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Association between long-term care and chronic and lifestyle-related disease modified by social profiles in community-dwelling people aged 80 and 90; SONIC study

Eri Kiyoshige[a], Mai Kabayama[a], Yasuyuki Gondo[b], Yukie Masui[c], Hirochika Ryuno[d], Yasuka Sawayama[a], Takako Inoue[a], Yuya Akagi[a], Toshiaki Sekiguchi[a], Kentaro Tanaka[a], Takeshi Nakagawa[e], Saori Yasumoto[b], Madoka Ogawa[c], Hiroki Inagaki[c], Ryousuke Oguro[f], Ken Sugimoto[f], Hiroshi Akasaka[f], Koichi Yamamoto[f], Yasushi Takeya[f], Yoichi Takami[f], Norihisa Itoh[f], Masao Takeda[f], Motonori Nagasawa[f], Serina Yokoyama[f], Satomi Maeda[f], Kazunori Ikebe[g], Yasumichi Arai[h], Tatsuro Ishizaki[c], Hiromi Rakugi[f], Kei Kamide[a,f,*]

[a] Division of Health Science, Osaka University, Graduate School of Medicine, Osaka, Japan
[b] Clinical Thanatology and Geriatric Behavioral Science, Graduate School of Human Sciences, Osaka University, Osaka, Japan
[c] Tokyo Metropolitan Institute of Gerontology, Research Team for Human Care, Tokyo, Japan
[d] Division of Health Science, Kobe University, Graduate School of Medicine, Hyogo, Japan
[e] Section of NILS-LSA, National Center for Geriatrics and Gerontology, Aichi, Japan
[f] Department of Geriatric and General Medicine, Osaka University Graduate School of Medicine, Osaka, Japan
[g] Department of Prosthodontics, Gerodontology and Oral Rehabilitation, Osaka University Graduate School of Dentistry, Osaka, Japan
[h] Center for Supercentenarian Medical Research, Keio University School of Medicine, Tokyo, Japan

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ABSTRACT

Background: Chronic and lifestyle-related diseases and social status were reported to be associated with long-term care (LTC). The social factors should be treated as social sub-groups of which characteristics show social profiles. However, few previous studies considered that. The present study aimed to investigate the associations between LTC and chronic and lifestyle-related diseases, and whether the associations were modified by the social sub-groups in the community-dwelling elderly.

Method: A cross-sectional study was conducted among 1004 community-dwelling participants aged 80 and 90. LTC was used as the outcome. Chronic and lifestyle-related diseases (i.e., stroke, heart disease, joint pain, osteoporosis, lung disease, cancer, hypertension, dyslipidemia, and diabetes) were used as the predictors. Education, household income, residential area, and support environment were analyzed by latent class analysis (LCA) to derive social profiles. We obtained odds ratios (ORs) of LTC from those diseases and tested interactions between those diseases and the social profiles by logistic regression analyses.

Result: The participants were categorized into two sub-groups of social factors (n = 675 and 329) by LCA. Logistic regression analyses showed ORs (95% CI) of LTC were 4.69 (2.49, 8.71) from stroke, 2.22 (1.46, 3.38) from joint pain, 1.99 (1.22, 3.25) from osteoporosis, and 2.05 (1.22, 3.40) from cancer adjusting for the social sub-groups. There were no significant interactions between the social subgroups and those diseases in relation to LTC except for osteoporosis.

Conclusion: The associations between LTC and chronic and lifestyle-related diseases were significant with adjusting for the social sub-groups, and not modified by that except osteoporosis.

1. Introduction

The global population is rapidly aging. Japan has experienced pronounced population aging, and now has the highest proportion of elderly adults in the world (B. K. Chen et al., 2016). Many elderly adults generally need significant care and support (Beard et al., 2016). In Japan, more than half of adults aged 80 years and over receive long-term care (LTC). Especially, 72% of Japanese adults aged 90 years old

* Corresponding author at: Department of Health Promotion Science, Osaka University Graduate School of Medicine, 1-7 Yamadaoka, Suita, Osaka, Japan.
E-mail address: kamide@sahs.med.osaka-u.ac.jp (K. Kamide).

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and over need some help from others (Ministry of Health, Labour & Welfare. Kaigoyobou Manual Kaiteiban, 2017; Ministry of Public Management, 2014).

Most of LTC was due to functional limitations, such as Activity of Daily Living (ADL) decline and physical function decline (Yeh et al., 2014). ADL decline among older adults has been associated with chronic diseases and lifestyle-related diseases, such as hypertension, diabetes, hyperlipidemia, and stroke (van der Vorst et al., 2016).

