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Research Article

Do Social Isolation and Loneliness Affect Healthcare Spending and Utilization in Japan?[a]

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Social isolation and loneliness are associated with worse health outcomes, and there is a growing literature that studies the economic cost of these conditions in terms of increased healthcare spending and utilization. However, a handful of existing studies mostly focus on Western countries. This article analyses the issue in the case of Japan using the Japanese Study of Aging and Retirement (JSTAR) dataset with the help of generalized linear and probit models. The results show that social isolation is associated with reduced healthcare spending, while loneliness does not have any statistically significant effect. Neither social isolation (living alone) nor loneliness has a statistically significant effect on healthcare utilization; that is, these measures are not associated with increased or decreased inpatient or outpatient visits. Therefore, care should be taken when launching social programs to tackle social isolation and loneliness to reduce healthcare spending and utilization because these two conditions might not be associated with increased healthcare spending universally.

JEL codes: D00, I10, H51

Keywords: Social isolation, Loneliness, Healthcare spending, Healthcare utilization

1 Introduction

Social isolation and loneliness can have negative effects on our health. A meta-analytic review by Holt-Lunstad et al. (2015) concludes that social isolation, loneliness, and living alone are associated with 29%, 26%, and 32% increased likelihood of mortality, respectively. Even though the literature examining the health cost of social isolation and loneliness is well-established, there are a few studies which focus mostly on Western countries in the literature analyzing the economic cost of these conditions in terms of increased healthcare spending and utilization. This article focuses on Japan to investigate if the results found for other countries hold true for an Asian country. It is important to focus on a non-western country because different cultures approach the issues of social isolation and loneliness differently. Japan also has a different healthcare system compared to, for example, the US, which likely affects the healthcare cost of social isolation and loneliness. Lastly, both social isolation and loneliness are important issues for Japan, which has an increasing number of "hikikomori", people with severe social withdrawal, and "kodokushi", lonely deaths.

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Before proceeding any further, the terms "social isolation" and "loneliness" should be defined because careless use of these terms caused some confusion in the earlier studies and made it difficult to compare these. Social isolation is objectively measurable, while loneliness is a subjective feeling. Social isolation refers to having few social relationships or infrequent social contacts, while loneliness is a perception of being isolated irrespective of the number, frequency, or quality of relationships that one has. It follows that one could be socially isolated but not feel lonely or be surrounded by family and friends but feel extremely lonely. Lastly, loneliness is sometimes called "perceived" or "subjective" social isolation.

An important part of defining the terms "social isolation" and "loneliness" is determining how they interact with each other. Cacioppo et al. (2014) argue, based on the evolutionary theory of loneliness, that loneliness plays a similar role to hunger, where one signals a lack of nutrition and the other a lack of social interactions. They argue that it is beneficial in an evolutionary sense to be in a group and have meaningful relationships, and feelings of loneliness signal to us when we stray from these. Although elegant, this theory is not entirely supported by empirical evidence. There is not a decisive study that investigates how loneliness and social isolation affect each other. However, there seems to be a consensus that there is not a one-way relationship between these two measures, and, although related, social isolation and loneliness seem to be distinct measures (Cornwell & Waite, 2009a; Coyle & Dugan, 2012; Leigh-Hunt et al., 2017; Taylor, 2020).

The literature seems to find conflicting evidence on how social isolation and loneliness affect healthcare spending and utilization. However, Mihalopoulos et al. (2019) points out the difficulty of comparing articles studying the healthcare cost of social isolation and loneliness due to different measures used for these terms. Therefore, the findings of the following articles do not necessarily mean conflicting evidence. Landeiro et al. (2015) finds for Portugal that social isolation is associated with increased healthcare spending per person by €532, which increases to €905 for highly isolated people. This is due to delayed discharge from hospitals. Shaw et al. (2017) find a higher effect for the US, $1,643 per person annually. They also find that loneliness is associated with reduced healthcare spending in the US ($764 per person annually). However, Fulton & Jupp (2015) and McDaid et al. (2016), without considering social isolation, find the opposite for the UK; loneliness is associated with increased healthcare spending by £800 and by £600 per person annually, respectively. Lastly, Mitsutake et al. (2018) find that social isolation is associated with reduced healthcare spending in Japan, though they do not mention the exact amount.

Social isolation and loneliness can affect healthcare spending in various ways.

