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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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\textbf{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 $\geq$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

\textbf{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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posited that co-existing 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 (Funabashi, 2013; Sagisawa & 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, & Hirasawa, 2012; Saito, Kondo, Ojima, Hirasawa, & 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 institutional 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 linear 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
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, \( P = 0.002 \)).
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

| Characteristics                  | Participants included in Analysis I | Participants excluded as they did not respond to the T2 survey | Participants included in Analysis II | Participants excluded from Analysis II | P-values * |
|----------------------------------|-------------------------------------|-------------------------------------------------------------|------------------------------------|----------------------------------------|------------|
| **Sex**                          | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Men                              | 43.6                                | 25.9                                                       | 38.2                               | 40.4                                   | <0.001     |
| Women                            | 56.4                                | 74.1                                                       | 61.8                               | 59.6                                   | 0.001      |
| **Age groups**                   | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| 65–74 years                      | 231                                 | 58.3                                                       | 236                                | 58.3                                   | 0.001      |
| ≥75 years                        | 165                                 | 58.3                                                       | 176                                | 58.3                                   | 0.001      |
| **Educational level**            | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Senior high school/junior college or lower | 117 | 58.3                                      | 121                                | 58.3                                   | 0.001      |
| University or higher             |                                    |                                                             |                                    |                                        |            |
| **Resident status**              | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Living alone                     | 89                                  | 58.3                                                       | 93                                 | 58.3                                   | 0.001      |
| Living with others               | 92                                  | 58.3                                                       | 96                                 | 58.3                                   | 0.001      |
| <3 million yen (approximately $33,000) | 117 | 58.3                                      | 121                                | 58.3                                   | 0.001      |
| **Household income**             | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| ≥3 million yen (approximately $33,000) | 92 | 58.3                                       | 96                                 | 58.3                                   | 0.001      |
| No response                      | 92                                  | 58.3                                                       | 96                                 | 58.3                                   | 0.001      |
| **IADL dependent**               | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Yes                              | 121                                | 58.3                                                       | 121                                | 58.3                                   | 0.001      |
| Good                             | 56.2                                | 58.3                                                       | 56.2                               | 58.3                                   | 0.001      |
| **Subjective health**            | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Poor                             | 176                                | 58.3                                                       | 176                                | 58.3                                   | 0.001      |
| No response                      | 176                                | 58.3                                                       | 176                                | 58.3                                   | 0.001      |
| **Depressive symptoms** (GDS ≥ 6) | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| Yes                              | 118                                | 58.3                                                       | 118                                | 58.3                                   | 0.001      |
| No response                      | 118                                | 58.3                                                       | 118                                | 58.3                                   | 0.001      |
| **Chronic diseases**             | Total %                             | Total %                                                     | Total %                            | Total %                                | Total %    |
| (cardiovascular disease, liver disease, or other diseases) | 40.5 | 58.3                                      | 40.5                               | 58.3                                   | 0.001      |
| No response                      | 40.5                                | 58.3                                                       | 40.5                               | 58.3                                   | 0.001      |

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.

* Chi-square test.
the Anderson model, the utilization of medical care is influenced by the care to manage their diseases even if they visit medical institutions. (1973). As a result, socially isolated patients may not receive adequate 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. 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. Future 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. Moreover, 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 3

| 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) |
|-------|---------------------------------------------------------------|----------------------------------------------------------------------------------|
| Group 1 (n = 725) | 89.9 0.065 ref. | 25th percentile 50th percentile 75th percentile 2011 |
| Group 2 (n = 242) | 85.5 0.688 (0.432–1.096) 0.115 | 37 62 88 0.688 (0.432–1.096) 0.115 |
| 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 |

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.

