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State Dependence of Long-Term Care and Preventive Effects of Care Expenditures

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and

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Abstract

How to provide long-term nursing care to the elderly is a major policy issue worldwide. Japan, with its highly aged society, is a nice laboratory of long-term care policies. The Japanese long-term care insurance system has emphasized prevention of progression of frailty of the elderly who have the risk of falling into the conditions of being in need of care. The notion of preventive effects of long-term care is potentially important not only for individuals but also for the society through reduced costs. Preventive effects take on more importance when deteriorated conditions tend to entail further deterioration (state dependence).

This paper investigates the preventive effects of long-term care expenditures as well as the degree of state dependence. Long-term care expenditures are found to significantly ameliorate care needs. We also confirmed state dependence of frailty. When the sample is restricted to the elderly with less severe conditions, preventive effect is stronger than for all the elderly. This result confirms our hypothesis: the earlier, the better.

1. Introduction

How to provide long-term nursing care to the elderly is a major policy issue worldwide. In Japan, in particular, thanks to its already highly aged society, the burden of long-term care is immense both for the households and for the society as a whole. Long-term care policies have tried to mitigate the severity and costs of long-term care without much success. The quantity and quality of care are perceived inadequate while costs are inexorably increasing. Rigorous analysis with detailed data is lacking to remedy this situation. Decision makers in Japan require much better information on the effect and efficiency of long-term care expenditures. The Japanese experience is valuable also for other countries because they, too, are experiencing or will experience the same quagmire.

The Japanese long-term care insurance system has emphasized prevention of deterioration of the conditions of the elderly who have the risk of being in need of care. In fact, the insurance provides not only for long-term care expenditures but also for preventive expenditures. The former is expenditures to provide long-term care and the latter is those to prevent the elderly from falling into the condition where long-term care is needed. In the system, a category, “Requiring Support,” is created for those who have the risk of deteriorating but not yet in need of long-term care. Strictly speaking, the elderly in this category already suffer from a slight physical and/or mental disorder. In general, therefore, long-term care expenditures are expected to prevent the conditions of the elderly from deteriorating further when such care is provided in early stages of frailty stemming from old age. Here, “prevention” can conceptually include services for those who are already in need of long-term care.

The emphasis on prevention is unique to the Japanese system. The German system, for example, covers relatively severe conditions only. In the case of health care, prevention of diseases is considered very important. In contrast, long-term care tends to be regarded only as taking care of the elderly who have already suffered from severe frailty and who have no hope of redeeming more favorable conditions. However, by preventing bedsore or bed-ridden inactivity, for example, long-term care can avoid deterioration of frailty and can ameliorate the condition of the elderly. The notion of preventive effects of long-term care is potentially important not only for individuals but also for the society through reduced costs.

Preventive effects take on more importance when deteriorated conditions tend to entail further deterioration: once an elderly's condition deteriorates, she tend to remain frail or even to become worse on top of the initial deterioration. This phenomenon, called state-dependence, is one of the key hypotheses this paper is going to investigate.

The other hypothesis we focus on is that long-term care has preventive effects. A difficult question is that it is not easy to pin down the preventive effects in the presence of endogeneity of care expenditures. Long-term care may prevent deterioration of the elderly's conditions and, hence, may contribute to the reduction of care expenditures. Here, however, comes a problem of reverse causality. An elderly who has a severe frailty will consume a lot of long-term care, which induces a positive relationship between care expenditures and deteriorated conditions. The problem is that care expenditures correlate with unobserved heterogeneity in the error term due to endogeneity. Note that lagged care levels in the dynamic panel model also give rise to this kind of correlation. As we will see later, empirical studies in Japan have obtained mixed results although they make great efforts to statistically estimate causal effects.

This paper investigates some preventive effects of long-term care in the Japanese care insurance system. We take into account state dependence of care needs by utilizing dynamic panel data. We adopt the estimation method proposed by Wooldridge (2005) to control endogeneity, or correlation between unobserved heterogeneity and explanatory variables. We further try to adjust for attrition bias following Albert and Follmann(2003).

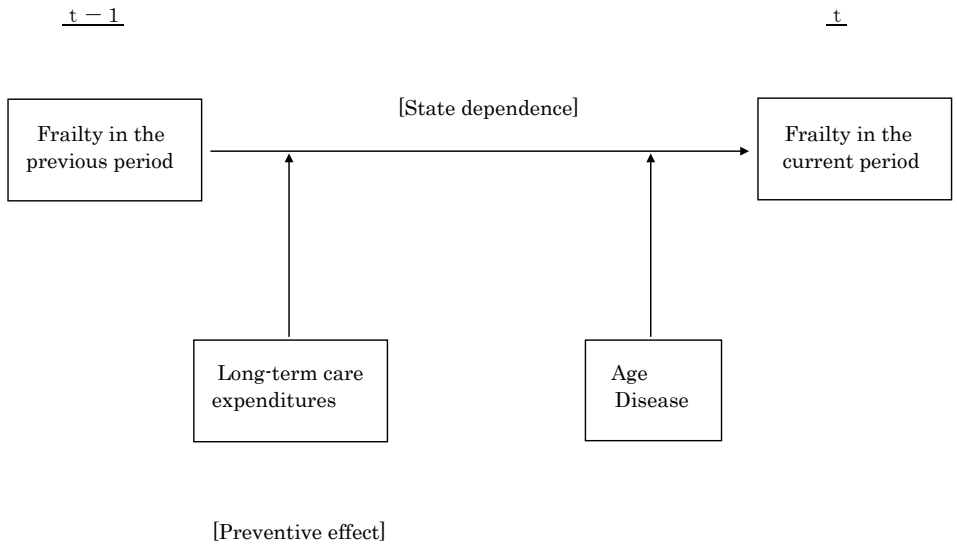
The paper is organized as follows. Section 2 introduces our conceptual framework and hypotheses. Section 3 reviews existing literature and 4 describes the institutional features of the Japanese long-term care insurance system. Section 5 explains the data sources and Section 6 provides descriptive statistics. Section 7 presents the model and Section 8 gives the results. Section 9 concludes.

2. Conceptual Framework and Hypotheses

Figure 1 depicts our conceptual framework. An elderly *i* with a long-term care level *j* at time *t-1* will transit to a care level *j'* at time *t*. Various factors affect this transition including age and pre-existing illness. Long-term care is expected to moderate the

transition to higher care level through preventive effects.

Figure 1 Conceptual Framework



Our main hypotheses are as follows. First, effects of shocks to physical and/or mental conditions are persistent. Once an elderly's condition deteriorates, she tends to remain feeble or even to become worse after that. This phenomenon is called state dependence.