1) Social isolation and loneliness might directly affect health negatively through stress, high blood pressure etc., which would, in turn, increase healthcare spending (Cacioppo et al., 2006; Cornwell & Waite, 2009b; Holt-Lunstad et al., 2010, 2015; Holwerda et al., 2011; Valtorta et al., 2016).
2) Social isolation and loneliness might indirectly affect health through unhealthy behavior, such as drinking, smoking, a sedentary lifestyle, not taking prescribed medication etc. This would again increase healthcare spending.
3) Social isolation might affect healthcare utilization in both ways. First, it might increase utilization as socially isolated people might feel more anxious about even minor health issues and feel the need to see a doctor (Mistry et al., 2001). In contrast, for people who are not socially isolated, someone in their social circle would

usually give advice or calm them down when they get agitated, eliminating the need to use healthcare. Second, it might reduce utilization for minor health issues due to the difficulty for some people to go to a healthcare facility by themselves (Prieto et al., 2019). So, if they are socially isolated without anyone to accompany them, and if the health issue they are having is not a critical one (if it is a critical health issue, they can call an ambulance), they might prefer not to go to a healthcare facility. For people who are not socially isolated, someone in their social circle would accompany them (or drive the car if they cannot drive), thus enabling their access to healthcare. Therefore, socially isolated people might use less healthcare for minor health issues. The review study of Valtorta et al. (2018) concludes that weak social ties likely increase the probability of hospital readmissions and lengthen hospital stays.

4) Loneliness might increase healthcare utilization and thus spending simply because some people, especially the elderly, might go to healthcare facilities to have someone to chat with to alleviate their loneliness. A survey reports that around 10% of all consultations were due to loneliness (Campaign to End Loneliness, 2013).[1]

There is a potential reverse causality issue concerning the first channel. Cornwell & Waite (2009a) find that social isolation and loneliness are greater among those who have worse health, but the direction of the causality is unclear. It is likely there is a two-way causation such that this is a self-reinforcing cycle. If this is the case, the effects of social isolation and loneliness on healthcare spending would be overestimated. The size of this overestimation would also depend on how important the first channel is. However, there is a lot of research that associates both social isolation and loneliness with worse health outcomes, although there is still a need for research on the exact mechanisms. Therefore, keeping in mind that the magnitude of the effects of social isolation and loneliness on healthcare spending might be overestimated, this article still provides valuable insights into how social isolation and loneliness are associated with healthcare spending.

The structure of this paper is as follows. Section 2 introduces the data and models used in the study. Section 3 provides the results, whereas Section 4 discusses the limitations of data and methodology applied in this study. Section 5 concludes.

2 Data and Models

This article uses data from the Japanese Study of Aging and Retirement (JSTAR) survey, which is the Japanese counterpart of similar surveys such as the Health and Retirement Survey (HRS) for the US, the English Longitudinal Study of Aging (ELSA) for the UK, and the Survey of Health, Aging, and Retirement (SHARE) for Europe. To the best of my knowledge, this study is the first to utilize the JSTAR dataset in the current context.

The sample analysed in this study is retrieved from the 2007 wave covering 4,300 respondents over the age of 50 from five Japanese cities.[2] Social isolation is defined as "living

[1] See also Ellaway et al. (1999), Molloy et al. (2010), Prieto et al. (2019), Barnes et al. (2021), and Mosen et al. (2021).

[2] The JSTAR is a longitudinal survey conducted by the Research Institute of Economy, Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo has waves in 2007, 2009, 2011, and 2013. A panel analysis would have been valuable, but only around 10% of the respondents in the 2007 wave remain in the 2013 wave due to dropping out of people. Only the 2007 wave was used as including the new respondents of the other waves in the analysis negligibly increases the sample size (only around 500).

alone" in the study.[3] The measure for loneliness comes from the statement "I felt lonely". There is a concern that respondents might not answer truthfully due to the stigma attached to the word "loneliness". However, the JSTAR dataset does not allow the construction of Hughes's 3-item Loneliness Scale.[4]

Lastly, a generalized linear model (GLM) proposed by Nelder & Wedderburn (1972) given in equation (1) is used to estimate the association between social isolation/loneliness and healthcare spending:

$$log(\mu_i) \;=\; \beta_0 \;+\; \beta_1 S_i \;+\; \beta_2 L_i \;+\; \beta_3 X_i \tag{1}$$

where $\mu_i = E(Y_i)$ is the mean of healthcare spending, S_i is social isolation, L_i is loneliness, and X_i is a vector of individual characteristics such as age and income. Since healthcare expenditures generally follow a skewed distribution, using a generalized linear model allowing for loosening the normal distribution assumption, as opposed to a regular linear model, is required. Therefore, a generalized linear model which assumes gamma distribution of errors with a log-link function is widely used in the literature in the context of healthcare spending.

