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Influence of co-existing social isolation and homebound status on medical care utilization and expenditure among older adults in Japan

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ABSTRACT

Objective: To examine whether co-existing social isolation and homebound status influence medical care utilization and expenditure in older adults.
Methods: Postal surveys on social isolation and homebound status were performed on older adults aged ≥65 years residing in a Japanese suburban city. Information on medical care utilization and expenditure was obtained from insurance claims data. These outcomes were examined over a three-year period (December 2008 to November 2011) for all participants (Analysis I, n = 1386) and during the last year of life for mortality cases (Analysis II, n = 107). A two-part model was used to analyze the influence of social isolation and homebound status on medical care utilization (first model: logistic regression model) and its related expenditure (second model: generalized linear model).
Results: Almost 12 % of participants were both socially isolated and homebound. Analysis I showed that these participants were significantly less likely to use outpatient and home medical care than participants with neither characteristic (odds ratio: 0.536, 95 % confidence interval: 0.303−0.948). However, Analysis II showed that participants with both characteristics had significantly higher daily outpatient and home medical expenditure in the year before death than participants with neither characteristic (risk ratio: 2.155, 95 % confidence interval: 1.338−3.470).
Discussion: Older adults who are both socially isolated and homebound are less likely to regularly utilize medical care, which may eventually lead to serious health problems that require more intensive treatment. Measures are needed to encourage the appropriate use of medical care in these individuals to effectively manage any existing conditions.

1. Introductions

Social isolation has become a major issue in aging societies worldwide. Socially isolated people generally have a higher prevalence of chronic diseases (Shankar, McMunn, Banks, & Steptoe, 2011; Valtorta, Kanaan, Gilbody, Ronzi, & Hanratty, 2016), higher mortality rates (Heffner, Waring, Roberts, Eaton, & Gramling, 2011; Holt-Lunstad, Smith, & Layton, 2010; Sakurai et al., 2018), poorer well-being (Dahlberg & McKee, 2018), and diminished functional capacity in daily life activities (Anme, 1997; Jingu, Egami, Kinukawa, Sano, & Takei, 2003). Moreover, these individuals may have a greater propensity to be homebound, which is a simple prognostic indicator of poor health

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; LSEHI, Latter-Stage Elderly Health Insurance; IADL, instrumental activities of daily living; NHI, National Health Insurance; RR, risk ratio.

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(Cohen-Mansfield, Shmotkin, & Hazan, 2010; Fujita, Fujiwara, Chaves, Motohashi, & Shinkai, 2006; Ganguli, Fox, Gilby, & Belle, 1996; Jacobs et al., 2008; Soones, Federman, Leff, Siu, & Ornstein, 2017). Homebound status is also reported to be positively associated with physical disability (Fujita et al., 2006; Jacobs et al., 2008), hospitalization (Ganguli et al., 1996), and mortality (Cohen-Mansfield et al., 2010; Soones et al., 2017) in older adults. Social isolation describes a general lack of social contact and reduced social network size, and homebound refers to the state of rarely or never leaving one's home (Fujiwara et al., 2017; Sakurai et al., 2018).

The above studies suggest that social isolation and homebound status may have independent deleterious health effects. Although the co-existence of these two characteristics in an individual may produce an interactive and cumulative effect on health, few studies have examined the influence of co-existing social isolation and homebound status on health status. Only one previous study found that approximately 10 % of older Japanese adults had co-existing social isolation and homebound status, which increased their risk of all-cause mortality (Sakurai et al., 2018). Social isolation and homebound status have also been identified as independent predictors of non-participation in public health care services (such as health checkups) to prevent chronic diseases in Japan (Funahashi, 2013; Sugisawa & Sugihara, 2011; Yoshida et al., 2008). A systematic review reported that weaker social relationships are associated with higher rates of hospital readmission and longer hospital stay (Valtorta, Moore, Barron, Stow, & Hanratty, 2018). Accordingly, we posited that co-existing social isolation and homebound status may impede the adequate use of preventive care and early access to medical care services regardless of need, thereby leading to serious health problems that require more intensive treatment (including hospitalization). However, to the best of our knowledge, no previous studies have examined the association of co-existing social isolation and homebound status with the use of medical care services.

Based on previous findings, we formulated two separate hypotheses on the influence of co-existing social isolation and homebound status on the use of medical care services. The first hypothesis is that older adults with co-existing social isolation and homebound status have less contact with medical care than those with either characteristic alone. Furthermore, both social isolation and homebound status may impede early access to medical care services, resulting in affected individuals seeking care only after their conditions have deteriorated. A previous study reported that older Japanese adults with co-existing social isolation and homebound status had an increased risk of mortality (Sakurai et al., 2018), and we posit that the deteriorated health statuses near the end of life would result in an increased use of medical services. Therefore, the second hypothesis is that co-existing social isolation and homebound status leads to increased medical spending at the end of life. To test these hypotheses, we performed a postal survey to determine whether co-existing social isolation and homebound status influence medical care utilization and expenditure among older adults during the three years following the survey and during the last year of life.