Many previous studies have shown associations of social factors with ADL decline and chronic diseases (Lindsay Smith, Banting, Eime, O'Sullivan, & van Uffelen, 2017; Sommer et al., 2015). Previous studies have shown strong association between ADL decline and residence areas (Aida et al., 2013), socioeconomic status, education (Kingston et al., 2015), and emotional and instrumental support, and social support (Neugebauer & Katz, 2004). In addition, chronic diseases including hypertension, diabetes, hyperlipidemia, and cardiovascular disease have been associated with social factors such as household income, education, social support, occupation, insurance status, housing condition, and maternal marital status (Lindsay Smith et al., 2017; Sommer et al., 2015; Mackenbach et al., 2008). Thus, the association of chronic diseases with LTC and ADL decline can be influenced by social factors, which implies that social factors should be considered and adequately treated in statistical models.

However, previous studies have treated social variables by each single observed variable but not by latent variables derived from multiple observed variables, even though statistical results and conclusions were possibly biased when social variables were treated as each single predictor in statistical models (Braveman et al., 2005; Pollack et al., 2007). In real-world, people have social profiles that are multi-dimensional phenomenon and based on multiple social variables including economic status, residence areas, and social support (Savage, Warde, & Devine, 2005). Therefore, social variables should be treated by social profiles based on multiple social variables. Social profiles can be derived from characteristics of sub-groups of social factors by Latent Class Analysis (LCA).

The present study aimed to investigate the associations between LTC and chronic and lifestyle-related diseases adjusted by the sub-groups of social factors obtained by LCA in community-dwelling elderly Japanese people aged 80 and 90 years old. The second aim of the present study was to investigate whether associations between LTC and chronic and lifestyle-related diseases can be modified by the sub-groups of the social factors.

2. Methods

2.1. Participants

The present study used a cross-sectional design and was based on the Septuagenarians, Octogenarians, Nonagenarians Investigation with Centenarians (SONIC) study, an ongoing study since 2010. The participants of the SONIC study were collected from Itami City, Hyogo prefecture (Western-urban); Asago City, Hyogo prefecture (Western-rural); Itabashi Ward, Tokyo (Eastern-urban); Nishitama District, Tokyo (Eastern-rural). We sent invitation letters to the residents between 2010 and 2013, and they were invited to participate in the SONIC study. The baseline participants composed 1000 participants aged 69–71 years old, 973 participants aged 79–81 years old, and 272 participants aged 89–91 years old. We are following up these participants every 3 years. The SONIC study was approved by the Institutional Review Board of Osaka University Graduate School of Medicine, Dentistry and Human Sciences (Osaka, Japan) and the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology (Tokyo, Japan). All participants provided written informed consent to participate.

The eligible criteria for the present study were the participants 1) aged 79–81 and 89–91, 2) who were free of dementia, and 3) who provided information about LTC. The participants with missing information on any possible confounders (i.e., education, household income, supporting conditions, histories of chronic diseases) were excluded (n = 169 for 79–81, and n = 72 for 89–91). The number of participants for this study was 1004; 804 were 79–81 years old and 200 were 89–91 years old.

2.2. The LTC assessment

In the present study, LTC status was assessed by use of LTC insurance. LTC insurance is national insurance and implemented for citizens over 65 years of age, as well as for citizens over 40 years of age deemed to require LTC services (Long-Term Care Insurance Act, 2018). The care needs levels for LTC services were categorized into the following 7 levels: support needs levels 1 and 2, and care needs levels 1–5. Higher care needs levels indicate more severe conditions that require greater levels of care and services to prevent functional limitation and support independent living.

The levels of LTC services were assessed by medical or social specialists' completed lectures about nursing care held by municipalities. They conducted a door-to-door survey using a 74 items questionnaire about physical and mental conditions of each insured individual. They also described special care for each insured individual which could not be assessed well by the questionnaire. Based on those information and physician diagnoses, care needs levels of LTC services were decided by LTC approval boards, comprised of specialists who were nominated by a mayor (physicians, dentists, pharmacists, nurses, public health nurses, dental hygienists, and care workers).

In the present study, we asked participants whether or not they were provided LTC services with a questionnaire by mail. We defined participants being provided any level of LTC services as having received LTC.

2.3. The social factors assessment

Education, household income, residential area, and supporting conditions were included as social factors. The social factors were asked in the questionnaire by health check-up of the SONIC study. We categorized years of education into three categories (≦9 years, 9–12 years, > 12 years) because 9 and 12 years are required to graduate from junior high school and high school, respectively. Subjective satisfaction of household income was asked by three categories (Dissatisfying, Neutral, Satisfying) in the questionnaire. Residential area (rural or urban) was categorized by their mail address. Supporting condition was asked by the following question: "Do you have someone to help you in your time of need?" This question was responded by "yes" or "no".