| Group | Use of inpatient care (analyzable data: n = 1386) | Number of days of inpatient care utilization (analyzable data: n = 407) |
|-------|--------------------------------------------------|----------------------------------|
| Group 1 (n = 725) | 28.3 0.321 ref. | 25th percentile 50th percentile 75th percentile 2011 |
| Group 2 (n = 242) | 27.3 0.734 (0.515–1.046) 0.087 | 5 9 26 ref. |
| Group 3 (n = 260) | 33.8 0.990 (0.799–1.382) 0.953 | 4 11 31 0.973 (0.718–1.319) 0.860 |
| Group 4 (n = 159) | 30.2 0.725 (0.477–1.104) 0.134 | 5 11 25 0.927 (0.705–1.220) 0.590 |

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| Group 3 (n = 260) | 33.8 0.990 (0.799–1.382) 0.953 | 4 11 31 0.973 (0.718–1.319) 0.860 |
| Group 4 (n = 159) | 30.2 0.725 (0.477–1.104) 0.134 | 5 11 25 0.927 (0.705–1.220) 0.590 |
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 inpatient care, USD (analyzable data: n = 407) | Expenditure for inpatient care per day, USD (analyzable data: n = 407) |
|-------|----------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------|
|       | 25th percentile | 50th percentile | 75th percentile | P-value | RR 95% CI | 25th percentile | 50th percentile | 75th percentile | P-value | RR 95% CI |
| Group 1 (n = 652) | 2447 | 4287 | 6730 | ref. | | 54 | 67 | 91 | ref. | | 56 | 69 | 91 |
| 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 = 48) | 4125 | 8118 | 22164 | 1.151 (0.980 - 1.351) | 0.065 | 63 | 80 | 109 | 1.063 (0.858 - 1.321) | 0.239 |

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, Group 4: socially isolated and non-homebound, Group 5: socially isolated and homebound.

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.
**Table 5**

| 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) |
|---------------------------------------------------------------|----------------------------------------------------------------------------------|
| **Group** | **%** | **P-value** | **First model** | **Expenditure for inpatient care per day, USD (analyzable data: n = 78)** |
| **AOR** | **95 % CI** | **P-value** | **AOR** | **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 | 72 | 89 | 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 |

**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.

- **Chi-square test.**

- **Logistic regression model.**

- **Generalized linear model for gamma-distributed data with a log-link function.**

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### References

Andersen, R., & Newman, J. F. (1973). Societal and individual determinants of medical care utilization in the United States. The Milbank Memorial Fund Quarterly Health and Society, 51(1), 95–124.

Anne, T. (1997). Evaluation of environmental stimulation and its relation to physical deterioration in the elderly after 3 years–A health-social longitudinal study. Nihon Koshu Eisei Zasshi, 44(3), 159–166.

Camagne, D. M. (2019). Stress and perceived social isolation (loneliness). Archives of Gerontology and Geriatrics, 82, 192–199. https://doi.org/10.1016/j.archger.2018.08.007

Cohen-Mansfield, J., Shmotkin, D., & Hazan, H. (2010). The effect of homebound status on all study participants. This work was supported in part by a Health and Labour Sciences Research Grant (grant number 2008-seisaku-ippan-012) from the Ministry of Health, Labour and Welfare, Japan. The sponsor had no role in the study design; collection, analysis and interpretation of data; writing of the article; or the decision to publish.

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**Table 5**

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

| 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) |
|---------------------------------------------------------------|----------------------------------------------------------------------------------|
| **Group** | **%** | **P-value** | **First model** | **Expenditure for inpatient care per day, USD (analyzable data: n = 78)** |
| **AOR** | **95 % CI** | **P-value** | **AOR** | **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 | 72 | 89 | 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 |

**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.

- **Chi-square test.**

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### References

Andersen, R., & Newman, J. F. (1973). Societal and individual determinants of medical care utilization in the United States. The Milbank Memorial Fund Quarterly Health and Society, 51(1), 95–124.

Anne, T. (1997). Evaluation of environmental stimulation and its relation to physical deterioration in the elderly after 3 years–A health-social longitudinal study. Nihon Koshu Eisei Zasshi, 44(3), 159–166.