Second, long-term care expenditures have preventive effects against worsening care level. As will be explained below, the Japanese long-term care insurance system covers both long-term care proper and care for prevention. The idea is that if preventive care can prevent the elderly from requiring more and more heavy long-term care, such expenditures would be cost effective and worth spending. Two sub-hypothesis are: on the one hand, such preventive effects are stronger for home care than for facility care. On the other, preventive care is more effective when implemented in early stages of frailty than when the person is already in an advanced stage.

3. Literature Review

State Dependence

Literature on state dependence of health is vast. Jones, et al. (2006a) provides a survey. Most closely related to our paper is Contoyannis, et al. (2004), which investigates the

dynamics of self-assessed health. The paper utilizes dynamic panel ordered probit models, which include lagged health status as an explanatory variable to capture state dependence. To allow for the possibility that the observed regressors may be correlated with the individual random effect, the individual random effects are parameterized as in Mundlak (1978), Chamberlain (1984) and Wooldridge (2005). They found substantial positive state dependence. Another example which explores state dependence is Heiss, et al. (2009). They analyze transition matrix for self-reported health, which is assumed to depend on a latent health variable, and find that future paths of health and disability are very strongly related to health and disability at age 50.

Care Expenditures and Outcomes

We are unaware of any English literature that examines the effect of long-term care expenditures and outcomes. A few papers study the relationship between health care expenditures and health outcomes. Martina, et al. (2007), for example, examines whether health spending improves health outcomes employing instrumental variables methods and finds that the cost of a life year saved in cancer is about £13,100 and in circulation about £8,000, which challenges the traditional view that health care has little marginal impact on health.

The relationship between long-term care expenditures and outcomes is studied in the context of the Japanese long-term care insurance system. Tajika and Kikuchi(2003) analyzes effectiveness of the long-term care utilization to sustain or improve elderly's long-term care levels in early stages of frailty. They do not adjust for selection bias by statistical techniques such as propensity score matching or instrumental variables. They did not observe preventive effects of care utilization. Yuda, et al. (2013) investigates the effects of the introduction of preventive long-term care benefits on the care level of the elderly in the very early stage of frailty. They utilize the propensity score matching method to control for selection. It should be noted, however, this method is valid only for selection on observables. They find that some of the preventive long-term care significantly sustain or improve the conditions of the elderly requiring help.

Attrition

Jones, et al. (2006b) documents health-related non-response in the British Household Panel Survey and utilizes an inverse probability weighted estimator as is proposed by Wooldridge (2005). They find evidence for non-response bias, which, however, turns out to be inconsequential.

4. Institutional Description

The Japanese long-term care insurance system covers, primarily, elderly people aged above 65 years old and above. People of age between 40 and 64 years old also enroll in the insurance. To obtain benefits a policyholder need to be certified as Requiring support or Requiring Long-term care by the insurer (municipality). Requiring Support is the classification for persons whose basic activities of daily living can be performed basically independently but for whom some support is needed for procedural activities of daily living to prevent becoming in need of long-term care. Requiring Long-term Care is for persons whose basic activities of daily living cannot be performed independently and long-term care is needed.

The certification is made for Requiring support levels 1 to 2[5] and Requiring Long-term care levels 1 to 5[6]. (See Appendix) These categories are defined in terms of the time needed to take care of the elderly, not in terms of the severity of the condition of the elderly. However, a positive correlation is observed between Support/Care Levels and frail conditions of the elderly (Tajika and Kikuchi, 2003). The Support level 1 is the least-frail elderly for whom, in typical cases, basic activities of daily living such as walking can be performed independently but some support is needed concerning standing up, getting up, standing on one foot. The Care level 5 is the most frail who, in typical cases, capabilities of movement have deteriorated so severely that daily living is almost impossible without long-term care. Tajika and Kikuchi (2003) points out that the Care level 3 is the threshold between mild and severe conditions. They classify the elderly with less than and equal to Care level 2 as mild.

The services provided to the elderly certified as Requiring Support are called "preventive benefits" while those provided to the elderly certified as Requiring Long-term Care are called "long-term care benefits". However, those services are not much different across these categories. Therefore, we will not distinguish between "preventive" and "long-term care" benefits.

The Japanese long-term care insurance system provides benefits for two types of care. One is home care, the other facility care. Home care includes home-visit care, day care, short-term admission to facilities and rental welfare equipment.

[5] Sometimes referred to as "Support Level 1(2)".
[6] In the following, sometimes referred to as "Care Level 1(-5)".

5. Data

The Tokyo Metropolitan Institute of Gerontology launched a longitudinal study of aging and health in 2002 at Kusatsu in Japan. All residents aged 65 years or older[7] have been invited to participate in baseline studies and follow-up surveys and medical examinations. The medical examination is called the Nikkori (Smile) examination and is held at a local public health center once a year. The survey is called the Iki-iki (Lively) survey and is conducted every two years. These surveys and examinations contain detailed physical and medical information including diseases that the elderly had suffered or is suffering from currently. In particular, they include information on pre-existing stroke and hypertension, which we will use as explanatory variables in the estimation. Actually, Levine, et al. (2014) documents that myocardial infarction and stroke hospitalizations are associated with significant increases in functional disability. All participants provided written informed consent under conditions approved by the Ethics Committee at the Tokyo Metropolitan Institute of Gerontology.

The physical and medical information is linked to the information on the long-term care benefits approved by the long-term care insurance system. The latter information also includes the Support Level or Care Level if the elderly is certified as Requiring Support or Requiring Long-term Care.

Since the Nikkori (Smile) medical examination and the Iki-iki (Lively) health survey are conducted annually and biannually, respectively, their annual data are transformed into quarterly data. In the estimation below, pre-existing diseases of stroke and hypertension are used. If an elderly is found to suffered a stroke in a year, she is judged to have a pre-existing stroke after the beginning of that year and not before that.

6. Descriptive Statistics

Table 1 shows basic statistics of the sample used for the estimation; from 2006 to 2009. The average age is 76.4 years old. As for the preexisting conditions, 11 per cent of the elderly has suffered from stroke, currently or in the past, and 46 per cent from hypertension.

[7] Up to 2005, 70 years or older.