2.4. The chronic diseases and lifestyle-related disease assessment

Histories of chronic diseases including stroke, heart disease, joint pain, osteoporosis, lung disease, and cancer were collected by self-reported questionnaire in health check-ups. In the present study, hypertension was defined by medication use of hypertension or blood pressure (BP) level (i.e., systolic BP > 150 mmHg or diastolic BP > 90 mmHg). Physicians and trained nurses used mercury sphygmomanometer to measure BP. BP was measured twice on each arm in a sitting position. The average of the first and second measurements on each arm was used for analysis. The present study defined hyperlipidemia by medication use of dyslipidemia, or low-density lipoprotein cholesterol≧140 mg/dL, or high-density lipoprotein cholesterol < 40 mg/dL, or triglyceride≧150 mg/dL. In the present study, diabetes was defined by medication use of diabetes, or hemoglobin A1c≧7.0%, or blood glucose≧200 mg/dL. Those definitions were based on the criterion of Japanese guidelines for aged people (Haneda et al., 2018; Kario, 2015; Teramoto et al., 2014).

Table 1
Social profiles for the two sub-groups of the social factors and characteristics of the present participants by the two sub-groups based on the SONIC study aged 79–81 and 89–91 years old.

Soci[a]l profiles for the two su[b]-groups, n (%)				
	All	The first social sub-group	The second social sub-group	P-values*
n (%)	1004	675 (67.2)	329 (32.8)	
Education				< 0.001
≦9 years	335 (33.5)	71 (10.53)	232 (70.53)	
9 to 12 years	405 (40.5)	356 (52.69)	68 (20.69)	
> 12years	261 (26.1)	248 (36.77)	29 (8.78)	
House-hold income				< 0.001
Dissatisfying	190 (18.9)	80 (11.77)	101 (30.6)	
Neutral	560 (55.8)	374 (55.43)	186 (56.63)	
Satisfying	252 (25.1)	221 (32.8)	42 (12.77)	
Living in the city (vs rural area)	622 (62.0)	503 (74.58)	136 (41.54)	< 0.001
No support	154 (15.4)	91 (13.51)	61 (18.58)	< 0.001

Characteristics of the participants stratified by the two sub-groups				
n (%)	All	The first social sub-group	The second social sub-group	P-values*
Long-Term Care (LTC)	140 (13.9)	87 (12.9)	53 (16.1)	0.20
80 years old	804 (80.1)	547 (81.0)	257 (78.1)	0.32
90 years old	200 (19.9)	128 (19.0)	72 (21.9)	0.32
Female	542 (54.0)	370 (54.8)	172 (52.4)	0.52
History of joint pain	334 (33.3)	231 (34.2)	103 (31.3)	0.40
History of osteoporosis	215 (21.4)	148 (21.9)	67 (20.4)	0.63
History of stroke	71 (7.1)	48 (7.1)	23 (7.0)	> 0.99
History of heart disease	209 (20.8)	142 (21.0)	67 (20.4)	0.87
Hypertension	741 (73.8)	496 (73.5)	245 (74.5)	0.80
Hyperlipidemia	583 (58.1)	404 (59.9)	179 (54.4)	0.12
Diabetes	130 (12.9)	81 (12.0)	49 (14.9)	0.24
History of lung disease	188 (18.7)	140 (20.7)	48 (14.6)	0.02
History of cancer	153 (15.2)	113 (16.7)	40 (12.2)	0.07

* Comparisons between the first and second sub-groups by chi-square test.

2.5. Statistical analyses

To derive social profiles from observed variables related to social factors, we conducted Latent Class Analysis. LCA is a form of categorical data analysis hypothesizing that latent categorical variables equivalent to latent classes (i.e., sub-groups) explains patterns of responses to categorical observed variables, and that the latent classes are mutually exclusive. Thus, we can obtain sub-groups that one person in a certain sub-groupshares a similar pattern of responses to the categorical observed variables with other persons in the same sub-group. Additionally, characteristics of the sub-groups can be considered as profiles of responses to the categorical variables of interest.

To obtain the latent sub-groups related to the social factors, we used the following four social observed variables for LCA: education, household income, residential area, and supporting condition. To determine the optimal number of the sub-groups, we compared models with one group, two sub-groups, three sub-groups, and four sub-groups. The best model was determined by Bayesian Information Criterion (BIC), a good-of-fit index that considers the rule of parsimony. Once the number of sub-groups was determined, characteristics of the sub-groups as the social profiles were summarized.

After we obtained social profiles, we investigated associations of each of the chronic and lifestyle-related diseases with LTC by logistic regression models. We obtained odds ratios (ORs) and 95% confidence intervals (CI). Model 1 was adjusted for age (80 years old / 90 years old) and sex (male/female). Model 2, fully-adjusted model, was model 1 with additional adjustment for the sub-groups derived by LCA (the first social sub-group/the second social sub-group), and the other chronic and lifestyle-related diseases of interest (i.e., those diseases were mutually adjusted in the same model). Additionally, we investigated interactions between those diseases and the sub-groups of the social factors in relation to LTC because those diseases and ADL decline have been reported to be associated with social factors (Lindsay Smith et al., 2017; Sommer et al., 2015). When we found the significant interaction terms, we investigated associations of those diseases with LTC stratified by the sub-groups of the social factors.