2. Methods

2.1. Study design and participants

The study area was the suburban city of Wako in Saitama prefecture, which is located to the north of Tokyo, Japan. The city's Basic Resident Registry was used to identify community-dwelling older adults aged 65 years or older. Data for analysis were obtained using two postal surveys (designated T1-A and T1-B) targeting these older adults residing in the city. The surveys excluded those living in institutional care facilities and those certified as Care Needs Level 2 (indicating partial dependence in daily life activities, such as toileting or feeding) or higher. A more detailed description of this study design is available elsewhere (Fujiwara et al., 2017). T1-A was sent to a total of 2528 residents, and T1-B was sent to 1641 residents living in single-person households.

Both surveys (T1-A and T1-B) used the same questionnaire, which comprised queries on social isolation, homebound status, demographic data (sex, age, educational level, resident status, and household income), and health status. The T1-A and T1-B surveys were conducted between July and December 2008. As the T1 questionnaire did not include queries on medical history, a follow-up questionnaire (designated T2) was sent to the participants two years later (July to August 2010) to obtain information on their medical history of chronic diseases (cardiovascular disease, liver disease, or other diseases) at the time of T1. Finally, another follow-up survey (designated T3) was sent in July 2012 to obtain updated information on the participants' health statuses.

2.2. Social isolation and homebound status

Based on previous studies conducted in Japan, we defined social isolation as a low frequency of contact with people other than co-residing family members (Kobayashi et al., 2011; Saito, Kondo, Kondo, Ojima, & Hirai, 2012; Saito, Kondo, Ojima, Hirai, & group, 2015; Sakurai et al., 2018; Takahashi et al., 2020). In accordance with those studies, social isolation was evaluated with each participant's frequency of face-to-face and non–face-to-face contact using the following four questions in the T1 survey: "How often do you see your family members or relatives who are living apart?", "How often do you make contact with your family members or relatives who are living apart by telephone, fax, or email?", "How often do you see your friends or neighbors?", and "How often do you make contact with your friends or neighbors by telephone, fax, or email?". We provided the following eight response options for each question: "6–7 times a week", "4–5 times a week", "2–3 times a week", "once a week", "2–3 times a month", "once a month", "less than once a month", and "almost never". The four questions demonstrated an acceptable internal consistency among our study participants (Cronbach's alpha = 0.70). The internal consistency of these four questions has also been previously confirmed (Saito et al., 2015). For this study, respondents who selected "2–3 times a month" or less frequent options for both non–co-residing family members or relatives and friends or neighbors were considered to be socially isolated (Kobayashi et al., 2011; Sakurai et al., 2018).

Homebound status was determined based on each participant's frequency of going outside using the following question in the T1 survey: "How often do you usually go outdoors? (e.g., going shopping, taking a walk, going to the hospital, or going to work or to participate in social activities)" (Fujita et al., 2006; Jacobs et al., 2008; Sakurai et al., 2014, 2017; Sakurai et al., 2018). The provided response options were "twice a day or more", "once a day", "once every 2–3 days", and "once a week or less"; participants who selected the latter two options (i.e., going out less than once a day) were considered to be "pre-homebound" as described in a previous study (Fujiwara et al., 2017). However, older adults who live alone are unlikely to lead an independent life if they go outside their homes so infrequently. As this study included a large proportion of such individuals, we regarded pre-homebound status to be the equivalent of being homebound (Fujiwara et al., 2017).

2.3. Outcome variables: medical care utilization and expenditure

Patient-level information on medical care utilization and expenditure was obtained from claims data for National Health Insurance (NHI) and Latter-Stage Elderly Health Insurance (LSEHI). In Japan, employed individuals and their dependents are covered by employment-based insurance, and the self-employed and retired population aged below 75 years are covered by the NHI. All older adults aged 75 years or older are covered by LSEHI. The claims data are generated by medical institutions for the purpose of reimbursement from insurers, and include the number of days that each patient used outpatient and home medical care or inpatient care. The data also contain the associated expenditures per month.

The following four outcomes were examined for both outpatient and

inpatient care: (1) utilization of medical care (yes or no), (2) number of days of medical care utilization, (3) medical expenditure, and (4) medical expenditure per day of medical care utilization. Medical expenditure per day of medical care utilization was calculated to measure the quantity (intensity) of medical care provided to a patient, thereby indicating the severity of his/her medical condition. The outcomes were extracted from the claims data for a three-year study period (December 2008 to November 2011) for all participants and for one year before death for mortality cases. Expenditures were converted from Japanese yen to US dollars using the December 2008 exchange rate (USD 1 = JPY 91) (OECD.Stat, 2018).

2.4. Covariates

To account for variations in participant characteristics, we selected other variables available from the T1 and T2 surveys that have been previously used for risk adjustments (T1 survey: sex, age, educational level, resident status, household income, instrumental activities of daily living [IADL], subjective health status, and depressive symptoms; T2 survey: chronic diseases) (Sakurai et al., 2018). Educational level was determined based on the highest level of education attained by each participant ("Senior high school/junior college or lower" or "University or higher"). For resident status, the participants were asked if they lived with any family members. Furthermore, participants were categorized according to household income ("<3 million yen" or "≥3 million yen", where 3 million yen is approximately $33,000; USD 1 = JPY 91).