Table 1 Descriptive Statistics

	2006Q3-2009Q4			2006		2007		2008		2009	
	Obs	Mean	Std. Dev.	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
Age	19,303	76.38	6.96	1,354	76.49	1,423	76.37	1,448	76.50	1,421	76.88
Sex (1:male 2:female)	19,303	1.57	0.49	1,354	1.58	1,423	1.58	1,448	1.58	1,421	1.58
Stroke (0:No 1:Yes)	19,303	0.11	0.31	1,354	0.11	1,423	0.11	1,448	0.11	1,421	0.11
Hypertension (0:No 1:Yes)	19,303	0.46	0.50	1,354	0.40	1,423	0.44	1,448	0.47	1,421	0.47
Care level(current)	19,303	1.40	1.28	1,354	1.31	1,423	1.33	1,448	1.31	1,421	1.33
		(share)									
Independent	*17,136*	*88.8%*		*1,188*	*87.7%*	*1,249*	*87.8%*	*1,279*	*88.3%*	*1,251*	*88.0%*
Mild(～Requiring Care 2)	*1,509*	*7.8%*		*126*	*9.3%*	*128*	*9.0%*	*129*	*8.9%*	*121*	*8.5%*
Severe(Requiring Care 3～)	*658*	*3.4%*		*40*	*3.0%*	*46*	*3.2%*	*40*	*2.8%*	*49*	*3.4%*
Requiring support 1	*336*	*1.7%*		*42*	*3.1%*	*43*	*3.0%*	*43*	*3.0%*	*39*	*2.7%*
Requiring support 2 / Requiring long-term care 1	*760*	*3.9%*		*59*	*4.4%*	*49*	*3.4%*	*47*	*3.2%*	*47*	*3.3%*
Requiring long-term care 2	*413*	*2.1%*		*25*	*1.8%*	*36*	*2.5%*	*39*	*2.7%*	*35*	*2.5%*
Requiring long-term care 3	*251*	*1.3%*		*22*	*1.6%*	*18*	*1.3%*	*17*	*1.2%*	*19*	*1.3%*
Requiring long-term care 4	*280*	*1.5%*		*11*	*0.8%*	*19*	*1.3%*	*18*	*1.2%*	*20*	*1.4%*
Requiring long-term care 5	*127*	*0.7%*		*7*	*0.5%*	*9*	*0.6%*	*5*	*0.3%*	*10*	*0.7%*
Long-term care expenditure 1)2)	2,167	14.21	10.73	166	13.59	174	13.64	169	14.39	170	14.31
in which											
Home care expenditure	2,167	8.95	9.40	166	8.32	174	8.69	169	9.47	170	9.39
Faciliy care expenditure	2,167	5.26	10.66	166	6.29	174	5.72	169	5.72	170	5.47

1) Care expenditure : not includes "Independent"
2) 10 thousand yen

To get a feel about the overall degree of frailty of the elderly, we assign a point to each condition; one to Independent, two to Requiring Support 1, three to Requiring Support 2, four to Requiring Long-term Care 1, and so on. When averaged over all elderly population, the mean of the frailty points is 1.40.

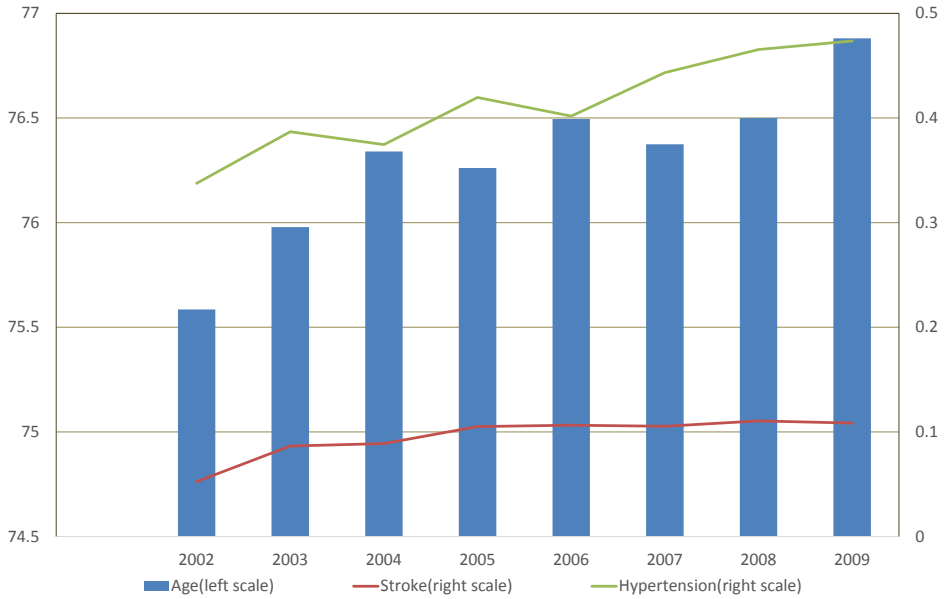
The share of the elderly in each frailty condition is 88.8 per cent for the elderlies who do not need support or care (Independent). As for Requiring Support/Care conditions, we aggregate categories in accordance with Tajika and Kikuchi (2003): aggregate categories from the Support Level 1 to the Care Level 2 into "Mild" while aggregating categories above the Care Level 3 into "Severe." The share is 7.8 per cent for the mild care level and 3.4 per cent for the severe care level. Below these figures, the ratio for each category is shown.

Care expenditures[8] per elderly who are authorized as Requiring Support or Long-term Care are 142,100 yen for the whole period. When divided into two categories, home care expenditures are 89,500 yen and facility care expenditures are 52,600 yen.

[8] In this paper, "long-term care expenditures" include the expenditures spent by the elderly in the category Requiring Support.

To provide a long-term perspective, we show the data from 2002 to 2009 in Figure 2. For the whole data period, the average age is 76.3 years. The average age has increased rapidly from 75.6 years in 2002 to 76.5 years in 2006. This trend continues in the estimation period, from 2006 to 2009, although at a slightly decelerated rate (76.9 years in 2009).