All statistical analyses were performed by statistical software R version 3.4.0. Latent class analyses were conducted by poLCA, an R package (Linzer & Lewis, 2011).

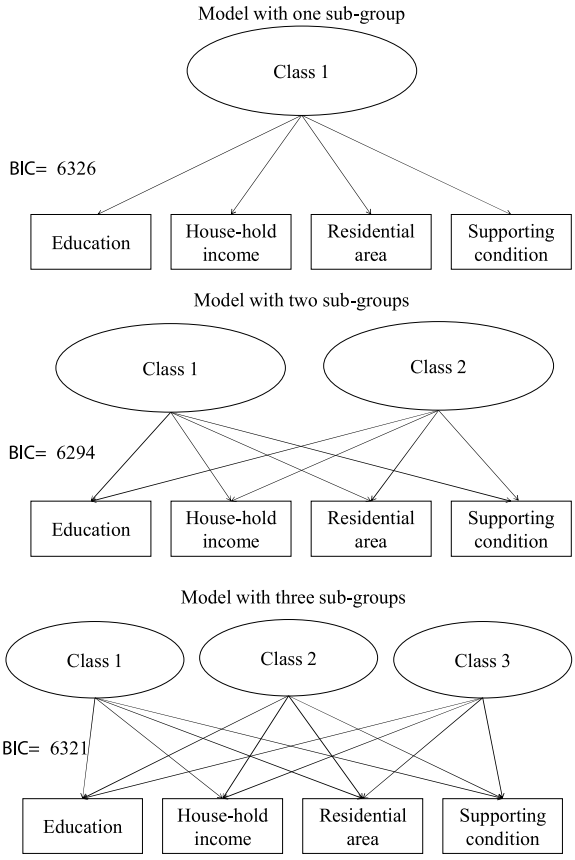

Fig. 1. Concept of Latent Class Analysis.
Each observed variable is partially explained by the latent classes (This is indicated by arrows). Ovals indicate latent variables. Squares indicate observed variables. BIC of model with four sub-group was 6352. Abbreviations: BIC, Bayesian Information Criterion.

3. Results

Of the eligible 1004 participants, 804 (80.1%) were 80 years old, 542 (54.0%) were females, and 140 (13.9%) had LTC. Additionally, many participants had hypertension (58.1%) and hyperlipidemia (73.8%) (Table1). Characteristics of the present participants were summarized in Table 1.

To find the number of sub-groups related to social factors and derive social profiles, we performed LCA using the following observed social variables: education, house-hold income, living in urban area, and no support. We investigated models with one group, two sub-groups, three sub-groups, and four sub-groups, and compared those models by BIC (Fig. 1). BIC were 6326 for model with one group, 6294 for model with two sub-groups, 6321 for three sub-groups, and 6352 for four sub-

Table 2
Adjusted Odds Ratios (95% CI) of LTC by diseases.

Chronic diseases and Lifestyle-related diseases		Model1[a]	Model2[b]	P-values for interaction[c]
Sex	Male	1 (Ref.)	–	–
	Female	1.98 (1.33, 2.98)	–	–
Age	80 years old	1 (Ref.)	–	–
	90 years old	7.83 (5.31, 11.62)	–	–
Sub-groups of the social factors	The first social sub-group	1 (Ref.)	–	–
	The second social sub-group	1.24 (0.83, 1.86)	–	–
History of stroke	No	1 (Ref.)	1 (Ref.)	0.28
	Yes	4.68 (2.54, 8.50)	4.69 (2.49, 8.71)[1]	
History of heart disease	No	1 (Ref.)	1 (Ref.)	> 0.99
	Yes	1.62 (1.03, 2.50)	1.56 (0.97, 2.47)	
Hypertension	No	1 (Ref.)	1 (Ref.)	0.32
	Yes	0.89 (0.57, 1.39)	0.87 (0.55, 1.39)	
Hyperlipidemia	No	1 (Ref.)	1 (Ref.)	0.21
	Yes	0.90 (0.61, 1.34)	0.90 (0.6, 1.35)	
Diabetes	No	1 (Ref.)	1 (Ref.)	0.78
	Yes	1.22 (0.70, 2.05)	1.19 (0.67, 2.07)	
History of joint pain	No	1 (Ref.)	1 (Ref.)	0.10
	Yes	2.14 (1.44, 3.18)	2.22 (1.46, 3.38)	
History of osteoporosis	No	1 (Ref.)	1 (Ref.)	< 0.001
	Yes	1.97 (1.23, 3.15)	1.99 (1.22, 3.25)	
History of lung disease	No	1 (Ref.)	1 (Ref.)	0.63
	Yes	1.24 (0.76, 1.98)	1.20 (0.72, 1.97)	
History of cancer	No	1 (Ref.)	1 (Ref.)	0.09
	Yes	1.86 (1.13, 3.00)	2.05 (1.22, 3.4)	