Questions regarding IADL were derived from the instrumental self-maintenance scale of the Tokyo Metropolitan Institute of Gerontology Index of Competence (Koyano, Shibata, Nakazato, Haga, & Suyama, 1991; Yoshida et al., 2007). These items included going out using public transportation, shopping for daily necessities, preparing meals, paying bills, and banking. The response to each item was "yes'' (able to do without the help of another person or special equipment) or "no'' (unable to do without the help of another person or special equipment). In this study, only subjects who were assessed as being independent in all the IADL items listed above were regarded as IADL independent (Ishizaki et al., 2006).

Participants reported their subjective health statuses as "excellent", "good", "fair", or "poor"; they were then assigned to either a good (excellent or good) or poor (fair or poor) group. Depressive symptoms were assessed using the 15-item short form of the Geriatric Depression Scale, with scores ranging from 0 to 15; participants were classified as having high (≥6 points) or low (<5 points) depressive symptoms based on the criteria used in a previous study (Kobayashi et al., 2011). Information on chronic diseases was obtained from the T2 survey responses.

2.5. Analyses

Participants were categorized into the following four groups based on combinations of social isolation and homebound status as described in a previous study (Sakurai et al., 2018): Group 1 comprised individuals who were neither socially isolated nor homebound, Group 2 comprised individuals who were socially isolated but not homebound, Group 3 comprised individuals who were not socially isolated but homebound, and Group 4 comprised individuals who were both socially isolated and homebound. We examined the differences in characteristics among the four groups using the chi-square test.

Next, a two-part model was used to estimate the associations of these groups with the (1) utilization of medical care, (2) number of days of medical care utilization, (3) medical expenditure, and (4) medical expenditure per day of medical care utilization separately for outpatient/home medical care and inpatient care. Because the number of days of medical care utilization, medical expenditure, and medical expenditure per day are expected to have a large number of zero values, the two-part model approach was selected due to its usefulness in addressing such distributions in outcome variables (Diehr, Yanez, Ash, Hornbrook, & Lin, 1999; Ishizaki et al., 2017).

Analysis I was conducted using all participants. The first model estimated the probability that an individual would use medical care during the three-year study period (December 2008 to November 2011), and the second model estimated the number of days of medical care utilization, medical expenditure, and medical expenditure per day of medical care utilization. Analysis II was conducted using only mortality cases. The outcome variable of the first model was the utilization of medical care during the year before death, and the outcome variable of the second model was medical expenditure per day of medical care utilization during the year before death.

For both Analyses I and II, we used logistic regression models for the first model and generalized linear models for gamma-distributed data with a log-link function for the second model. Analysis I included the following covariates: sex, age, educational level, resident status, household income, IADL, subjective health, depressive symptoms, and chronic diseases. Analysis II included the following covariates: sex, age, educational level, resident status, household income, IADL, subjective health, and depressive symptoms. Generalized liner models with gamma-distributed data are considered to be suitable for analyses of costs or number of days of medical care utilization because they can address the frequently right-skewed distribution of such data (Dodd, Bassi, Bodger, & Williamson, 2006; Florez-Tanus, Parra, Zakzuk, Caraballo, & Alvis-Guzman, 2018; Ishizaki et al., 2017; Laberge, Wodchis, Barnsley, & Laporte, 2017). In the two-part model, the first equation estimated the probability that an individual has used any medical care services, and the second equation estimated the level of use for those identified as users in the first equation. The expected level of medical care utilization for a participant was then calculated by multiplying these two estimates together (Diehr et al., 1999). The effect size in the first model was quantified using adjusted odds ratios (AORs), which indicate the likelihood of using medical care among the groups. The effect size in the second model was quantified using risk ratios (RRs), which indicate the likelihood of having a higher number of days of medical care utilization, medical expenditure, and medical expenditure per day among the groups. The 95 % confidence intervals (CIs) were also calculated for each variable.

P-values (two-tailed) below 0.05 were considered statistically significant. All analyses were conducted using SPSS version 23.0 (IBM Corp., Armonk, NY, USA).

2.6. Ethics approval

The study was approved (Approval No: 25_1560) by the Ethics Board of the Research Division of the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology. All participants provided informed consent.