In order to see if social isolation and loneliness are associated with an increased likelihood of inpatient or outpatient visits, the following latent variable model is estimated:[5]

$$Y_i^{'} \;=\; \beta_0 \;+\; \beta_1 S_i \;+\; \beta_2 L_i \;+\; \beta_3 X_i \;+\; \epsilon_i \tag{2}$$

which takes the following form:

$$P(Y_i = 1 | S_i, L_i, X_i) = \Phi(\beta_0 \;+\; \beta_1 S_i \;+\; \beta_2 L_i \;+\; \beta_3 X_i) \tag{3}$$

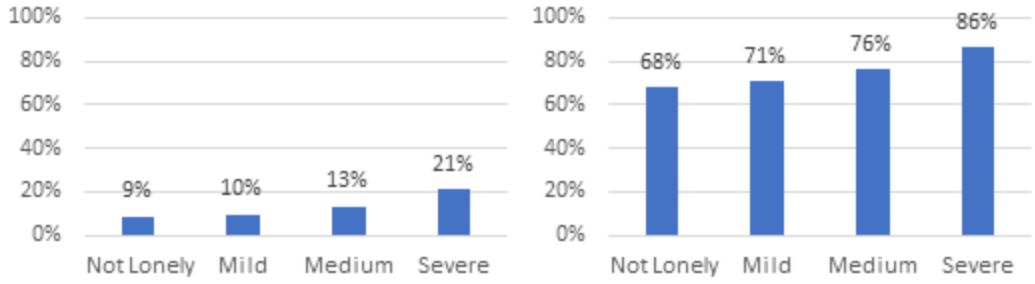
where P shows the probability of having inpatient or outpatient visits (separate model for each), and Φ is the cumulative distribution function. We do not observe Y; instead, we observe $\mathrm{Y}^{'}$, which satisfies the following condition.

$$Y \;=\; \begin{cases} 1 & \text{if } \mathrm{Y}^{'} > 0 \\ 0 & \text{otherwise} \end{cases}$$

[3] There are numerous measures used for social isolation in the literature. Cornwell & Waite (2009a) proposed a single scale to measure social isolation by combining the following indicators: social network size, social network range (number of types of relationships), the proportion of social network members who live in the household, the average frequency of interaction with network members, average closeness with network members, household size, living alone, having a spouse or partner, number of friends, number of children, number of grandchildren, attending religious services, attending meetings of an organized group, socializing with friends and relatives, socializing with neighbors, and volunteering. Unfortunately, The JSTAR dataset does not have all the variables necessary to construct this social isolation scale.

[4] Detailed explanation of all the measures used in the estimations and descriptive statistics are available in Appendices A and B, respectively.

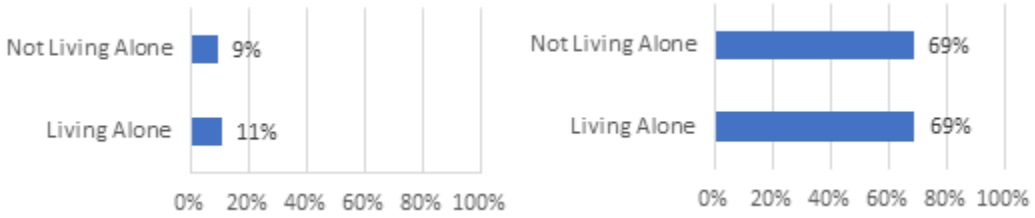
[5] The JSTAR dataset does not allow for differentiating respondents regarding their number of hospital visits. Differentiating respondents would change the weights of the control variables in terms of how much they affect the likelihood of having inpatient or outpatient visits. However, we simply consider two alternatives (inpatient and outpatient visits) as inverse measures of health separately. Therefore, note that the models do not consider/focus on differentiating/comparing inpatient and outpatient visits.



(a) Inpatient **(b)** Outpatient

Figure 1: Loneliness and Inpatient/Outpatient Visits
Source: Author's calculations using the JSTAR dataset.
Note: Visits refer to having had an inpatient and outpatient visit in the last year.