Figure 2 Age and Pre-existing diseases: Stroke and Hypertension



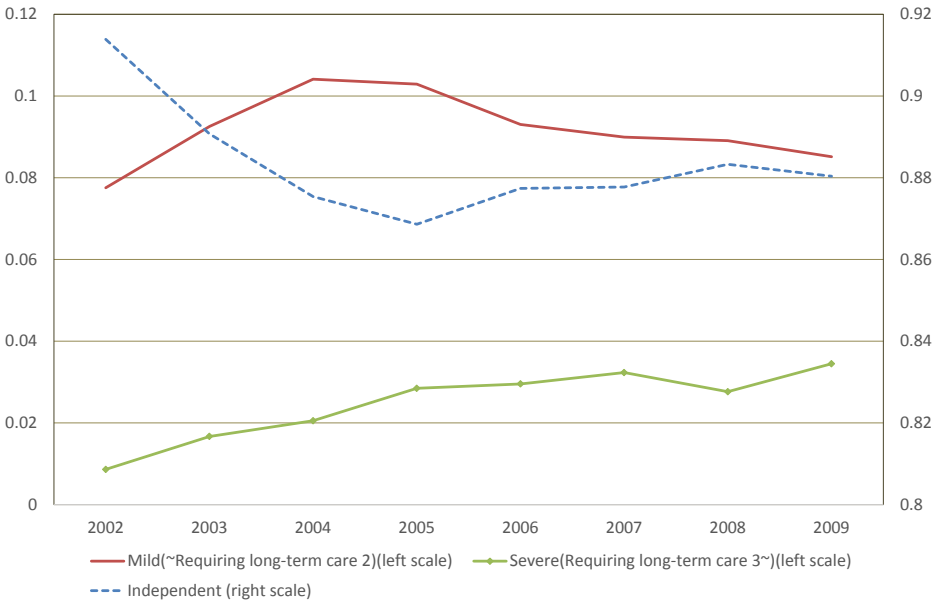
Ten per cent of the elderly has suffered from stroke, currently or in the past, and 41 per cent from hypertension for the whole data period. From 2002 to 2006, the ratios for stroke rose from 5 per cent to 11 per cent and that for hypertension from 34 per cent to 40 percent. After 2006, these ratios are stable for stroke (11 per cent in 2009) and increasing for hypertension (47 per cent in 2009).

The mean of the frailty points, the overall degree of frailty of the elderly which is calculated as above, is 1.29 (not shown). This index rose from 1.17 in 2002 to 1.31 in 2009. After 2006, its movement is a little erratic, but it seems that the rising trend continued (1.33 in 2009).

Figure 3 shows the trend in the share of the elderly in each frailty condition. The trends suggest an increasing frailty during the period. The elderly who do not need support or care (Independent) account for 88.3 per cent in the whole period. The share of the Independent category declined from 91.4 per cent in 2002 to 86.9 per cent in 2005 before slightly increased after 2006 (88.0 per cent in 2009). The share of the “Mild”

category is 9.2 per cent over the whole period with a rise from 7.8 per cent in 2002 to 9.3 per cent in 2006 and a decline thereafter (8.5 per cent in 2009). On the other hand, the share of the "Severe" category is 2.5 percent over the whole period with a continuously rising trend throughout the period from 0.9 percent in 2002 to 3.4 percent in 2009 although the trend slightly decelerated after 2006.

Figure 3 Distribution of Care Levels: Independent, Mild and Severe



Care expenditures per elderly who are authorized as Requiring Support or Long-term Care are 130,000 yen for the whole period. Figure 4 shows the trend of care expenditures. They increased from 110,000 yen in 2002 to 136,000 yen in 2006 although the increase after 2006 is slightly subdued (143,000 yen in 2009). When decomposed into home care and facility care expenditures, the former is 82,000 yen while the latter is 57,000 yen for the period as a whole. Home care expenditures increased steadily from 65,000 yen in 2003[9] to 83,000 yen in 2006 (939,000 yen in 2009). On the other hand, facility care expenditures, first, increased from 55,000 yen in 2002 to 63,000 yen in 2006 and, then, decreased to 55,000 yen in 2009.

[9] A sharp drop from 2002 to 2003 is likely to be an anomaly.

Figure 4 Care Expenditures: Total, Home Care and Facility Care

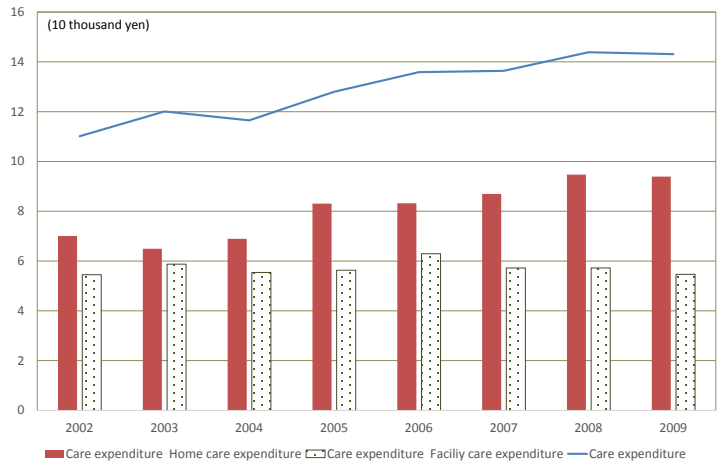


Table 2 is a matrix which shows the transition probabilities from the care level of one year earlier to the current care level including death. For example, 97 percent of the independent elderly remain independent after a year, 0.7 percent of them will become Requiring Support level 1, 0.5 percent the support level 2, and so on. The large percentage figures on the diagonal indicate that people tend to find themselves in the same categories as those in the previous year. Naturally, they often stay near the original categories even if they make transitions and it is infrequent that they jump into far away categories.[10] These strongly indicate state dependence of frail conditions. In the "Mild" categories, the elderly tend to make transitions to more severe categories than to less severe ones. It is a little surprising that a moderate number of the elderly in the "Severe" categories still go back to less severe categories. People tend to die more often when they are in more severe categories.

Table 2 Transition Matrix

		Care level (current)									Total
		independent	Requiring Support 1	Requiring Support 2	Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5	death	
Care level (t-4)	independent	97.0%	0.7%	0.5%	0.4%	0.3%	0.2%	0.2%	0.1%	0.6%	100.0%
	Requiring Support 1	2.2%	57.0%	21.9%	9.6%	5.6%	1.5%	0.4%	0.0%	1.9%	100.0%
	Requiring Support 2	0.0%	13.5%	45.1%	21.1%	7.6%	4.2%	3.4%	2.1%	3.0%	100.0%
	Requiring long-term care 1	0.0%	4.2%	15.8%	41.0%	24.8%	7.9%	2.2%	0.7%	3.5%	100.0%
	Requiring long-term care 2	0.0%	2.1%	3.3%	16.6%	51.7%	13.6%	9.1%	0.9%	2.7%	100.0%
	Requiring long-term care 3	0.0%	1.3%	2.6%	5.7%	8.8%	43.6%	25.1%	7.5%	5.3%	100.0%
	Requiring long-term care 4	0.0%	0.0%	0.5%	0.0%	10.1%	11.6%	61.1%	11.6%	5.1%	100.0%
	Requiring long-term care 5	0.0%	0.0%	2.8%	0.0%	0.0%	8.3%	13.8%	67.9%	7.3%	100.0%
Total		88.6%	1.6%	1.7%	1.9%	2.0%	1.2%	1.4%	0.7%	0.9%	100.0%

[10] The transition from Care Level 5 to Support Level 2 is an amazing exception. (It is rare, to be sure.) This case is an anomaly due to a small sample size.