3. Results

Fig. 1 shows the flow chart of study participant selection. A total of 4169 questionnaires were sent during the T1 survey, and 2914 responses were obtained (response rate: 69.9 %); of these, 2275 participants provided usable data. These 2275 participants were sent the T2 questionnaire in 2010, and 1782 responses were obtained (response rate: 78.3 %). We excluded 77 participants who had died or moved out from the area of study. Also, we excluded 17 participants who used dialysis or other high-cost medical services (incurring ≥400,000 yen, or approximately $4,395, per month). The rationale for their exclusion was that the extremely high expenditures associated with these patients would severely skew the expenditure estimates and obscure the relationships between the characteristics of interest and care utilization. Finally, we excluded 302 participants who had missing responses for social isolation, homebound status, educational level, resident status, or IADL. The data of the remaining 1386 participants were used in Analysis I. Next, we identified 196 individuals who had died during the time period

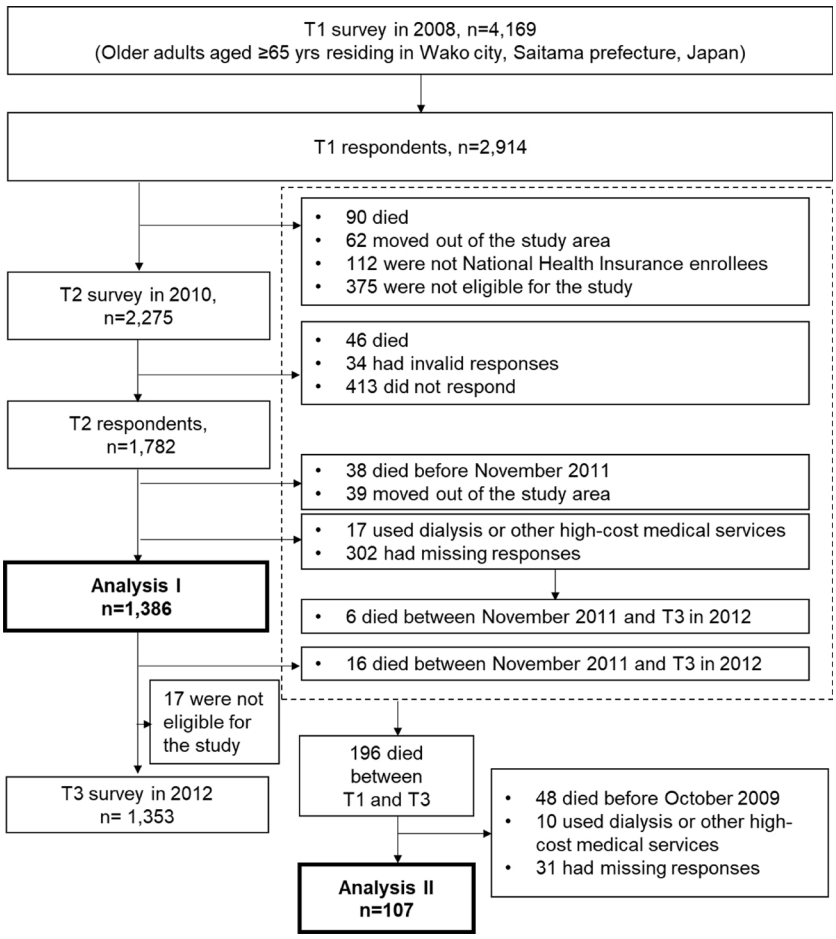

Fig. 1. Flow chart of study participant selection from the baseline T1 survey in 2008 until the follow-up T3 survey in 2012.

between the T1 and T3 surveys using Wako city's Basic Resident Registry. Of these, 48 individuals were excluded from Analysis II due to the lack of medical expenditure data for the year before death. We also excluded 10 participants due to their use of dialysis or other high-cost medical services. Finally, 31 participants were excluded for missing responses. The data of the remaining 107 participants were used in Analysis II.

Table 1 summarizes the characteristics of individuals who were included in and excluded from Analysis I and Analysis II. Participants who were excluded from Analysis I had significantly higher proportions of older adults aged 75 years or older, living with others, no response for income, higher IADL dependence, poorer subjective health, depressive symptoms, and social isolation and/or homebound status than those included in the analysis. Participants who were excluded from Analysis II had significantly higher proportions of participants living with others, higher IADL dependence, and poorer subjective health than those included in the analysis.

3.1. Analysis I

Table 2 summarizes the participants' characteristics according to the groups stratified by combinations of social isolation and homebound status. A total of 159 participants (11.5 %) were classified into Group 4 (both socially isolated and homebound). Participants who were homebound (Groups 3 and 4) generally had higher proportions of older adults aged 75 years or older, lower educational level, lower household income, IADL dependence, poor subjective health, depressive symptoms, and chronic diseases.

Table 3 shows the associations of social isolation and homebound status with medical care utilization and the number of days of medical care utilization during the three-year study period in Analysis I. Group 4 participants were significantly less likely to use outpatient and home medical care than Group 1 participants (AOR: 0.536, 95 % CI: 0.303–0.948, $P = 0.032$). Similarly, Group 4 participants had significantly fewer days of outpatient and home medical care utilization than Group 1 participants (RR: 0.832, 95 % CI: 0.712–0.972, $P = 0.021$). No significant associations were observed for inpatient care.

Table 4 shows the associations of social isolation and homebound status with medical expenditure and medical expenditure per day. Socially isolated participants in Group 2 (RR: 0.860, 95 % CI: 0.758–0.977, $P = 0.021$) and Group 4 (RR: 0.834, 95 % CI: 0.715–0.974, $P = 0.022$) had significantly lower expenditure for outpatient and home medical care than Group 1 participants. Similarly, Group 2 participants had significantly lower outpatient and home medical care expenditure per day than Group 1 participants (RR: 0.899, 95 % CI: 0.835–0.968, $P = 0.005$). No significant associations were observed for inpatient care.

