)	Ref	–							Ref	–	Ref	–
Missing data	1.36	1.15–1.60							0.97	0.81–1.15	0.97	0.81–1.15
Frequency of social participation per year (times)												
First quartile (men: 0 times, women: 0 times)	Ref	–							Ref	–	Ref	–
Second quartile (men: 1–24 times, women: 1–24 times)	0.64	0.55–0.74							0.82	0.71–0.95	0.82	0.71–0.96
Third quartile (men: 25–102 times, women: 24–138 times)	0.48	0.42–0.56							0.74	0.63–0.86	0.75	0.64–0.87
Fourth quartile (men: >102 times, women: >138 times)	0.32	0.26–0.38							0.54	0.45–0.65	0.55	0.45–0.66
Missing data	0.57	0.50–0.65							0.75	0.66–0.86	0.76	0.66–0.86

In conclusion, laughter may lower the risk of poor subjective health of older people, and this effect was observed even after adjusting for depression, socioeconomic status, and social participation. Moreover, laughing frequently regardless of situations may be effective for decreasing the risk. The mechanisms and determinants of laughter warrant further study to use laughter effectively to improve the physical and psychological health of old people.

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DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

Alpass FM, Neville S (2003) Loneliness, health and depression in older males. *Aging Ment Health.* 7:212–216.

Bennett MP, Lengacher C (2009) Humor and Laughter May Influence Health IV. Humor and Immune Function. *Evid Based Complement Alternat Med.* 6: 159–164.

Bennett PN, Parsons T, Ben-Moshe R, Weinberg M, Neal M, Gilbert K, Rawson H, Ockerby C, Finlay P, Hutchinson A (2014) Laughter and humor therapy in dialysis. *Semin Dial.* 27:488–493.

Berk LS, Tan SA, Fry WF, Napier BJ, Lee JW, Hubbard RW, Lewis JE, Eby WC (1989) Neuroendocrine and stress hormone changes during mirthful laughter. *Am J Med Sci.* 298:390–396.

Dolgoff-Kaspar R, Baldwin A, Johnson MS, Edling N, Sethi GK (2012) Effect of laughter yoga on mood and heart rate variability in patients awaiting organ transplantation: A pilot study. *Altern Ther Health Med.* 18:61–66.

Donkor ES, Owolabi MO, Bampoh PO, Amoo PK, Aspelund T, Gudnason V (2014) Profile and health-related quality of life of Ghanaian stroke survivors. *Clin Interv Aging.* 9:1701–1708.

Gervais M, Wilson DS (2005) The evolution and functions of laughter and humor: A synthetic approach. *Q Rev Biol.* 80:395–430.

Hasan H, Hasan TF (2009) Laugh yourself into a healthier person: A cross cultural analysis of the effects of varying levels of laughter on health. *Int J Med Sci.* 6:200–211.

Hirsch RD, Junglas K, Konradt B, Jonitz MF (2010) Humor therapy in the depressed elderly: Results of an empirical study. *Z Gerontol Geriatr.* 43:42–52.

Hooff J (1972) A comparative approach to the phylogeny of laughter and smiling. Retrieved February 6, 2015, from http://www.academia.edu/2217566/A_comparative_approach_to_the_phylogeny_of_laughter_and_smiling.

Kubzansky LD (2011) Key 2010 publications in behavioral medicine. *Cleve Clin J Med.* 78(Suppl 1):S65–S68.

LaFrance M, Hecht MA, Paluck EL (2003) The contingent smile: a meta-analysis of sex differences in smiling. *Psychol Bull.* 129:305–334.

Martin RA (2002) Is laughter the best medicine? Humor, laughter, and physical health. *Curr Dir Psychol Sci.* 11:216–220.

Provine RR (1993) Laughter punctuates speech: Linguistic, social and gender contexts of laughter. *Ethology.* 95:291–298.

Ramachandran VS (1998) The neurology and evolution of humor, laughter, and smiling: The false alarm theory. *Med Hypotheses*. 51:351–354.

Sakai Y, Takayanagi K, Ohno M, Inose R, Fujiwara H (2013) A trial of improvement of immunity in cancer patients by laughter therapy. *Jpn Hosp*. 53–59.

Schimmack U, Radhakrishnan P, Oishi S, Dzokoto V, Ahadi S (2002) Culture, personality, and subjective well-being: Integrating process models of life satisfaction. *J Pers Soc Psychol*. 82:582–593.