[a] Model1 adjusted for sex and age.
[b] Model2 adjusted for sex, age, sub-groups of the social factors obtained by latent class analysis in Table 2, and the other chronic and life-related diseases of interest (i.e., those diseases were mutually adjusted in the same model). Note that when history of osteoporosis was main predictor, history of joint pain was not adjusted in the Model2, because history of joint pain would be an intermediate variable.
[c] Interaction between diseases and latent class of social demographic factors. Abbreviations: CI, confidence interval; Ref, reference.

Table 3
Multivariable-adjusted odds ratios (95% CI) of LTC for osteoporosis, stratified by the sub-groups of the social factors and sex [a].

	Osteoporosis	ORs in the first social sub-group (n = 675)	ORs in the second social sub-group (n = 329)
Males and Females	No	1 (Ref.)	1 (Ref.)
	Yes	2.93 (1.66, 5.2)	0.80 (0.32, 1.92)
Males	No	1 (Ref.)	1 (Ref.)
	Yes	2.42 (0.24, 15.92)	NA
Females	No	1 (Ref.)	1 (Ref.)
	Yes	3.62 (1.88, 7.19)	0.84 (0.3, 2.24)

[a] All models were stratified by the sub-groups of the social factors obtained by LCA in Table 2. All models were adjusted for age, sex, histories of stroke, heart disease, lung disease, and cancer, hypertension, hyperlipidemia, and diabetes. Abbreviations: CI, confidence interval; Ref, reference; LTC, long-term care.

groups. We determined the model with two sub-groups as the best model because of the lowest BIC among the four models.

In the best model, 675 (67.2%) participants belonged to Latent class 1 (the first social sub-group) and 329 (32.8%) to Latent class 2 (the second social sub-group). Compared to the second social sub-group participants, the first social sub-group participants were likely to be educated for a longer time, to be satisfied with their household income, and to live in an urban area. We summarized the detailed characteristics of the sub-groups of the social factors equivalent to the social profiles, and characteristics of the present participants stratified by the two sub-groups (Table 1).

We investigated the association of those diseases with LTC (Table 2). LTC was significantly associated with the histories of stroke, heart disease, joint pain, osteoporosis, and cancer. ORs (95%CI) of LTC were 4.68 (2.54, 8.50) for having stroke, 1.62 (1.03, 2.50) for having heart diseases, 2.14 (1.44, 3.18) for having joint pain, 1.97 (1.23, 3.15) for having osteoporosis, and 1.86 (1.13, 3.00) for having cancer. OR (95%CI) of LTC was 1.24 (0.83, 1.86) for the second social sub-group compared with the first social sub-group. We obtained similar results in model 2 as the fully-adjusted model.

Additionally, we found a significant interaction between osteoporosis and the sub-groups of the social factors ($p < 0.001$) in relation to LTC, though there were no significant interactions between the sub-groups of the social factors and the other chronic and lifestyle-related diseases ($p > 0.09$) (Table 2). Thus, we investigated associations between the history of osteoporosis and LTC stratified by the sub-groups of the social factors using logistic regression analyses (Table 3). ORs (95%CI) of LTC for having osteoporosis compared with no having osteoporosis were 2.93 (1.66, 5.2) in the first social sub-group and 0.80 (0.32, 1.92) in the second social sub-group. Because osteoporosis prevalence was different between men and women, we investigated the association of osteoporosis with LTC stratified by sex and the sub-groups of the social factors (Table 3). Compared with not having osteoporosis, ORs (95%CI) of LTC for having osteoporosis were 3.62 (1.88, 7.19) in women with the first social sub-group, and were 0.84 (0.3, 2.24) in women with the second social sub-group.

4. Discussion

The present study aimed to investigate the associations between LTC and chronic and lifestyle-related diseases adjusted for the sub-groups of social factors, and to consider whether they can be modified. LTC was significantly associated with histories of stroke, heart disease, joint pain, osteoporosis, and cancer with adjustment for the two social sub-groups derived by LCA; the first social sub-group, 67.2% and the second social sub-group, 32.8%. Almost all of the associations between LTC and chronic and lifestyle-related diseases were not significantly modified by the two social sub-groups except for osteoporosis. The association of osteoporosis with LTC was significantly modified by the social sub-groups, and the association was significant in the first social sub-group but not in the second social sub-group.