3.2. Analysis II

Table 5 shows the associations of social isolation and homebound status with medical care utilization and medical expenditure per day in the last year of life for mortality cases. Group 4 participants were significantly less likely to use inpatient care than Group 1 participants (AOR: 0.109, 95 % CI: 0.019–0.636, $P = 0.014$). However, Group 4 participants had significantly higher outpatient and home medical care expenditure per day than Group 1 participants (RR: 2.155, 95 % CI: 1.338–3.470, $P = 0.002$).

Table 1
Characteristics of Participants Included in and Excluded from Analysis I and Analysis II.

Characteristics		Participants included in Analysis I		Participants excluded as they did not respond to the T2 survey		Participants excluded after the T2 survey			Participants included in Analysis II		Participants excluded from Analysis II		
		Total	%	Total	%	Total	%	*P*-values[a]	Total	%	Total	%	*P*-values[a]
Sex	Men	1386	40.3	493	43.6	181	45.7	0.114	107	59.8	89	50.6	0.194
	Women	1386	59.7	493	56.4	215	54.3		107	40.2	89	49.4	
Age groups	65–74 years	1386	63.1	493	57.6	231	58.3	0.045	107	37.4	89	33.7	0.593
	≥75 years	1386	36.9	493	42.4	165	41.7		107	62.6	89	66.3	
Educational level	Senior high school/junior college or lower	1386	84.8	447	87.0	293	88.3	0.185	107	87.9	74	89.2	0.782
	University or higher	1386	15.2	447	13.0	39	11.7		107	12.1	74	10.8	
Resident status	Living alone	1386	38.2	481	30.8	129	33.7	0.008	107	43.0	82	22.0	0.002
	Living with others	1386	61.8	481	69.2	254	66.3		107	57.0	82	78.0	
Household income	<3 million yen (approximately $33,000)	1386	52.6	493	42.2	179	45.2	< 0.001	107	57.0	89	49.4	0.161
	≥3 million yen (approximately $33,000)	1386	32.5	493	27.4	84	21.2		107	23.4	89	19.1	
	No response	1386	14.9	493	30.4	133	33.6		107	19.6	89	31.5	
IADL dependent	No	1386	88.6	471	74.1	282	82.0	< 0.001	107	66.4	78	44.9	0.004
	Yes	1386	11.4	471	25.9	62	18.0		107	33.6	78	55.1	
Subjective health	Good	1386	70.9	493	56.2	232	58.6	< 0.001	107	52.3	89	22.5	< 0.001
	Poor	1386	15.1	493	25.2	89	22.5		107	29.9	89	51.7	
	No response	1386	14.1	493	18.7	75	18.9		107	17.8	89	25.8	
Depressive symptoms (GDS ≥ 6)	No	1386	61.1	493	43.4	174	43.9	< 0.001	107	39.3	89	30.3	0.394
	Yes	1386	21.9	493	25.6	82	20.7		107	35.5	89	38.2	
	No response	1386	17.0	493	31.0	140	35.4		107	25.2	89	31.5	
Social isolation and homebound status	Group 1	1386	52.3	396	39.4	70	43.2	< 0.001	107	23.4	51	13.7	0.435
	Group 2	1386	17.5	396	19.9	26	16		107	23.4	51	21.6	
	Group 3	1386	18.8	396	22.2	37	22.8		107	22.4	51	23.5	
	Group 4	1386	11.5	396	18.4	29	17.9		107	30.8	51	41.2	

Abbreviations: GDS, geriatric depression scale. Group 1; not socially isolated and non-homebound, Group 2; socially isolated and non-homebound, Group 3; not socially isolated and homebound, and Group 4; socially isolated and homebound.
[a] Chi-square test.

4. Discussion

Through the integration of postal survey data and insurance claims data, we examined the influence of social isolation and homebound status on medical care utilization and expenditure in a sample of older adults residing in a Japanese city. Almost 12 % of all participants were both socially isolated and homebound, and these individuals had significantly lower utilization of outpatient and home medical care and

Table 2
Characteristics (Percentages) of Participants According to Groups Stratified by Combinations of Social Isolation and Homebound Status.