Takeda M, Hashimoto R, Kudo T, Okochi M, Tagami S, Morihara T, Sadick G, Tanaka T (2010) Laughter and humor as complementary and alternative medicines for dementia patients. *BMC Complement Altern Med*. 10:28.

Wongpakaran N, Wongpakaran T, Van Reekum R (2013) The use of GDS-15 in detecting MDD: A comparison between residents in a Thai long-term care home and geriatric outpatients. *J Clin Med Res*. 5:101–111.

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Influence of socioeconomic status on the association between body mass index and cause-specific mortality among older Japanese adults: The AGES Cohort Study

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ABSTRACT

Objective. Many studies have suggested a U-shaped curve for the association between body size and mortality risks, i.e., mortality risks increase in those who are both overweight and underweight. The strength of the associations may vary according to socioeconomic statuses (SES), as they determine levels of access to healthcare and psychosocial stresses. We investigated the modifying effects of SES on the relationship between body mass index (BMI) and mortality.

Method. We used prospective cohort data of participants in the Aichi Gerontological Evaluation Study in 2003 ($n = 14{,}931$), who were 65 years or older and physically and cognitively independent at baseline, and residing in eight municipalities in Japan. Data on all-causes mortality and mortality from cancer, cardiovascular disease, and respiratory disease was obtained from municipal government registries.

Results. Proportional hazard regression analyses showed that, among men, the associations between overweight (BMI ≥ 25 kg/m^2) and higher mortality risks by any cause were stronger among lower income groups. Even adjusting for multiple confounding factors, hazard ratios (95% confidence intervals) for mortality by all causes among low income group (household income < 1.5 million yen) were 1.96 (1.02–3.73) for overweight compared with BMIs between 23.0 and 24.9, whereas they were 0.94 (0.57–1.38) among men in high income group (income > 3 million yen). The modifying effects of income were not marked among women.

Conclusion. Household income, which may directly reflect accessibility to healthcare and psychosocial stress among older Japanese men, may be an important modifying factor in the health risks attributable to overweight.

Introduction

Many epidemiological studies have shown the association between weight status and mortality risks (Flegal et al., 2013; de Gonzalez et al., 2010). For antecedent pathology, obesity is a risk factor for type 2 diabetes, hypertension, cardiovascular disease, stroke, and many types of cancer (Haslam and James, 2005; Kastarinen et al., 2000; Peeters et al., 2003; Vainio and Bianchini, 2002; Wannamethee et al., 1998). Over the past few decades, the prevalence of obesity has increased worldwide and currently over 1 billion adults are estimated to be overweight, 3 million of whom are obese (Abelson and Kennedy, 2004). In addition to obesity, the associations between underweight and health risk have also received much attention. For example, two pooled analyses of prospective studies in Western (Prospective Studies Collaboration, 2009) and Asian (Zheng et al., 2011) countries both showed a U-shaped association between body size (measured as body mass index [BMI]), and mortality risk, such that mortality risk was higher among people with high or low BMI.

Studies have suggested that the association between BMI and health varies across socio-demographic characteristics, including age, gender, and race (Abell et al., 2007; Calle et al., 1999; Lahmann et al., 2002; Stevens et al., 1998; Stommel and Schoenborn, 2010; WHO expert consultation, 2004). However, the effect-modifying roles of more social characteristics have not been known. In particular, the risk of death

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attributable to low BMI can be altered by socioeconomic status (SES), such as income and education. For example, people with lower incomes are likely to have less access to healthcare and be exposed to continual psychosocial stresses (Kagamimori et al., 2009). Although the health insurance system covers all citizens in Japan, socioeconomic disparity in healthcare access is evident. Murata et al. (2010), using a large-scale community survey data, reported that the reason for not getting health care was attributed to health care cost among low-income older people in Japan. Toyokawa et al. (2012) also showed that the proportion of respondents who have refrained from going to hospital despite of illness or injury was higher among low-income people compared with high-income people.