Figure 1 suggests that loneliness is associated with an increased likelihood of both inpatient and outpatient visits. However, the probit estimations suggest that there is not a statistically significant effect. Figure 2 suggests that living alone does not have an effect on the likelihood of inpatient or outpatient visits, and the probit estimations support this.



(a) Inpatient **(b)** Outpatient

Figure 2: Living Alone and Inpatient/Outpatient Visits
Source: Author's calculations using the JSTAR dataset.
Note: Visits refer to having had an inpatient and outpatient visit in the last year.

3 Results and Discussion

The GLM estimation results presented in Table 1 suggest that social isolation (living alone) is associated with reduced healthcare spending by ¥79,000 (in 2007 prices, approx. $550) per person annually in Japan. Loneliness, however, does not have any statistically significant effect on healthcare spending. Other characteristics, such as having serious health problems (heart disease, stroke, cancer etc.) and old age, are associated with increased healthcare spending, as expected. Notably, employment is associated with reduced healthcare spending by ¥53,800 (approx. $370) per person annually, while household income does not have any statistically significant effect.

Table 1: The Results of the Generalized Linear Model

Dependent Variable: Medical Expenditure	I		II	
	Coef.	**SE**	**Coef.**	**SE**
loneliness	-0.4	5.0		
lonely_severe			-0.9	7.4
lonely_medium			1.4	6.5
lonely_mild			1.8	2.6
living_alone	-7.9**	4.1	-7.86*	4.1
sendai	-3.99	2.7	-4	2.7
kanazawa	7.43**	2.9	7.45**	2.9
takikawa	7.86***	3.1	7.89***	3.1
shirakawa	-1.6	2.9	-1.6	2.9
smoking	-1.3	2.3	-1.3	2.3
totalcesd	0.0	0.2	0.0	0.2
drinking	0.9	2.1	0.9	2.1
education	-0.4	0.4	-0.4	0.4
male	-1.3	2.6	-1.2	2.6
married	0.0	3.3	0.2	3.3
children	-0.4	1.0	-0.4	1.0
employed	-5.38**	2.2	-5.38**	2.2
adl	14.49***	2.1	14.5***	2.1
heartdisease	9.68***	3.1	9.7***	3.1
highbloodpressure	6.07***	2.1	6.06***	2.1
stroke	20.31***	5.5	20.17***	5.5
diabetes	15.82***	3.2	15.86***	3.2
lungdisease	-4.5	7.5	-4.3	7.5
jointdisorder	-1.8	4.3	-1.9	4.3
cancer	9.46*	5.0	9.54*	5.0
household_income	-35.9	0.0	-35.9	0.0
age55_59	0.7	3.0	0.8	3.0
age60_64	6.4**	3.2	6.44**	3.2
age65_69	13.57***	3.3	13.64***	3.3
age70_74	14.99***	3.6	15.12***	3.6
age75_	-6.1	7.9	-5.9	8.0
bmi_20	2.7	2.9	2.7	2.9
bmi25_29	0.0	2.3	0.0	2.3
bmi30_34	2.3	6.0	2.3	6.0
cons	14.7	6.9	14.7	6.9
n	2,546		2,546	

Note: Author's calculations using the JSTAR dataset. SE stands for Standard Error. *, **, *** refers to 10%, 5%, and 1% significance level, respectively.

Next, the effects that social isolation (defined as living alone) and loneliness might have on healthcare utilization measured by inpatient (Table 2) and outpatient (Table 3) visits are analyzed. The results suggest that neither social isolation nor loneliness are associated with an increased likelihood of inpatient or outpatient visits. Although there are studies that find an association between social isolation/loneliness and healthcare utilization, a review of the literature by Valtorta et al. (2018) shows that most studies do not find an association. The results indicate that, as expected, having serious health problems increases the likelihood of both inpatient and outpatient visits, and so does old age. Notably, being male increases the likelihood of inpatient visits but reduces the likelihood of outpatient visits.