Characteristics		Group 1 (n = 725)	Group 2 (n = 242)	Group 3 (n = 260)	Group 4 (n = 159)	*P*-value[a]
Sex	Men	36.0	66.5	24.2	46.5	<0.001
	Women	64.0	33.5	75.8	53.5	
Age	65–74 years	70.3	69.8	45.8	48.4	<0.001
	≥75 years	29.7	30.2	54.2	51.6	
Educational level	Senior high school/junior college or lower	83.4	79.3	91.9	87.4	0.001
	University or higher	16.6	20.7	8.1	12.6	
Resident status	Living alone	39.4	27.3	45.0	38.4	<0.001
	Living with others	60.6	72.7	55.0	61.6	
Household income	<3 million yen (approximately $33,000)	49.0	50.4	59.2	61.6	0.003
	≥3 million yen (approximately $33,000)	35.6	36.8	26.5	22.0	
	No response	15.4	12.8	14.2	16.4	
IADL dependent	No	95.0	89.3	80.4	71.7	<0.001
	Yes	5.0	10.7	19.6	28.3	
Subjective health	Good	78.2	73.6	59.6	51.6	<0.001
	Poor	8.6	15.3	21.9	33.3	
	No response	13.2	11.2	18.5	15.1	
Depressive symptoms (GDS ≥ 6)	No	71.0	58.7	48.5	40.3	<0.001
	Yes	13.2	26.9	29.6	41.5	
	No response	15.7	14.5	21.9	18.2	
Chronic diseases (cardiovascular disease, liver disease, or other diseases)	No	35.0	28.1	24.6	25.8	0.026
	Yes	50.9	54.5	60.0	57.2	
	No response	14.1	17.4	15.4	17.0	

Abbreviations: GDS, geriatric depression scale. Group 1; not socially isolated and non-homebound, Group 2; socially isolated and non-homebound, Group 3; not socially isolated and homebound, and Group 4; socially isolated and homebound.
[a] Chi-square test.

Table 3
Associations of Social Isolation and Homebound Status with Medical Care Utilization and the Number of Days of Medical Care Utilization between December 2008 and November 2011.

Group	Use of outpatient and home medical care (analyzable data: n = 1386)					Number of days of outpatient and home medical care utilization (analyzable data: n = 1235)					
	%	*P*-value[a]	First model[b]			25th percentile	50th percentile	75th percentile	Second model[c]		
			AOR	95 % CI	*P*-value				RR	95 % CI	*P*-value
Group 1 (n = 725)	89.9	0.065	ref.			32	58	92	ref.		
Group 2 (n = 242)	85.5		0.688	(0.432−1.096)	0.115	27	54	89	1.021	(0.898−1.161)	0.752
Group 3 (n = 260)	91.9		0.861	(0.500−1.482)	0.589	43	69	109	0.965	(0.854−1.090)	0.568
Group 4 (n = 159)	86.2		0.536	(0.303−0.948)	0.032	37	62	88	0.832	(0.712−0.972)	0.021
Group	Use of inpatient care (analyzable data: n = 1386)					Number of days of inpatient care utilization (analyzable data: n = 407)					
	%	*P*-value[a]	First model[b]			25th percentile	50th percentile	75th percentile	Second model[c]		
			AOR	95 % CI	*P*-value				RR	95 % CI	*P*-value
Group 1 (n = 725)	28.3	0.321	ref.			5	9	26	ref.		
Group 2 (n = 242)	27.3		0.734	(0.515−1.046)	0.087	4	11	31	0.973	(0.718−1.319)	0.860
Group 3 (n = 260)	33.8		0.990	(0.709−1.382)	0.953	5	11	25	0.927	(0.705−1.220)	0.590
Group 4 (n = 159)	30.2		0.725	(0.477−1.104)	0.134	8	20	39	1.186	(0.831−1.691)	0.347

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; RR, risk ratio. Group 1; not socially isolated and non-homebound, Group 2; socially isolated and non-homebound, Group 3; not socially isolated and homebound, and Group 4; socially isolated and homebound.
Covariates: sex, age, educational level, resident status, household income, instrumental activities of daily living, subjective health, depressive symptoms, and chronic diseases.
[a] Chi-square test.
[b] Logistic regression model.
[c] Generalized linear model for gamma-distributed data with a log-link function.

its associated expenditure during the three-year study period than participants with neither characteristic. However, participants who were both socially isolated and homebound had higher outpatient and home medical care expenditure per day during the year before death than participants with neither characteristic.

Individuals with co-existing social isolation and homebound status were less likely to utilize outpatient and home medical care even though neither characteristic alone was associated with medical care utilization. This finding was consistent with our first hypothesis. Furthermore, the association was observed after adjusting for variations in chronic diseases. Therefore, individuals with co-existing social isolation and homebound status may be underutilizing outpatient and home medical care even if they require regular treatment to manage chronic diseases. In addition, socially isolated participants had significantly lower overall and daily outpatient and home medical care expenditure than those with neither characteristic. In contrast, homebound status alone was not associated with outpatient and home medical care utilization and its associated expenditure. As social isolation has been reported to be associated with cognitive decline and a lower propensity to request for help (Shankar, Hamer, McMunn, & Steptoe, 2013; Takahashi, Koike, & Ando, 2014), socially isolated individuals may be unable to effectively communicate all of their symptoms and needs to medical professionals. Additionally, homebound individuals may have fewer barriers to communication with medical professionals than socially isolated individuals because homebound status is often the result of physical (rather than cognitive) decline. For example, homebound status was not associated with cognitive decline among older Japanese adults without physical disabilities who have easier to access medical care than older adults with physical disabilities (Harada et al., 2016). As described in the Anderson model, the utilization of medical care is influenced by the needs of patients as perceived by medical staff (Andersen & Newman, 1973). As a result, socially isolated patients may not receive adequate care to manage their diseases even if they visit medical institutions. However, this study could not definitively identify the reasons why socially isolated patients were less likely to utilize adequate care, and future research is needed to understand these relationships in order to develop interventions that facilitate access to care for these individuals.