Less well educated people may be less able to recognize their health risks and modify such risks because of limited health knowledge (Nutbeam, 2000; Sorensen et al., 2012). In addition, low-SES people are more likely to do unhealthy behaviors such as smoking (Cavelaars et al., 2000; Hymowitz et al., 1991) and excessive drinking (Droomers et al., 1999) than high SES people. Because such unhealthy behaviors tend to be combined with overweight/underweight among people with low education, health risks of low SES people are increased. Therefore, the shape of the BMI-mortality association may differ across SES groups. More specifically, we hypothesized that those who have lower SES may show steeper slopes on those association curves. The purpose of this study was to test this hypothesis using a large cohort of Japanese older adults.

Materials and methods

Data

The present analyses were based on data from the Aichi Gerontological Evaluation Study (AGES), an ongoing Japanese prospective cohort study (Kondo, 2010). In 2003, AGES investigators conducted a postal survey of 38,652 randomly sampled community-dwelling older individuals aged 65 years or older, who were physically and cognitively independent in their activities of daily living, and lived in one of eight municipalities. Their independency was confirmed as they were not eligible for public long-term care insurance benefits at baseline. We received responses from 21,047 people across the eight municipalities. Excluding those who had missing information on self-reported height or weight ($n = 2062$), whose data on sex or age were inconsistent with official municipal records ($n = 521$), who required nursing care (limitation in basic activities of daily living including walking, bathing, and toilet use) ($n = 1393$), who died within 1 year ($n = 197$), who lost more than 2 kg in 6 months ($n = 1918$), or who had an outlier BMI value (BMI ≤ 14 kg/m^2 ($n = 18$) or BMI ≥ 40 kg/m^2 ($n = 8$)), analyses were conducted on 14,930 subjects. Data were anonymized and the AGES protocol was reviewed and approved by the Ethics Committee on Research of Human Subjects at Nihon Fukushi University.

Deaths by all causes and specific causes

In this study, the follow-up data were available up to four years until May 23, 2008. By special permission, we gathered information from the National Death Certificate Database on the underlying causes of death, which were coded according to the International Classification of Diseases 10th Revision (ICD-10). For this analysis, we separately investigated the association of baseline BMI with deaths by the three leading causes in Japan, namely, malignant neoplasm (ICD-10 codes: C00–C97), cardiovascular disease (including coronary heart disease, stroke and other cardiovascular disease: I00–I99), and respiratory disease (J00–J99), as well as deaths by all causes. Less common causes of death were not included in the analysis because of the limited number of cases.

BMI

BMI (kg/m^2) was calculated from information on height and weight reported in the baseline survey questionnaire. There is evidence that self-reported height and weight data have acceptable accuracy (Huber, 2007; Spencer et al., 2002; Stunkard and Albaum, 1981) for use in epidemiologic studies. Respondents with BMI ≥ 40 kg/m^2 ($n = 8$) or ≤14 kg/m^2 ($n = 18$) were excluded from the analyses because of suspicion regarding the accuracy of their responses, following a previous study in Japan (Inoue et al., 2004). BMI categories were based on the World Health Organization classification: <18.5, 18.5–22.9, 23.0–24.9, 25.0–27.4, 27.5–29.9, and 30 or higher (World Health Organization, 2000). In Japan, the proportion of obese adults (BMI ≥ 30 kg/m^2) is very small (3.4%) relative to Western countries among OECD (Organisation for Economic Cooperation and Development) countries (Ministry of Health, Labour and Welfare, 2002). Therefore, the Japan Society for the Study of Obesity (Japan Society for the Study of Obesity, 1999) uniquely defined obesity in Japan as BMI of ≥25 kg/m^2, and we amalgamated the three higher BMI categories because of the low numbers with very high BMI.

SES

Information on household income and educational attainment in the baseline survey were used as indicators of SES. For annual household income, the respondents reported their income as one of 14 predetermined categories (1, less 0.5 million yen; 2, 0.5–1 million yen; 3, 1–1.5 million yen; 4, 1.5–2 million yen; 5, 2–2.5 million yen; 6, 2.5–3 million yen; 7, 3–4 million yen; 8, 4–5 million yen; 9, 5–6 million yen; 10, 6–7 million yen; 11, 7–8 million yen; 12, 8–9 million yen; 13, 9–10 million yen; 14, more than 10 million yen). One million yen was converted into 8625.90 US dollars according to the average Japanese yen-to-US dollar exchange rate of 115.93 US dollars in 2003. From the perspective of household living standards, the costs of consumable goods and services, such as utility expenses and durable goods, per family member are decreased with an increasing number of family members. According to previous studies (Idler and Benyamini, 1997; Atkinson et al., 1995), the annual household income was then equivalized by dividing it by the square root of the number of family members and categorized into one of three levels (less than 1.5 million yen, 1.5–3 million yen, and more than 3 million yen). The respondents whose response to this question was missing were categorized into a missing value category (832 males [11.7%] and 2090 females [26.7%]) and excluded from the main analyses. Educational attainment was given in the survey as one of four categories of years of education (1 = less than 6 years, 2 = 6–9 years, 3 = 10–12 years, 4 = 13 or more years). For the purposes of the analysis, educational attainment was categorized as ≤9 years (junior high-school graduate) or ≥10 years.