Table 2: Probit Estimations for Inpatient Visits

	I				II			
	Coef.	**RSE**	**MFE**	**SE**	**Coef.**	**RSE**	**MFE**	**SE**
loneliness	-0.14	0.19	-0.05	0.08				
lonely_severe					-0.07	0.26	-0.03	0.1
lonely_medium					-0.28	0.27	-0.11	0.11
lonely_mild					-0.08	0.11	-0.03	0.04
living_alone	-0.05	0.17	-0.02	0.07	-0.05	0.17	-0.02	0.07
sendai	0.12	0.11	0.05	0.04	0.12	0.11	0.05	0.04
kanazawa	0.02	0.13	0.01	0.05	0.01	0.13	<0.01	0.05
takikawa	0.07	0.12	0.03	0.05	0.07	0.12	0.03	0.05
shirakawa	-0.17	0.14	-0.07	0.06	-0.18	0.14	-0.07	0.06
smoking	0.14	0.1	0.05	0.04	0.14	0.1	0.05	0.04
totalcesd	0.02***	0.01	0.01***	<0.01	0.02***	0.01	0.01***	<0.01
drinking	-0.14	0.09	-0.05	0.04	-0.14	0.09	-0.05	0.04
education	<0.01	0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01
male	0.29***	0.11	0.11***	0.04	0.29***	0.11	0.11***	0.04
married	-0.08	0.14	-0.03	0.06	-0.09	0.14	-0.03	0.06
children	0.01	0.04	<0.01	0.02	0.01	0.04	<0.01	0.02
employed	-0.23***	0.09	-0.09***	0.04	-0.23**	0.09	-0.09**	0.04
adl	0.27***	0.07	0.10***	0.03	0.27***	0.07	0.10***	0.03
heartdisease	0.33***	0.11	0.13***	0.04	0.33***	0.11	0.13***	0.04
highbloodpressure	0.07	0.09	0.03	0.04	0.07	0.09	0.03	0.04
stroke	0.32*	0.18	0.12*	0.07	0.33*	0.18	0.13*	0.07
diabetes	0.47***	0.11	0.18	0.04	0.47***	0.11	0.18***	0.04
lungdisease	0.3	0.26	0.12	0.1	0.3	0.26	0.11	0.1
jointdisorder	-0.02	0.17	-0.01	0.07	-0.01	0.17	<0.01	0.07
cancer	0.81***	0.16	0.31***	0.06	0.81***	0.16	0.31***	0.06
household_income	0.97	0	0.37	<0.01	0.98	0	0.38	<0.01
age55_59	0.18	0.13	0.07	0.05	0.18	0.13	0.07	0.05
age60_64	-0.18	0.16	-0.07	0.06	-0.18	0.16	-0.07	0.06
age65_69	0.24*	0.14	0.09*	0.06	0.24*	0.14	0.09*	0.06
age70_74	<0.01	0.16	<0.01	0.06	<0.01	0.16	<0.01	0.06
age75_	0.5*	0.28	0.19*	0.11	0.5*	0.27	0.19*	0.11
bmi_20	0.22*	0.12	0.08*	0.05	0.22*	0.12	0.08*	0.05
bmi25_29	0.05	0.09	0.02	0.04	0.04	0.09	0.02	0.04
bmi30_34	0.02	0.23	0.01	0.09	0.01	0.24	<0.01	0.1
cons	-2.11	0.28			-2.1	0.28		
Pseudo R^2	0.0341				0.0343			
n	2,546				2,546			

The results support the findings of Mitsutake et al. (2018) that social isolation is associated with reduced healthcare spending in Japan, despite the differences in the definition of social isolation (they measure it as "having less contact than once a week with anyone outside the household") and the sample characteristics (their sample only includes people aged 65+, while the sample in this study includes people aged 50+). They argue that socially isolated people might not get the healthcare they need because they find that social isolation is negatively associated with outpatient care use. However, the results of this article suggest that social isolation is not associated with less outpatient care use. This could mean that, although socially isolated people make the same amount of outpatient and inpatient visits as their non-socially isolated counterparts, they might not accept treatment or use their medications, resulting in reduced healthcare spending. It could also mean that socially isolated people might reduce their healthcare utilization other than inpatient or outpatient

visits, such as long-term care services, which could not be tested due to data limitations. However, the fact that both this article and Mitsutake et al. (2018) find the same effect of social isolation on healthcare spending despite using different measures points to something inherent in Japan, such as culture or the healthcare system.