The present results of the social sub-groups derived by LCA were similar to those of previous studies that also utilized LCA to derive social sub-groups (Scharoun-Lee et al., 2011; Yuan et al., 2014). In the present study, compared with the second social sub-group participants, the first social sub-group participants had higher prevalence of long-term education, satisfaction for household income, and living in urban areas. In the previous study, five sub-groups of socioeconomic status were derived based on education, income, residence, employment, and transitions in social roles (Scharoun-Lee et al., 2011). The five sub-groups can be roughly categorized into two types of which one was characterized by high education and high income and the other was characterized by low education and low income. Additionally, living in an urban area was associated with high socioeconomic status, and living in a rural area was associated with low socioeconomic status (Gordon, 2003). Thus, the two sub-groups of the social factors in the present can be supported by those previous studies.

We expected significant associations between the sub-groups of the social factors and LTC because many previous studies found significant associations between social factors and ADL decline (Aida et al., 2013; Kingston et al., 2015; Neugebauer & Katz, 2004). However, the present study showed no significant association between the sub-groups of the social factors and LTC. This might have to do with differences between ADL and LTC. Additionally, the previous studies treated the social variables by each single observed variable (Aida et al., 2013; Kingston et al., 2015; Neugebauer & Katz, 2004), though the present study treated them by latent variables derived from multiple observed variables. Previous studies have discussed that statistical results and conclusions could be biased when social variables were treated as each single predictor in statistical models (Braveman et al., 2005; Pollack et al., 2007). In the real world, people have social profiles that are a multi-dimensional phenomenon and based on multiple social variables (Savage et al., 2005). Thus, further studies are required to clarify whether social profiles (i.e., characteristics of the social sub-groups) are associated with LTC and ADL.

The present study showed the significant association between LTC and chronic and lifestyle-related diseases, which were similar to previous studies. In the present study, histories of stroke, heart disease, joint pain, osteoporosis, and cancer, were significantly associated with LTC. These associations were presented in several previous studies (Naruse, Sakai, Matsumoto, & Nagata, 2015; W. Chen et al., 2013; Ito, Inagaki, Okamura, Shimokado, & Awata, 2012), which meant that the present results were supported by those previous results. The present study newly showed that the associations were significant even after adjusting for the sub-groups of social factors reflecting the social profiles. Additionally, the present study showed no significant interactions between the social sub-groups and histories of stroke, heart disease, joint pain and cancer in relation to LTC. Thus, the preset study showed that those four diseases were significantly associated with LTC regardless of social sub-groups. Because these four diseases were ranked highly in the causes of death in Japan, those who suffered from any of these diseases are likely to receive LTC. Thus, social sub-groups did not modify the association between those four diseases and LTC.

Although the present study showed no significant interactions between the social sub-groups and the four diseases in relation to LTC, there was a significant interaction between the social sub-groups and osteoporosis in relation to LTC ($p < 0.001$). We additionally conducted the analyses stratified by social sub-groups of which the main predictor was osteoporosis. As a result, in the first social sub-group, osteoporosis was significantly associated with LTC (ORs = 2.93 95%CI, 1.66, 5.2), though in the second social sub-group, osteoporosis was not significantly associated with LTC (ORs = 0.80 95%CI, 0.32, 1.92). Possible reasons of this difference can be as follows. According to previous research, low-educated people tend not to use public healthcare service (Pirisi, 2000). Receiving LTC insurance can be seen as use of public healthcare service. In addition, osteoporosis could indirectly link to death or ADL decline. Thus, osteoporosis was not significantly associated with LTC in people categorized into the second social sub-group characterized by low education, but significantly associated with LTC in people of the first social sub-group. Therefore, it may be beneficial to provide public health service information to low-educated people.

Additionally, in females of the first social sub-group, osteoporosis was significantly associated with LTC (OR = 3.62, 95%CI, 1.88 7.19), though in male of the first social sub-group, osteoporosis was not significantly associated with LTC (OR = 2.42, 95%CI, 0.24 15.92). Possible reasons of the sex difference can be a pathogenetic mechanism of elderly female. Elderly females likely suffer from osteoporosis (Zebaze et al., 2010) because estrogen deficiency during menopause causes bone fragility and leads to postmenopausal osteoporosis.

4.1. Limitation and strength

The strength of the present study was deriving social sub-groups by LCA. Due to the feature of LCA, we were able to derive the social sub-groups without priori assumptions or biases introduced by researchers (Kato, Sullivan, & Pedersen, 2010). Additionally, in the real world, the social sub-groups contain several social factors, which can be adequately treated by LCA.

Nevertheless, the present study had the following limitations. First, the present study used a cross-sectional design. Therefore, we could not consider the causality of the association between diseases and LTC. Second, the number of people with LTC may be underestimated because the present study assessed LTC by use of LTC insurance. There may be people with LTC who did not use LTC insurance. Third, we could not consider levels of LTC because of the small number of present participants with severe levels of LTC. Fourth, the present study used the limited number of social factors when deriving the social sub-groups (i.e., education, household income, residential area, and supporting condition). Deriving social subgroups that reflect real-world social subgroups requires more social factors such as income, housing condition, and occupation.