Covariates

Age, marital status, self-rated health, and current illness were considered potential confounding factors. Marital status was categorized as married, divorced/separated, never married, and other. Self-rated health was measured by a single survey question about current health status (excellent, good, fair, or poor). Utilization of medical care services was used as an index of current illness.

Statistical analysis

After collecting descriptive data, we used Cox proportional hazard models to calculate the hazard ratio (HR) and 95% confidence interval (CI) for mortality during the follow-up period. Proportional hazard assumptions were confirmed for main variables, namely, BMI, income and education by using Schoenfeld residuals. First, univariate HRs according to BMI status were calculated for all-cause and cause-specific mortality. Second, in multivariate models, we adjusted for age, marital status, self-rated health, and current illness. Then models were stratified by SES. A BMI of 23.0–24.9 kg/m^2 was selected as the reference category, following a preceding Japanese cohort study (Inoue et al., 2004). We imputed missing data using the technique of multivariate imputation by chained equations. In that process, multivariate Cox proportional hazard models were independently applied to 10 copies of the data with missing values suitably imputed. Estimates of the variables were averaged to give a single mean estimate and adjusted standard errors.

Results

The baseline characteristics of the subjects are displayed in Table 1. There were 14,930 subjects, including 7100 men and 7830 women. During the 57,313 person-years of follow-up, a total of 857 people died (565 men and 292 women). There were 351 deaths (244 men and 107 women) from cancer, 244 (135 men and 89 women) from cardiovascular disease, and 107 (83 men and 24 women) from respiratory disease.

Table 1
Baseline characteristics and mortality rates of adults aged 65 years or older in eight municipalities in Japan, 2003–2008.

	Male					Female				
	N	Incidence[a]	Person-years	Incidence rate (per 1000 person-years)	95% CI	N	Incidence[a]	Person-years	Incidence rate (per 1000 person-years)	95% CI
Sex	7100	565	27,506	20.54	18.91, 22.31	7830	292	29,808	9.80	8.73, 10.99
Age group										
65–69	2703	121	10,903	11.10	9.29, 13.26	2717	45	10,697	4.21	3.14, 5.63
70–74	2234	136	8688	15.65	13.23, 18.52	2338	57	8841	6.45	4.97, 8.36
75–79	1381	148	5185	28.54	24.30, 33.53	1713	78	6435	12.12	9.71, 15.13
80–84	573	92	2037	45.17	36.82, 55.41	772	44	2802	15.70	11.69, 21.10
85+	209	68	693	98.16	77.39, 124.49	290	68	1033	65.85	51.92, 83.52
Body mass index, kg/m^2										
<18.5	476	79	1736	45.51	36.50, 56.74	607	51	2274	22.43	17.05, 29.51
18.5–22.9	3248	271	12,592	21.52	19.11, 24.24	3644	123	13,852	8.88	7.44, 10.60
23.0–24.9	1875	114	7328	15.56	12.95, 18.69	1715	56	6543	8.56	6.59, 11.12
≥25	1501	101	5850	17.26	14.21, 20.98	1864	62	7138	8.69	6.77, 11.14
Marital status										
Married	5963	424	23,214	18.26	16.61, 20.09	4177	102	16,028	6.36	5.24, 7.73
Divorced/separated	656	101	2412	41.87	34.45, 50.88	3005	166	11,263	14.74	12.66, 17.16
Never married	36	3	136	22.09	7.13, 68.51	210	8	800	10.00	5.00, 19.99
Other	445	37	1744	21.22	15.37, 29.28	438	16	1716	9.32	5.71, 15.22
Self-rated health										
Good	5292	327	20,806	15.72	14.10, 17.52	5707	178	21,877	8.14	7.02, 9.42
Poor	1739	227	6441	35.24	30.94, 40.14	1967	108	7337	14.72	12.19, 17.77
Missing	69	11	259	42.53	23.55, 76.79	156	6	593	10.12	4.55, 22.53
Present illness										
No	1290	68	5156	13.19	10.40, 16.73	1240	23	4822	47.70	3.17, 7.18
Ill, no medical care needed	782	62	3086	20.09	15.67, 25.77	616	21	2360	8.90	5.80, 13.65
Ill, decided not to proceed with medical care	417	40	1625	24.62	18.06, 33.56	524	16	2005	7.98	4.89, 13.03
Yes	4346	378	16,632	22.73	20.55, 25.14	5026	221	19,033	11.61	10.18, 13.25
Missing	265	17	1006	16.89	10.50, 27.17	424	11	1587	6.90	3.84, 12.51
Educational attainment										
<9 years	3668	319	14,292	22.32	20.00, 24.91	4395	185	17,155	10.78	9.34, 12.46
≧10 years	3038	215	11,657	18.44	16.14, 21.08	3059	93	11,190	8.31	6.78, 10.18
Missing	394	31	1557	19.91	14.00, 28.31	376	14	1463	9.57	5.67, 16.16
Equivalent income[b]										
<1.5 million yen (less than USD12,900)	1349	113	4908	23.02	19.15, 27.68	1796	62	6540	9.48	7.39, 12.16
1.5–3 million yen (USD12,900–25,900)	3100	245	12,162	20.14	17.77, 22.83	2461	77	9491	8.11	6.49, 10.14
>3 million yen (more than USD25,900)	1819	123	7268	16.92	14.18, 20.19	1483	53	5788	9.16	7.00, 11.99
Missing	832	84	3167	26.52	21.42, 32.85	2090	100	7988	12.52	10.29, 15.23