Table 3: Probit Estimations for Outpatient Visits

	I				II			
	Coef.	**RSE**	**MFE**	**SE**	**Coef.**	**RSE**	**MFE**	**SE**
loneliness	0.05	0.16	0.02	0.06				
lonely_severe					0.25	0.26	0.1	0.1
lonely_medium					0.01	0.2	<0.01	0.08
lonely_mild					0.14	0.08	0.05	0.03
living_alone	-0.18	0.13	-0.07	0.05	-0.19	0.13	-0.07	0.05
sendai	-0.06	0.08	-0.02	0.03	-0.06	0.08	-0.02	0.03
kanazawa	-0.02	0.09	-0.01	0.04	-0.02	0.09	-0.01	0.04
takikawa	-0.29***	0.09	-0.11***	0.04	-0.29***	0.09	-0.11***	0.04
shirakawa	0.01	0.09	0.01	0.04	0.01	0.09	<0.01	0.04
smoking	-0.02	0.07	-0.01	0.03	-0.03	0.07	-0.01	0.03
totalcesd	0.01	0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01
drinking	-0.1*	0.06	-0.04*	0.02	-0.11*	0.06	-0.04*	0.02
education	0.02*	0.01	0.01*	<0.01	0.02	0.01	0.1	<0.01
male	-0.27***	0.08	-0.1***	0.03	-0.26	0.08	-0.1	0.03
married	0.06	0.1	0.02	0.04	0.08	0.1	0.3	0.04
children	-0.04	0.03	-0.02	0.01	-0.04	0.03	-0.02	0.01
employed	-0.19***	0.07	-0.07***	0.03	-0.19***	0.07	-0.07***	0.03
adl	-0.05	0.07	-0.02	0.03	-0.05	0.07	-0.02	0.03
heartdisease	0.2*	0.11	0.08*	0.04	0.2*	0.11	0.08*	0.04
highbloodpressure	0.97***	0.07	0.37***	0.03	0.96***	0.07	0.37***	0.03
stroke	0.46**	0.22	0.18**	0.09	0.46**	0.22	0.18**	0.09
diabetes	0.64***	0.12	0.25***	0.05	0.64***	0.12	0.25***	0.05
lungdisease	0.24	0.25	0.09	0.1	0.25	0.25	0.1	0.1
jointdisorder	0.83***	0.19	0.32***	0.08	0.81***	0.19	0.31***	0.08
cancer	0.73***	0.2	0.28***	0.08	0.73***	0.2	0.28***	0.08
household_income	-0.02	0	-0.01	<0.01	0.02	0	0.1	<0.01
age55_59	0.03	0.09	0.01	0.04	0.03	0.09	0.1	0.04
age60_64	-0.05	0.09	-0.02	0.04	-0.04	0.09	-0.02	0.04
age65_69	0.08	0.1	0.03	0.04	0.09	0.1	0.03	0.04
age70_74	0.25**	0.11	0.1**	0.04	0.26**	0.11	0.1**	0.04
age75_	0.61**	0.3	0.23**	0.12	0.64**	0.3	0.25**	0.12
bmi_20	0.03	0.09	0.01	0.04	0.03	0.09	0.1	0.04
bmi25_29	0.08	0.07	0.03	0.03	0.08	0.07	0.03	0.03
bmi30_34	-0.03	0.2	-0.01	0.08	-0.03	0.2	-0.01	0.08
cons	0.12	0.21			0.13	0.21		
Pseudo R^2	0.0327				0.0328			
n	2,546				2,546			

Note: Author's calculations using the JSTAR dataset. SE, RSE, and MFE stand for Standard Error, Robust Standard Error, and Marginal Fixed Effects, respectively. *, **, *** refers to 10%, 5%, and 1% significance level, respectively.

The results of this article also weakly support the findings of Shaw et al. (2017) that loneliness is associated with reduced healthcare spending (coefficients of loneliness and severe loneliness are negative, although both these variables are statistically insignificant). However, this article finds the opposite effect of social isolation. This could be due to differences in either measures we use for social isolation or healthcare systems.

Lastly, at the expense of sounding morbid, it should be said that social isolation and loneliness likely decrease healthcare spending through early deaths.[6] We know that healthcare spending is disproportionately concentrated in the older ages; the older a person gets, the more things go wrong in the body, which creates a need for medical intervention and leads to higher healthcare spending. Therefore, interventions that reduce social isolation and loneliness which, in turn, reduce the number of early deaths, might actually increase healthcare spending because these people will now live through older ages where there is a higher possibility of needing healthcare. This is something return on investment studies on this topic fail to consider. However, this does not mean we should not try to reduce social isolation and loneliness. It is quite the opposite. We should try to reduce these conditions even if our interventions do not reach their healthcare spending reduction goals. We should still try to eliminate human suffering and extend life.