5. Conclusion

The present study showed that people aged around 80 and 90 years old could be categorized into the two social sub-groups by LCA because many previous studies did not consider social sub-groups of which characteristics can show social profiles. In the present study, the social sub-groups derived by LCA were not significantly associated with LTC. However, chronic and lifestyle-related diseases were significantly associated with LCA even after adjustment for the social sub-groups. Interestingly, there was a significant interaction between osteoporosis and the social sub-groups in relation to LTC. Osteoporosis was significantly associated with LTC in the first social sub-group, but not significantly in the second social sub-group. This may suggest that it could be important to provide health information related to public services of LTC for the elderly, especially for those who are low-educated, a feature of the second social sub-group participants.

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Declarations of interest

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References

Aida, J., Kondo, K., Kawachi, I., Subramanian, S. V., Ichida, Y., Hirai, H., ... Watt, R. G. (2013). Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. *Journal of Epidemiology and Community Health, 67*(1), 42–47. https://doi.org/10.1136/jech-2011-200307.

Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., ... Chatterji, S. (2016). The World report on ageing and health: A policy framework for healthy ageing. *The Lancet, 387*(10033), 2145–2154. https://doi.org/10.1016/S0140-6736(15)00516-4.

Braveman, P. A., Cubbin, C., Egerter, S., Chideya, S., Marchi, K. S., Metzler, M., ... Posner, S. (2005). Socioeconomic status in health research. *JAMA, 294*(22), 2879. https://doi.org/10.1001/jama.294.22.2879.

Chen, B. K., Jalal, H., Hashimoto, H., Suen, S., Eggleston, K., Hurley, M., ... Bhattacharya, J. (2016). Forecasting trends in disability in a super-aging society: Adapting the Future Elderly Model to Japan. *Journal of the Economics of Ageing, 8*, 42–51. https://doi.org/10.1016/j.jeoa.2016.06.001.

Chen, W., Fukutomi, E., Wada, T., Ishimoto, Y., Kimura, Y., Kasahara, Y., ... Matsubayashi, K. (2013). Comprehensive geriatric functional analysis of elderly populations in four categories of the long-term care insurance system in a rural. *depopulated and aging town in Japan,* 63–69. https://doi.org/10.1111/j.1447-0594.2012.00859.x.

Gordon, D. (2003). *Area-based deprivation measures: A U.K. Perspective. Neighborhoods and health*. Oxford University Press179–208. https://doi.org/10.1093/acprof:oso/9780195138382.003.0008.

Haneda, M., Noda, M., Origasa, H., Noto, H., Yabe, D., Fujita, Y., ... Araki, E. (2018). Japanese clinical practice guideline for diabetes 2016. *Journal of Diabetes Investigation, 9*(3), 657–697. https://doi.org/10.1111/jdi.12810.

Ito, K., Inagaki, H., Okamura, T., Shimokado, K., & Awata, S. (2012). Factors associated with mental health well-being of urban community-dwelling elders in Japan: comparison between subjects with and without long-term care insurance certification. *Nihon Ronen Igakkai Zasshi Japanese Journal of Geriatrics, 49*(1), 82–89. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22466777.

Kario, K. (2015). Key points of the Japanese society of hypertension guidelines for the management of hypertension in 2014. *Pulse (Basel, Switzerland), 3*(1), 35–47. https://doi.org/10.1159/000381300.

Kato, K., Sullivan, P. F., & Pedersen, N. L. (2010). Latent class analysis of functional somatic symptoms in a population-based sample of twins. *Journal of Psychosomatic Research, 68*(5), 447–453. https://doi.org/10.1016/j.jpsychores.2010.01.010.

Kingston, A., Davies, K., Collerton, J., Robinson, L., Duncan, R., Kirkwood, T. B. L., ... Jagger, C. (2015). The enduring effect of education-socioeconomic differences in disability trajectories from age 85 years in the Newcastle 85+ Study. *Archives of Gerontology and Geriatrics, 60*(3), 405–411. https://doi.org/10.1016/j.archger.2015.02.006.

Lindsay Smith, G., Banting, L., Eime, R., O'Sullivan, G., & van Uffelen, J. G. Z. (2017). The association between social support and physical activity in older adults: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 56. https://doi.org/10.1186/s12966-017-0509-8.

Linzer, D. A., & Lewis, J. B. (2011). poLCA : An *R* package for polytomous variable latent class analysis. *Journal of Statistical Software, 42*(10), 1–29. https://doi.org/10.18637/jss.v042.i10.

Long-Term Care Insurance Act. (n.d.). Retrieved February 8, 2018, from http://www.japaneselawtranslation.go.jp/law/detail_main%3Fvm%3D%26id%3D94.