[a] Incidence of mortality from all causes.
[b] The USD amounts were computed by using the average JPY/USD exchange rate, 115.93, in 2003.

Overall, we observed a U-shaped association between BMI and mortality by any cause, with higher mortality rates for the lowest and highest BMI categories. The mortality rates per 1000 person-years among those in the lowest BMI category (<18.5 kg/m^2) were 45.51 for men and 22.43 for women, and among those with the highest BMI (≥25.0 kg/m^2) mortality rates were 17.26 for men and 8.69 for women (Table 1).

The U-shaped trends in cause-specific mortality by BMI category were less marked, and only showed significantly higher rates for lower BMI groups (Table 2). These trends were similarly observed in the multivariate Cox models adjusted for age, marital status, self-rated health and current illness at the time of the survey (Table 3).

When multiple regression models were stratified by SES, strong evidence was found for the influence of income on the association between BMI and mortality risk among men. Men with lower incomes showed steeper U-shaped slopes on the BMI-mortality association (HR = 2.41, 95% CI: 1.18, 4.92 for the lowest BMI group (<18.5 kg/m^2); HR = 1.68, 95% CI: 0.96, 2.95 for the second lowest BMI group (18.5–22.9 kg/m^2); and HR = 1.96, 95% CI: 1.02, 3.73 for the highest BMI group (≥25.0 kg/m^2)). In the high income category, there were no significant differences in HR among BMI groups (HR = 1.60, 95% CI: 0.82, 2.96 for the lowest BMI group; HR = 0.89, 95% CI: 0.57, 1.38; HR = 0.94, 95% CI: 0.55, 1.61 for the highest BMI group) (Fig. 1, full results are shown in the Supplementary data, Tables S1 and S2). In the analyses according to educational attainment, men showed a significant association between low BMI and high risk of mortality regardless of educational attainment (Fig. 2). Among women in the low BMI category, women with more education tended to have higher mortality rates, but this was not significant after adjustment.

We found a marginal evidence of the effect modifications of SES on BMI/mortality associations. Among men, the estimates of the cross term of the highest BMI (BMI ≥ 25.0) was 2.16 ($p = .071$) with low-income and 0.91 ($p = .741$) with low education. Among women, the estimate for the cross term of the highest BMI and low-education was 0.46 ($p = .048$) (Tables 4, 5).

Discussion

Our results showed that the lowest BMI groups had the highest risk of total mortality in both men and women. Results from analyses on cause-specific mortality showed similar patterns. The new and important finding of our study is that, although statistically marginal, low