4 Limitations

This study, using a novel dataset, examines the association between social isolation/loneliness and healthcare spending/utilization in Japan, contributing to our understanding of the subject. Focusing on Japan is especially important as the results of this article show that social isolation and loneliness are not universally associated with increased healthcare spending and utilization. Therefore, we should be careful before launching programs to tackle these two conditions with the hope of reducing healthcare spending. That said, this article has the following limitations. First, the estimated models do not allow for determining causality. Therefore, care should be taken when evaluating the results so as not to put too much emphasis on them. Social isolation has numerous aspects, so focusing on a single aspect of it, such as living alone and using it by itself as a measure of social isolation, is problematic. However, as it is mentioned above, lack of data prevents the construction of the social isolation scales used in the literature. That said, whether a person lives alone or not is likely more important compared to things like the number of friends that person has or how frequently he/she meets them in the context of this study. This is because someone who lives in the same household as you likely has more impact on your healthcare use by enabling you access to healthcare services, giving counsel and advice, following up on your medicine use etc., compared to a friend who does not live with you. The second limitation of the study relates to healthcare utilization. Living alone likely increases long-term care use and nursery services; however, the JSTAR dataset only has data for inpatient and outpatient visits. Lastly, this article only focuses on people who are age 50 and older in accordance with the literature. However, social isolation and loneliness affect the younger population as well, especially during adolescence. Therefore, additional research is needed that focuses on the younger population in the context of social isolation and loneliness and their effects on healthcare spending and utilization.

5 Conclusion

Social isolation is associated with reduced healthcare spending in Japan by ¥79,000 (approximately $550) per person annually, while loneliness does not have a statistically

[6] Approximately how much can be estimated by subtracting the age of death from average life expectancy and multiplying by average per-capita healthcare spending between the age of death and average life expectancy.

significant effect. Neither social isolation nor loneliness has a statistically significant effect on healthcare utilization; that is, these conditions are not associated with increased or decreased inpatient or outpatient visits. The reason why social isolation is associated with reduced healthcare spending in Japan compared to increased healthcare spending found in the literature for the US and Portugal might be due to different measures used for it, or it might reflect differences in healthcare systems. On the other hand, the literature finds mixed results on the association between loneliness and healthcare spending/utilization. Overall, this study provides some evidence that social isolation and loneliness might not be universally associated with increased healthcare spending and utilization. Therefore, care should be taken before launching social programs to tackle these two conditions with the hope of reducing healthcare spending and utilization.

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Appendices

Appendix A: Variable Explanations

Variable	Definition
Inpatient	"In the past year, have you spent one or more nights in the hospital?" =1 if the respondent had an inpatient visit in the last year.
Outpatient	"In the past year, have you been an outpatient at a hospital or clinic or received acupuncture, moxibustion, or bonesetting treatment?" =1 if the respondent had an outpatient visit in the last year.
Smoking	"Do you regularly use tobacco, or did you use it in the past?" 1) Yes, I smoke now 2) I smoked in the past, but I have quit 3) No, I have never smoked regularly. =1 if 1 or 2, 0 otherwise.
Drinking	"In the past 6 months, how frequently did you drink alcohol?" 1) Daily 2) 5-6 days a week 3) 3-4 days 4) 1-2 days 5) Several times per month 6) Hardly ever or never drink =1 if 1,2,3 or 4, otherwise 0.
ADL (Activities of Daily Living)	"Do you have difficulties in the following everyday activities?" 1) Putting on or removing socks and shoes 2) Moving around the room 3) Bathing on own 4) Eating by self 5) Getting into or out of bed 6) Using western style toilet Each yes (no) gets 1 (0), and the sum gives the ADL score. The higher, the worse.
Male	=1 if the respondent is male, 0 otherwise.
Married	=1 if the respondent is currently married, 0 otherwise.
Children	Number of Children
Employed	=1 if the respondent is working or temporarily not working, otherwise 0.
Living Alone	=1 if the respondent isn't married, doesn't live with parents and children, 0 otherwise
Age	Age of the respondent, 50-54 is the reference group
Household Income	Sum of respondent's income and spouse's income.
Education	People without a grade are treated as graduated because they are quite a few. Years of education based on the following table Elementary = 7 High School = 12 Junior College = 14 Vocational School = 11 University = 16 Graduate School (Master) = 18 Graduate School (PhD) = 21 Other = Don't know = Refused to answer = 12