The second hypothesis was supported by the finding that participants with co-existing social isolation and homebound status had significantly higher expenditure per day for outpatient and home medical care during the year before death than participants with neither characteristic. The increased expenditures were indicative of an increased use of these care services, which suggests that participants with both characteristics were less likely to utilize these services until their conditions had severely deteriorated. Despite an increased use of outpatient and home medical care, such patients have a higher risk of mortality. This may contribute to the association of co-existing social isolation and homebound status with early death, as previously reported (Sakurai et al., 2018).

Our study also found that participants with co-existing social isolation and homebound status were less likely to use inpatient care at the end of life than participants with neither characteristic. Contrary to our results, a previous study reported a positive association between social isolation and hospitalization (Greysen et al., 2013). Individuals who are both socially isolated and homebound may be less likely to use adequate inpatient care to manage their diseases even if required at the end of life. Further research is therefore needed to examine whether individuals with co-existing social isolation and homebound status use inpatient care when required.

This study has several limitations. First, we had operationally defined social isolation and homebound status using the frequency of contact with people and the frequency of going outside, respectively. Consequently, the participants identified with these characteristics may include those who choose to avoid contact with others or going outside. Furthermore, the number of such individuals is likely to have increased following the emergence of COVID-19. The prevalence of social isolation and homebound status along with this study's significance could change drastically depending on whether the study was conducted before or after COVID-19 outbreak. Future studies are therefore needed to identify those who actively choose to avoid contact with others or going outside due to fears about COVID-19. Moreover, our study participants with social isolation and homebound status included those who are physically or cognitively unable to contact people or go outside. Although our analyses incorporated IADL, we were unable to account for any underlying emotional or stress-related reasons (Campagne, 2019) for these characteristics. Also, our questions on the frequency of contact did not include contact with other people such as meal delivery staff, mail carriers, and house cleaning staff. Therefore, even if a participant had contacted these people more than once a week, that participant was

Table 4
Associations of Social Isolation and Homebound Status with Medical Expenditure and Medical Expenditure per Day between December 2008 and November 2011.

Group	Expenditure for outpatient and home medical care, USD (analyzable data: n = 1235)						Expenditure for outpatient and home medical care per day, USD (analyzable data: n = 1235)					
	25th percentile	50th percentile	75th percentile	Second model[a] RR	95 % CI	*P*-value	25th percentile	50th percentile	75th percentile	Second model[a] RR	95 % CI	*P*-value
Group 1 (n = 652)	2447	4287	6730	ref.			54	67	91	ref.		
Group 2 (n = 207)	1953	4310	6653	0.860	(0.758–0.977)	0.021	55	71	88	0.899	(0.835–0.968)	0.005
Group 3 (n = 239)	3050	4915	9106	1.107	(0.980–1.251)	0.102	55	70	96	1.063	(0.990–1.141)	0.094
Group 4 (n = 137)	2429	4437	7137	0.834	(0.715–0.974)	0.022	52	68	93	0.939	(0.858–1.028)	0.172
Group	Expenditure for inpatient care, USD (analyzable data: n = 407)						Expenditure for inpatient care per day, USD (analyzable data: n = 407)					
	25th percentile	50th percentile	75th percentile	Second model[a] RR	95 % CI	*P*-value	25th percentile	50th percentile	75th percentile	Second model[a] RR	95 % CI	*P*-value
Group 1 (n = 205)	2689	5907	15,212	ref.			482	558	724	ref.		
Group 2 (n = 66)	3283	5895	22,195	0.953	(0.708–1.281)	0.748	446	535	845	1.088	(0.948–1.248)	0.228
Group 3 (n = 88)	3085	5603	16,333	1.072	(0.817–1.408)	0.615	436	576	837	1.112	(0.985–1.256)	0.087
Group 4 (n = 48)	4125	8118	22,164	1.151	(0.809–1.637)	0.434	378	512	663	0.965	(0.822–1.131)	0.658

Abbreviations: CI, confidence interval; RR, risk ratio. Group 1; not socially isolated and non-homebound, Group 2; socially isolated and non-homebound, Group 3; not socially isolated and homebound, and Group 4; socially isolated and homebound.
Covariates: sex, age, educational level, resident status, household income, instrumental activities of daily living, subjective health, depressive symptoms, and chronic diseases.
[a] Generalized linear model for gamma-distributed data with a log-link function.