7. The Model

The dependent variable is the indicator variable which shows the level of need for support or care. On top of the independent state where there is no need for support nor care, there are two categories of Requiring support and five categories of Requiring Long-term Care so that $y_{it} = \{1,\ 2, \ldots, 8\}$ with 1 indicating the independent state and 8 Requiring Long-term care 5. To model this categorical variable, an ordered probit model is employed because there is a natural order in it. To incorporate state dependence, lagged dependent dummy variables (y_{i2t} through y_{i8t}) are included as an explanatory variable.

The latent variable model is

$$y_t^* = z_{it}\gamma + \sum_{j=2}^{8} \rho_j\, y_{i,j,t-1} + c_i + u_{it}. \qquad (1)$$
$$\rho_j y_{i,\,j,t-1} \qquad j = 2, \cdots, 8$$

Cut points for respective categories are

$$\alpha_1 < \alpha_2 < \cdots < \alpha_J.$$

The actual outcome, y, realizes according as the latent variable, y^*, is located below, between or above the cut points:

$$\begin{aligned} \mathrm{y} = 1 \quad & \text{if } \ y^* \le \alpha_1 \\ \mathrm{y} = 2 \quad & \text{if } \ \alpha_1 < y^* \le \alpha_2 \\ \mathrm{y} = 3 \quad & \text{if } \ \alpha_2 < y^* \le \alpha_3 \\ & \vdots \\ \mathrm{y} = 8 \quad & \text{if } \ y^* > \alpha_J \end{aligned}$$

Probability distributions are specified as normal distribution, $\Phi(.)$.

$$\begin{aligned} &\mathrm{P}\left(y_{it} = 1 | z_{it} + \textstyle\sum_{j=2}^{8} \rho_j y_{i,j,t-1} + c_i\right) = \Phi\left([\alpha_1 - (z_{it}\gamma + \textstyle\sum_{j=2}^{8} \rho_j y_{i,j,t-1} + c_i)\right] \\ &\mathrm{P}(y_{it} = 2 | \cdot) \\ &= \Phi\left[\alpha_2 - \left(z_{it}\gamma + \textstyle\sum_{j=2}^{8} \rho_j\, y_{i,j,t-1} + c_i\right)\right] - \Phi\left([\alpha_1 - (z_{it}\gamma + \textstyle\sum_{j=2}^{8} \rho_j\, y_{i,j,t-1} + c_i)\right] \\ &\qquad\qquad \vdots \\ &\mathrm{P}\left(y_{it} = J | z_{it} + \textstyle\sum_{j=2}^{8} \rho_j\, y_{i,j,t-1} + c_i\right) = 1 - \Phi\left([\alpha_J - (z_{it}\gamma + \textstyle\sum_{j=2}^{8} \rho_j\, y_{i,j,t-1} + c_i)\right] \qquad (2) \end{aligned}$$

Explanatory variables include age, sex and preexisting conditions such as stroke and hypertension. As we mentioned previously, Levine, et al. (2014) documents that myocardial infarction and stroke hospitalizations are associated with significant increases in functional disability and we can use hypertension as a surrogate indicator of MI.

A dummy for each quarter is included to control for factors which are specific to each period, for example, quality of care in the long-term care insurance system. To mitigate wild variations of quarter dummies, autoregressive restriction is imposed. Specifically, the dummy, λ_t, for each period is distributed as normal whose mean, m_t^{λ}, depends on the realized value of the dummy for the previous period.

$$\lambda_t \sim N(m_t^{\lambda}, {\sigma_t^{\lambda}}^2) \tag{3}$$
$$m_t^{\lambda} = \delta_t \cdot \lambda_{t-1} \tag{4}$$

Contoyannis, et al. (2004) adopts the method proposed by Wooldridge(2005) also to control for the initial value problem. The initial value problem occurs when the regression equation includes the lagged dependent variable as an independent variable, in which case the dependent variable at time zero, y_0, is out of the model and how to model the correlation between y_0 and the unobserved heterogeneity is problematic. Of course, the correlation between the dependent variable and the lagged dependent variable through the unobserved heterogeneity is a more general problem in the dynamic panel data model. In the likelihood or Bayesian framework, the unobserved heterogeneity is given a distribution and multiplied out as is described in Wooldridge (2002). The correlation between the initial value, y_0, and the unobserved heterogeneity is not modeled, however. Hence, we have to worry about that correlation.

Wooldridge (2005) proposes that the unobserved heterogeneity be modeled as dependent on the initial value, y_0, in addition to strictly exogenous variables in the model, $z_i = \{z_{i1}, \ldots, z_{iT}\}$.[11] In actual implementation, as described in Wooldridge (2005), we can estimate the mode by including $\bar{z}_i$ in explanatory variables at each time period, where $\bar{z}_i$ is the average over the sample period of explanatory variables for an individual i.

[11] Wooldridge's method is an extension of the method proposed by Chamberlain (1980), which in turn adopts an idea contained in Mundlak (1978) to the case of the initial value problem.

$$c_i|z_i, y_{i0} \sim Normal(\lambda_1 + \bar{z}\lambda_2 + \sum_{j=2}^{8} \lambda_{3j} \cdot y_{i,j,0} \quad , \sigma_a^2) \tag{5}$$

or

$$c_i = \lambda_1 + \bar{z}\lambda_2 + \sum_{j=2}^{8} \lambda_{3j} \cdot y_{i,j,0} \quad + a_i, \; a_i \sim Normal(0, \sigma_a^2). \tag{6}$$

Substituting equation (6) into equation (1) gives the equation to be estimated.