Mackenbach, J. P., Stirbu, I., Roskam, A.-J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., ... Kunst, A. E. (2008). Socioeconomic inequalities in health in 22 european countries. *The New England Journal of Medicine, 358*(23), 2468–2481. https://doi.org/10.1056/NEJMsa0707519.

Ministry of Health, Labour and Welfare. Kaigoyobou Manual Kaiteiban (2017). *Manual for preventive care; 2016.* Retrieved fromhttp://www8.cao.go.jp/kourei/whitepaper/w-2017/zenbun/pdf/1s2s_03.pdf.

Ministry of Public Management (2014). *Estimate of the population* (n.d.) Retrieved November 15, 2017, fromhttp://www.stat.go.jp/data/jinsui/2014np/index.htm.

Naruse, T., Sakai, M., Matsumoto, H., & Nagata, S. (2015). Diseases that precede disability among latter-stage elderly individuals in Japan. *Bioscience Trends, 9*(4), 270–274. https://doi.org/10.5582/bst.2015.01059.

Neugebauer, A., & Katz, P. P. (2004). Impact of social support on valued activity disability and depressive symptoms in patients with rheumatoid arthritis. *Arthritis Care & Research, 51*(4), 586–592. https://doi.org/10.1002/art.20532.

Pirisi, A. (2000). Low health literacy prevents equal access to care. *Lancet (London, England), 356*(9244), 1828. https://doi.org/10.1016/S0140-6736(05)73297-9.

Pollack, C. E., Chideya, S., Cubbin, C., Williams, B., Dekker, M., & Braveman, P. (2007). Should Health Studies Measure Wealth? *American Journal of Preventive Medicine, 33*(3), 250–264. https://doi.org/10.1016/j.amepre.2007.04.033.

Savage, M., Warde, A., & Devine, F. (2005). Capitals, assets, and resources: Some critical issues1. *The British Journal of Sociology, 56*(1), 31–47. https://doi.org/10.1111/j.1468-4446.2005.00045.x.

Scharoun-Lee, M., Gordon-Larsen, P., Adair, L. S., Popkin, B. M., Kaufman, J. S., & Suchindran, C. M. (2011). Intergenerational profiles of socioeconomic (Dis) advantage and obesity during the transition to adulthood. *Demography, 48*(2), 625–651. https://doi.org/10.1007/s13524-011-0024-5.

Sommer, I., Griebler, U., Mahlknecht, P., Thaler, K., Bouskill, K., Gartlehner, G., ... Mendis, S. (2015). Socioeconomic inequalities in non-communicable diseases and their risk factors: An overview of systematic reviews. *BMC Public Health, 15*(1), 914. https://doi.org/10.1186/s12889-015-2227-y.

Teramoto, T., Sasaki, J., Ishibashi, S., Birou, S., Daida, H., Dohi, S., ... Japan Atherosclerosis Society Committee for Epidemiology and Clinical Management of Atherosclerosis (2014). Diagnosis of atherosclerosis. Executive summary of the japan atherosclerosis society (JAS) guidelines for the diagnosis and prevention of atherosclerotic cardiovascular diseases in Japan—2012 version. *Journal of Atherosclerosis and Thrombosis, 21*(4), 296–298. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24335045.

van der Vorst, A., Zijlstra, G. A. R., De Witte, N., Duppen, D., Stuck, A. E., Kempen, G. I. J. M., ... D-SCOPE Consortium (2016). Limitations in activities of daily living in community-dwelling people aged 75 and over: A systematic literature review of risk and protective factors. *PloS One, 11*(10), e0165127. https://doi.org/10.1371/journal.pone.0165127.

Yeh, K.-P., Lin, M.-H., Liu, L.-K., Chen, L.-Y., Peng, L.-N., & Chen, L.-K. (2014). Functional decline and mortality in long-term care settings: Static and dynamic approach. *Journal of Clinical Gerontology and Geriatrics, 5*(1), 13–17. https://doi.org/10.1016/J.JCGG.2013.08.001.

Yuan, C., Wei, C., Wang, J., Qian, H., Ye, X., Liu, Y., ... Hinds, P. S. (2014). Self-efficacy difference among patients with cancer with different socioeconomic status: Application of latent class analysis and standardization and decomposition analysis. *Cancer Epidemiology, 38*(3), 298–306. https://doi.org/10.1016/J.CANEP.2014.02.012.

Zebaze, R. M., Ghasem-Zadeh, A., Bohte, A., Iuliano-Burns, S., Mirams, M., Price, R. I., ... Seeman, E. (2010). Intracortical remodelling and porosity in the distal radius and post-mortem femurs of women: A cross-sectional study. *The Lancet, 375*(9727), 1729–1736. https://doi.org/10.1016/S0140-6736(10)60320-0.