considered to be socially isolated. Second, the study periods comprised only a three-year span and one year before death. In addition, Analysis II was conducted using a relatively small sample, and may not be sufficiently powered to detect the association of co-existing social isolation and homebound status with medical care utilization and expenditures during the last year of life. Therefore, further studies are needed over a longer time frame with larger sample sizes. Third, our assessments of the frequency of contact with others and going outside were limited to the baseline, and did not account for any possible changes in social isolation or homebound status over the study period. Further studies that include time-varying social isolation and homebound status are needed to gain a better understanding of the influence of these characteristics on medical care utilization. Fourth, the study subjects were limited to residents of one city. In 2013, Wako city had the sixth lowest medical expenditure per NHI enrollee among the 63 municipalities in Saitama prefecture, which in turn had the sixth lowest medical expenditure per NHI enrollee among Japan's 47 prefectures (Saitama Prefectural Government, 2016). Therefore, our participant-level medical expenditures may be underestimated when compared with the entire Japanese population. Moreover, this study may have underestimated the proportion of individuals with both socially isolated and homebound status as the participants included in Analysis I were less likely to have either characteristic than excluded individuals. Therefore, the proportion of individuals with both characteristics among community-dwelling older adults aged 65 years or older in a suburban city such as Wako city may even exceed 12 %. Finally, this study did not include data on the utilization of long-term care. Further studies are needed to investigate the influence of co-existing social isolation and homebound status on the utilization of long-term care and its associated expenditure because some forms of medical care (e.g., nursing care and rehabilitation services) are provided under the long-term care system in Japan (Ministry of Health, Labour & Welfare, 2002).

5. Conclusions

Older adults with co-existing social isolation and homebound status are less likely to regularly utilize outpatient and home medical care, which may eventually lead to worsening health problems that require more intensive treatment. Measures are needed to encourage the appropriate use of medical care in older adults with both these characteristics to manage their conditions and prevent the deterioration of health.

CRediT authorship contribution statement

Seigo Mitsutake: Conceptualization, Formal analysis, Methodology, Visualization, Writing - original draft. **Takashi Koike:** Conceptualization, Data curation, Investigation, Writing - original draft. **Tatsuro Ishizaki:** Conceptualization, Validation, Writing - review & editing. **Ryota Sakurai:** Data curation, Investigation, Writing - review & editing. **Masashi Yasunaga:** Investigation, Writing - review & editing. **Mariko Nishi:** Investigation, Writing - review & editing. **Taro Fukaya:** Investigation, Writing - review & editing. **Erika Kobayashi:** Investigation, Writing - review & editing. **Hiroyuki Suzuki:** Investigation, Writing - review & editing. **Kumiko Nonaka:** Investigation, Writing - review & editing. **Masashige Saito:** Conceptualization, Writing - review & editing. **Masami Hasebe:** Investigation, Writing - review & editing. **Yoh Murayama:** Investigation, Writing - review & editing. **Yoshinori Fujiwara:** Supervision, Conceptualization, Funding acquisition, Writing - review & editing.

Declaration of Competing Interest

None.

Table 5
Associations of Social Isolation and Homebound Status with Medical Care Utilization and Medical Expenditure per Day During the Year Before Death.

Group	Use of outpatient and home medical care (analyzable data: n = 107)					Expenditure for outpatient and home medical care per day, USD (analyzable data: n = 91)					
	%	*P*-value[a]	First model[b]			25th percentile	50th percentile	75th percentile	Second model[c]		
			AOR	95 % CI	*P*-value				RR	95 % CI	*P*-value
Group 1 (n = 25)	92.0	0.163	ref.			69	101	135	ref.		
Group 2 (n = 25)	72.0		0.327	(0.047−2.259)	0.257	69	89	162	1.220	(0.774−1.999)	0.430
Group 3 (n = 24)	91.7		0.938	(0.084−10.504)	0.959	55	87	142	1.624	(0.934−2.823)	0.085
Group 4 (n = 33)	84.8		0.513	(0.068−3.848)	0.516	85	118	258	2.155	(1.338−3.470)	0.002
Group	Use of inpatient care (analyzable data: n = 107)					Expenditure for inpatient care per day, USD (analyzable data: n = 78)					
	%	*P*-value[a]	First model[b]			25th percentile	50th percentile	75th percentile	Second model[c]		
			AOR	95 % CI	*P*-value				RR	95 % CI	*P*-value
Group 1 (n = 25)	88.0	0.106	ref.			414	533	626	ref.		
Group 2 (n = 25)	60.0		0.181	(0.031−1.061)	0.058	315	365	505	0.845	(0.612−1.168)	0.308
Group 3 (n = 24)	79.2		0.249	(0.037−1.658)	0.151	317	378	629	0.972	(0.706−1.339)	0.863
Group 4 (n = 33)	66.7		0.109	(0.019−0.636)	0.014	250	383	479	0.794	(0.588−1.073)	0.133

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; RR, risk ratio. Group 1; not socially isolated and non-homebound, Group 2; socially isolated and non-homebound, Group 3; not socially isolated and homebound, and Group 4; socially isolated and homebound.
Covariates: sex, age, educational level, resident status, household income, instrumental activities of daily living, subjective health, and depressive symptoms.
[a] Chi-square test.
[b] Logistic regression model.
[c] Generalized linear model for gamma-distributed data with a log-link function.

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