Wooldridge (2005) points out that these explanatory variables, $z_i = \{z_{i1}, \ldots, z_{iT}\}$, included in the modeling of the unobserved effect must be strictly exogenous conditional on c_i in the following sense: for t = 1, 2, . . . , T,

$$\mathrm{E}\,(y_{it} \mid z_{i1}, \ldots, z_{iT}, \; c_i) = \mathrm{E}\,(y_{it} \mid z_{it}, c_i). \tag{7}$$

Strict exogeneity requires that the explanatory variable not correlate with the dependent variable for all leads and lags conditional on the unobserved heterogeneity. In our case, explanatory variables include lagged long-term care expenditures. We have to check the exogeneity of lagged expenditures in two respects. On the one hand, lagged long-term care expenditures share the unobserved heterogeneity with the dependent variable. On the other hand, care expenditures without lags are simultaneously determined with the care level, y_{it} so that, analogously to simultaneous equation bias, past and future expenditures are correlated with the care levels. Concerning the first aspect, as is explained in Wooldridge (2002) using an example of production function, lagged long-term care expenditures can be assumed to be exogenous once conditioned on the unobserved effect although they are not exogenous when not conditioned on the unobserved effect. As for the second aspect, we use lagged expenditures in the regression model so that simultaneity is eliminated.

Prior distributions for the coefficient, ρ_j, on the lagged care level, $y_{i,j,t-1}$, and the coefficients, γ, on explanatory variables, z_{it}, including the lagged long-term care expenditures together with the unobserved heterogeneity, a_i, are assumed to be normal distributions with mean zero and variance 1000: take a generic coefficient μ, then, $\mu \sim N(0,1000)$. The choice of the variance of 1000 is intended to represent a diffuse prior. Gelman and Hill (2007) give a thoughtful discussion on the appropriateness of this value in the context of the logistic models or log-transformed regressors. They argue that in logistic and logarithmic regressions, typical changes in outcomes are on

the scale of 0.1 or 1, but not 10 or 100, so that one would not expect to see coefficients much higher than 10 in absolute values as long as the regressors are also on a reasonable scale. Although their choice of the value of variance is 100^2, we believe that their argument applies to our choice, 1000.

Prior distribution on the variance, $\sigma_t^{\lambda^2}$, of the time dummy, λ_t, is specified so as to its standard deviation , σ_t^{λ}, is uniformly distributed over the domain (0, 100). Prior distribution for the unobserved heterogeneity, a_i, is also specified so as to its standard deviation , σ_a^2, is uniformly distributed over the domain(0,100). The range of 0 to 100 is chosen, again, in view of the argument made by Gelman and Hill (2007). Uniform prior on standard deviation is generally the preferred prior by practitioners.[12] While we could have also applied uniform priors to the coefficients on the lagged care level and other explanatory variables, we adopted more conventional and slightly more informative priors for these variables as was explained above. Prior distribution on the coefficient, δ_t, of the AR process of time dummies, λ_t, are more stringent $N(0,10)$ because we would like to tighten the variation of time dummies.

The model is estimated by the Markov chain Monte Carlo (MCMC) method utilizing the WinBUGS software. Convergence is checked by the Gelman-Rubin statistics. Burn-in is 2,000 and the number of iterations used in calculation is 10,000.

The Missing data mechanism is modeled as the shared random effect model, in which the observation mechanism is independent of the missing data mechanism conditional on the unobserved random effect (Daniels and Hogan, 2008). Dropping the suffixes, the decomposition of the joint probability of the dependent variable, *y*, and the indicator of missing data, *r*, conditional on the explanatory variables, *x*, can be represented as

$$p(y, r \mid x) = \int p(y, r \mid b, x) p(b)\, db. \tag{8}$$

The missing data mechanism is molded à la Albert and Follmann (2003). Missing data are categorized into two patterns: missing intermittently and dropped out. In the former case, an individual is sometimes missing and sometimes observed. In the latter case, an individual will never be observed after her observation is first missed. The drop

[12] Spiegelhalter, et al. (2004) contains a detailed discussion on the prior for the standard deviation of the random effects.

out category includes the cases of death, moving out of the town and cause unknown. 87 percent of the elderly did not drop out, while 0.9 percent experienced intermittent sassing and 12 percent dropped out.

$$R_{it} = \begin{cases} 0 & if\ observed \\ 1 & if\ intermittently\ missing \\ 2 & if\ dropped\ out \end{cases}$$

The probability of observed/intermittently missing/dropped out is assumed to follow a logit distribution starting from the status other than dropped out.

$$p\left(R_{it} = l \middle| b_i, R_{i,t-1} \neq 2\right) = \begin{cases} \frac{1}{1+\sum_{l=1}^{2}\exp(x_{lit}\eta+\gamma_l b_i)} & l = 0 \\ \frac{exp(x_{lit}\eta+\gamma_l b_i)}{1+\sum_{l=1}^{2}exp(x_{lit}\eta+\gamma_l b_i)} & l = 1,2 \end{cases} \quad (9)$$

Since l=2 is an absorbing state, the transition probability starting the status of dropped out is

$$p\left(R_{it} = 2 \middle| R_{i,t-1} = 2\right) = 1 \quad (10)$$

Correlation between random effects, $b^o$and b^d, in the shared parameter model is specified as a multivariate normal distribution with a mean vector M and a variance-covariance matrix Ω. The prior distribution of the diagonal elements, ω_{kk}, k=1,2, of Ω is assumed to be uniform. The off-diagonal elements, $\omega_{21} = \omega_{12}$, are linked to the diagonal elements through the definition of the correlation coefficient, which is also assumed to follow a uniform distribution.

$$B \sim MVN(M, \Omega)$$

$$B \equiv \begin{pmatrix} b^o \\ b^d \end{pmatrix}, \qquad M \equiv \begin{pmatrix} m^o \\ m^d \end{pmatrix}$$

$$\Omega \equiv \begin{pmatrix} \omega_{11}^2 & \omega_{12} \\ \omega_{21} & \omega_{22}^2 \end{pmatrix}$$

$$\omega_{11} \sim duni(0,100\ ),\ \omega_{22} \sim duni(0,100\ )$$
$$\omega_{12} \sim \rho \cdot \omega_{11} \cdot \omega_{22},\ \omega_{21} = \omega_{12},$$
$$\rho \sim duni(-1,1\ ) \quad (11)$$

Other prior distributions are as follows. The vector of coefficients β_k follows an independent multivariate normal distribution, whose generic component is $\beta_{kl} \sim Normal(0, 0.1)$. Priors for $\delta_k, \theta_k, \delta_d, \theta_d, \phi_{at}$ and ϕ_{dt} are normal distribution, one of which is generically $\delta_k \sim Normal(0, 0.1)$.

8. Estimation Results

The estimation period is from the third quarter of 2006 to the fourth quarter of 2009. In total 2,053 elderly are included in the sample.

Results of 6 estimations are presented below. In the first estimation, Requiring Long-term Care level is regressed on lagged care level dummies [13], age, sex, pre-existing stroke and hypertension, lagged care expenditures, quarter dummies, averages of explanatory variables and the first observed care level dummies. The averages of explanatory variables are averages of an individual's care expenditures and pre-existing diseases (stroke and hypertension).