Campagne, D. M. (2019). Stress and perceived social isolation (loneliness). Archives of Gerontology and Geriatrics, 82, 192–199. https://doi.org/10.1016/j.archger.2018.08.007

Cohen-Mansfield, J., Shmotkin, D., & Hazan, H. (2010). The effect of homebound status on all study participants. This work was supported in part by a Health and Labour Sciences Research Grant (grant number 2008-seisaku-ippan-012) from the Ministry of Health, Labour and Welfare, Japan. The sponsor had no role in the study design; collection, analysis and interpretation of data; writing of the article; or the decision to publish.

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Saito, M., Kondo, N., Kondo, K., Ojima, T., & Hirai, H. (2012). Gender differences on the impacts of social exclusion on mortality among older Japanese: AGES cohort study. Soc Sci Med, 75(5), 940-945. https://doi.org/10.1016/j.socscimed.2012.04.006
Sakurai, R., Fujiwara, Y., Yasunaga, M., Takeuchi, R., Murayama, Y., ... Ishii, K. (2017). Neural basis for the relationship between frequency of going outdoors and depressive mood in older adults. International Journal of Geriatric Psychiatry, 32(6), 589-595. https://doi.org/10.1002/gps.4497
Sakurai, R., Suzuki, H., Fujiwara, Y., Yasunaga, M., Takeuchi, R., Murayama, Y., ... Ishii, K. (2017). Neural basis for the relationship between frequency of going outdoors and depressive mood in older adults. International Journal of Geriatric Psychiatry, 32(6), 589-595. https://doi.org/10.1002/gps.4497
Sugisawa, H., & Sugihara, Y. (2011). [The effects of social networks on health check-up service use among pre-frail older adults (candidate so-called ‘specified elderly individuals’) compared with older people in general]. Nihon Koshu Eisei Zasshi, 58(9), 743-753.
Takahashi, T., Koike, T., & Ando, T. (2014). Help-seeking preference of the elderly living alone in a housing complex - from the research data in Kadencho housing complex in Yokohama. Yokohama Journal of Technology Management Studies, 13, 47-55.
Takahashi, T., Nonaka, K., Matsunaga, H., Hasebe, M., Murayama, H., Koike, T., ... Fujiwara, Y. (2020). Factors relating to social isolation in urban Japanese older people: A 2-year prospective cohort study. Archives of Gerontology and Geriatrics, 86, Article 103936. https://doi.org/10.1016/j.archger.2019.103936
Valtorta, N. K., Kanaan, M., Gilbody, S., Ronzi, S., & Hanratty, B. (2016). Loneliness and social isolation as risk factors for coronary heart disease and stroke: Systematic review and meta-analysis of longitudinal observational studies. Heart, 102(13), 1009-1016. https://doi.org/10.1136/heartjnl-2015-308790
Valtorta, N. K., Moore, D. C., Barron, L., Stow, D., & Hanratty, B. (2018). Older adults’ social relationships and health care utilization: A systematic review. American Journal of Public Health, 108(4), e1-e10. https://doi.org/10.2105/ajph.2017.304256
Yoshida, H., Fujimoto, Y., Anano, H., Kumagi, S., Watanabe, N., Sanyus, L., ... Shinkai, S. (2007). Economic evaluation of disability prevention programs for community-dwelling elderly secular trend analyses of medical and care expenses comparing participants and non-participants in the programs. Nihon Koshu Eisei Zasshi, 54(3), 156-167.
Yoshida, Y., Iwasa, H., Kwon, J., Furuma, T., Kim, H., Yoshida, H., & Suzuki, T. (2008). Characteristics of non-participants in comprehensive health examinations (“Otashakenshin”) among an urban community dwelling elderly: basic research for prevention of the geriatric syndrome and a bed-ridden state. Nihon Koshu Eisei Zasshi, 55(4), 221-227.