Center for Epidemiological Studies Depression (CESD) score	"We would like to ask you about your physical and emotional condition in the last week. Please indicate if any of the following has occurred in the last week. If something occurred, but did not continue for at least one day, answer 'not at all'." Felt unusual in some way Had no appetite Felt depressed and could not be consoled by family or friends Felt I could do anything a normal person could do Could not concentrate on what I was doing Felt depressed Something that is normally effortless was difficult to do Felt the future was bright Felt that my life so far has been a failure Felt frightened Could not sleep well Felt happy Felt more taciturn than usual People around me seemed cold to me Felt happy (excited/optimistic/hopeful?) Cried or felt like crying Felt sad Felt that people around me disliked me Did not feel like doing anything 1) Not at all 2) 1-2 days 3) 3-4 days 4) 5 days or more As mentioned, the "felt lonely" statement is removed from the scale because it is used as a separate variable. The following scores are assigned to each option, and they are summed for the total CESD score (For positively worded statements, this was done in reverse: $1 >> 0, 2 >> 1, 3 >> 2, 4 >> 3$
Loneliness	"We would like to ask you about your physical and emotional condition in the last week. Please indicate if any of the following has occurred in the last week. If something occurred, but did not continue for at least one day, answer 'not at all'." There are 20 statements in the CESD-20 depression scale, and one of them is 'felt lonely', which is used to form the 'loneliness' measure. This article also uses the CESD-20 scale in the models. However, the 'felt lonely' statement is omitted from the CESD-20 scale. This is standard practice. 1) Not at all 2) 1-2 days 3) 3-4 days 4) 5 days or more This article uses just 'loneliness' in one model and the other three dummy variables as an alternative in other models, where not_lonely is the reference group. Loneliness = 1 if 3 or 4 to the above question. lonely_severe = 1 if 4, 0 otherwise. lonely_medium = 1 if 3, 0 otherwise. lonely_mild = 1 if 2, 0 otherwise. not_lonely = 1 if 1, 0 otherwise.
BMI	Body-Mass Index. BMI_20 covers BMI smaller than 20, whereas BMI_35 covers BMI greater than 35. A BMI between 20 and 25 is the reference group.
Chronic Diseases	"Please tell me if you have been diagnosed by a doctor for:" 1) Heart Disease 2) High Blood Pressure 3) Cerebral Accident (Stroke) 4) Diabetes 5) Chronic Lung Disease 6) Joint Disorder (Arthritis, Rheumatism) 7) Cancer Each of these is a dummy variable equal to 1 if the answer is yes.
City dummies	Sendai Kanazawa Takikawa Shirakawa Adachi (omitted – reference group)

Appendix B: Descriptive Statistics

Continuous Variables	**# of Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
adl	4,148	0.11	0.59	0.00	6.00
bmi	4,118	23.02	3.80	0.00	64.92
cesd	3,514	11.82	5.61	0.00	49
children	4,292	1.99	1.02	0.00	8
education	4,160	10.95	3.1	7	21
household_inc. (¥10,000)	3,670	467.8	470.86	0.00	11,650
med_exp (in ¥10,000)	4,292	19.9	54.76	0.00	1,050
Dummy Variables	**# of Obs.**	**Percentage of Respondents**			
Sendai	4,292	22			
Kanazawa	4,292	24			
Takikawa	4,292	13			
Shirakawa	4,292	19			
Adachi	4,292	21			
smoking	4,092	48			
living_alone	4,292	9			
loneliness	4,017	5			
lonely_severe	4,017	2			
lonely_medium	4,017	2			
lonely_mild	4,017	17			
drinking	4,055	47			
male	4,164	50			
married	4,160	81			
employed	4,149	57			
heartdisease	4,243	10			
highbloodpressure	3,827	32			
stroke	4,243	3			
diabetes	4,243	10			
lungdisease	4,243	1			
jointdisorder	4,243	5			
cancer	4,243	4			
age50_54	4,160	15			
age55_59	4,160	22			
age60_64	4,160	20			
age65_69	4,160	21			
age70_74	4,160	21			
age75_	4,160	2			
bmi_20	4,118	14			
bmi20_24	4,118	62			
bmi25_29	4,118	22			
bmi30_34	4,118	2			
bmi_35	4,118	0.1			
outpatient	4,112	69			
inpatient	4,109	9			