The second estimation adjusts for drop out by simultaneous estimation of the care level equation and the drop out equation with shared parameter. The explanatory variables in both equations are the same as the first estimation. The third estimation decomposes care expenditures into home care and facility care expenditures, while the first and second estimations used total care expenditures.

The fourth estimation restricted sample to the elderly who are in relatively mild categories, Requiring Support 1 and 2 using total expenditures. These constitute tests of the hypothesis: the earlier the better. The fifth and sixth estimations restricted the sample to slightly more severe categories, Requiring Long-term Care 1 and 2.

(1) Single equation; Total expenditures

Table 3 shows the results for the estimation of the care level equation. In this first estimation, we did not adjust for attrition. The lagged care expenditures are total expenditures without being decomposed into home and facility care expenditures.

[13] In this chapter and Table 1-9,"care level" includes Requiring Support level (1-2) and Requiring Lon-term Care level (1-5).

Table 3　Single Equation (Total long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Lagged care level dummy					
Requiring support 1	1.49	0.10	1.31	1.49	1.69
Requiring support 2	2.24	0.09	2.07	2.24	2.42
Requiring long-term care 1	2.97	0.09	2.78	2.96	3.15
Requiring long-term care 2	3.64	0.11	3.41	3.64	3.86
Requiring long-term care 3	4.51	0.14	4.23	4.51	4.79
Requiring long-term care 4	5.27	0.20	4.90	5.28	5.64
Requiring long-term care 5	6.83	0.23	6.37	6.83	7.27
Lagged long-term care expenditures	−0.04	0.00	−0.04	−0.04	−0.03
Age	0.24	0.17	−0.06	0.23	0.61
Sex	−0.07	0.06	−0.19	−0.07	0.05
Stroke	0.59	0.32	−0.04	0.59	1.25
Hypertension	−0.14	0.15	−0.45	−0.14	0.16
Time dummy					
2006Q3	−1.11	1.57	−4.00	−0.22	0.76
2006Q4	−1.29	1.56	−4.15	−0.38	0.53
2007Q1	−1.13	1.55	−3.98	−0.21	0.65
2007Q2	−1.09	1.53	−3.92	−0.18	0.66
2007Q3	−1.09	1.52	−3.92	−0.20	0.62
2007Q4	−1.20	1.52	−4.02	−0.34	0.48
2008Q1	−1.32	1.51	−4.14	−0.50	0.35
2008Q2	−1.22	1.50	−4.03	−0.45	0.44
2008Q3	−2.35	1.49	−5.14	−1.63	−0.69
2008Q4	−0.40	1.48	−3.18	0.28	1.26
2009Q1	−1.31	1.50	−4.12	−0.64	0.39
2009Q2	−1.14	1.50	−3.95	−0.50	0.58
2009Q3	−1.34	1.50	−4.16	−0.75	0.41
2009Q4	−1.27	1.50	−4.10	−0.74	0.49

The estimated coefficients on the care level in the previous quarter are large and highly statistically significant. With a significant negative coefficient, care expenditures have preventive effects against worsening care conditions.

Sex[14] and hypertension tend to be negative, but insignificant. Time dummies are negative over time which indicates the existence of common factors affecting the individuals at each period. We may interpret such tendency as representing the quality of long-term care services.

To provide an indication of the magnitude of the association between current care level and lagged care level, we can compute the average treatment effects (ATEs) of each category on lagged care level. Wooldridge (2002) computes the partial effect with respect to a binary data. We extend this idea to ordered probit model as Jones, et al.(2006).

[14] 1：Male, 2：Female

To obtain the ATEs of each lagged care level, j, on current care level, k, we compare the probability of being care level, k, including the effects of the lagged, j, with the probability excluding the effects of the lagged, j.

Specifically, let q_{ik} be the probability below k including the effects of the lagged, j, similar, qd_{ik} excluding the effects of the lagged, j. Then the ATEs are computed by taking differences of q_{ik} and qd_{ik} averaged on individuals. Following Wooldridge (2002), to account for individual effects, we adjust the original parameters[15] by multiplied by $(1+\widehat{\sigma_a^2})^{-1/2}$.

$$\begin{aligned} q_{ik} &\equiv \phi\left[\widehat{a_j} - \left(z_{it}\widehat{\gamma_a} + \widehat{\rho_{a,j}} y_{i,j,t-1} + \widehat{c_{ai}}\right)\right] \\ qd_{ik} &\equiv \phi\left[\widehat{a_j} - \left(z_{it}\widehat{\gamma_a} + \widehat{\rho_{a,j}} y_{i,j,t-1} + \widehat{c_{ai}} - \widehat{\rho_{a,j}} y_{i,j,t-1}\right)\right] \end{aligned} \qquad (12)$$

Δ_j^k denotes the ATEs of lagged care level, j, and current care level, k.

if k = 1

$$\Delta_j^k = \frac{1}{N}\sum_{i=1}^{N} q_{ik} - \frac{1}{N}\sum_{i=1}^{N} qd_{ik}$$

if k = 2, … ,7

$$\Delta_j^k = \frac{1}{N}\sum_{i=1}^{N} q_{ik} - \frac{1}{N}\sum_{i=1}^{N} q_{i,k-1} - \left(\frac{1}{N}\sum_{i=1}^{N} qd_{ik} - \frac{1}{N}\sum_{i=1}^{N} qd_{i,k-1}\right)$$

if k = 8

$$\Delta_j^8 = 1 - \frac{1}{N}\sum_{i=1}^{N} q_{i7} - \left(1 - \frac{1}{N}\sum_{i=1}^{N} qd_{i7}\right) \qquad (13)$$

Table 4 shows the ATEs of lagged care level state on the probability of current care levels. A positive sign implies a positive association with current care level. In general, the ATEs on the diagonal are higher than the ATEs off the diagonal, which means current care levels tends to be the same as the previous care levels.

For example, Requiring Long-term Care 2 in previous quarter, the ATE of reported Requiring Long-term Care 2 (0.327), is higher than other levels.

[15] Subscript "a" below denotes the original parameters, and "$\widehat{\ }$" denotes estimates.

Table4　ATE(Average Treatment Effect）on probability of reporting Care level

Care levels (t-1)	Care levels (t)							
	Independent	Requiring support 1	Requiring support 2	Requiring long-term care 1	Requiring long-term care 2	Requiring long-term care 3	Requiring long-term care 4	Requiring long-term care 5
Requiring support 1	−0.395	−0.088	0.172	0.212	0.088	0.010	0.001	0.000
Requiring support 2	−0.427	−0.227	0.065	0.290	0.237	0.053	0.009	0.000
Requiring long-term care 1	−0.393	−0.297	−0.095	0.198	0.364	0.162	0.059	0.003
Requiring long-term care 2	−0.322	−0.320	−0.209	0.027	0.327	0.290	0.189	0.019
Requiring long-term care 3	−0.288	−0.325	−0.252	−0.081	0.149	0.294	0.410	0.094
Requiring long-term care 4	−0.249	−0.310	−0.278	−0.128	0.026	0.158	0.481	0.300
Requiring long-term care 5	−0.271	−0.320	−0.268	−0.118	−0.019	0.019	0.212	0.765

This confirms the existence of state dependence. This indicates that long-term care level has a kind of self-magnifying effects in that once a person gets into a situation where she needs nursing care; her care level tends to worsen cumulatively. It is likely that a person below Requiring Long-term Care 2 in the previous quarter tends to Requiring Long-term Care 2 or 3, while it is less likely that she requires no Long-term Care.

(2) Simultaneous equations; Total expenditures

In Table 5, a drop-out equation is simultaneously estimated with the care level equation. Results on care expenditures are similar to the case of the single equation estimation. The lagged care level estimate is also robust to the adjustment for attrition bias. Thus, the preventive effects of care expenditures and state dependence are confirmed even when dropping out is controlled for. Moreover, age and stroke affect it significantly. And coefficients on care levels in the drop-out equation are not easy to interpret. Hence, we will report only the results of the single equation estimation below because we have confirmed the robustness of the results on lagged expenditures and lagged care levels.

Table 5 Simultaneous Equations (Total long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Care level equation					
Lagged care level dummy					
Requiring support 1	1.49	0.10	1.32	1.49	1.69
Requiring support 2	2.25	0.09	2.08	2.24	2.41
Requiring long-term care 1	2.98	0.09	2.81	2.99	3.15
Requiring long-term care 2	3.65	0.11	3.44	3.65	3.86
Requiring long-term care 3	4.54	0.13	4.30	4.52	4.79
Requiring long-term care 4	5.30	0.19	4.99	5.27	5.69
Requiring long-term care 5	6.82	0.24	6.41	6.79	7.32
Lagged long-term care expenditures	−0.04	0.00	−0.05	−0.04	−0.03
Age	0.22	0.07	0.15	0.18	0.32
Sex	−0.06	0.06	−0.16	−0.06	0.07
Stroke	0.71	0.23	0.22	0.72	1.13
Hypertension	−0.08	0.15	−0.38	−0.08	0.21
Time dummy					
2006Q3	−2.26	2.55	−5.97	−0.94	0.20
2006Q4	−2.43	2.55	−6.12	−1.14	0.06
2007Q1	−2.27	2.54	−5.94	−0.99	0.24
2007Q2	−2.22	2.54	−5.87	−0.97	0.29
2007Q3	−2.23	2.54	−5.91	−1.00	0.31
2007Q4	−2.32	2.54	−6.00	−1.12	0.24
2008Q1	−2.43	2.53	−6.09	−1.28	0.16
2008Q2	−2.34	2.53	−6.03	−1.19	0.24
2008Q3	−3.46	2.53	−7.10	−2.31	−0.82
2008Q4	−1.49	2.53	−5.17	−0.37	1.13
2009Q1	−2.39	2.53	−6.04	−1.35	0.25
2009Q2	−2.21	2.52	−5.85	−1.18	0.44
2009Q3	−2.41	2.52	−6.07	−1.41	0.28
2009Q4	−2.34	2.51	−5.99	−1.37	0.35
Drop-out equation					
Age					
(1)not drop-out	−0.62	0.05	−0.67	−0.64	−0.54
(2)temporary drop-out	−0.49	0.05	−0.56	−0.51	−0.41
(3)drop-out	−0.44	0.05	−0.49	−0.46	−0.36
Sex					
(1)not drop-out	0.40	1.17	−1.30	0.61	1.87
(2)temporary drop-out	0.31	1.16	−1.48	0.51	1.90
(3)drop-out	0.31	1.16	−1.38	0.52	1.80
care level (current)					
(1)not drop-out					
Independent	2.27	1.78	0.55	1.42	4.83
Requiring help 1	3.63	8.23	−7.33	4.50	14.34
Requiring help 2	−3.49	14.46	−18.20	−11.15	18.01
Care level 1	15.45	11.45	0.09	16.23	30.53
Care level 2	10.54	16.37	−4.06	0.07	35.25
Care level 3	−0.44	19.87	−29.61	8.12	21.38
Care level 4	20.68	15.35	−2.21	21.10	40.83
Care level 5	9.33	7.58	−2.54	8.19	24.67
(2)temporary drop-out					
Independent	−3.03	1.81	−4.90	−3.90	−0.34
Requiring help 1	0.24	8.22	−10.84	1.05	11.01
Requiring help 2	−7.78	14.49	−22.44	−15.48	13.89
Care level 1	10.58	11.50	−4.91	11.24	25.43
Care level 2	4.49	16.37	−10.37	−5.85	29.37
Care level 3	−6.12	19.88	−35.59	2.19	15.53
Care level 4	−18.78	22.71	−64.90	−18.26	21.29
Care level 5	2.65	7.58	−9.51	1.61	17.71
(3)drop-out					
Independent	0.65	1.78	−1.08	−0.20	3.22
Requiring help 1	0.76	8.24	−10.20	1.59	11.53
Requiring help 2	−7.16	14.48	−21.76	−14.87	14.49
Care level 1	10.17	11.45	−5.30	11.02	25.33
Care level 2	4.56	16.37	−10.06	−5.91	29.07
Care level 3	−5.61	19.87	−34.72	2.98	16.18
Care level 4	14.51	15.34	−8.25	14.94	34.66
Care level 5	3.67	7.61	−7.99	2.75	19.09

(3) Single equation; Separated expenditures

Table 6 shows the results when care expenditures are separated into two categories: home care expenditures and facility care expenditures.

The effects of two categories are the same; both are significantly ameliorate care levels. This result is contrary to our hypothesis: home care and facility care is effective in preventing aggravating frailty. However, this may be because in this estimation we do not distinguish between early and late stages of frailty. We will explore this distinction next.

Table 6 Single Equation (Separated long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Lagged care level dummy					
Requiring support 1	1.50	0.10	1.31	1.50	1.70
Requiring support 2	2.26	0.09	2.08	2.26	2.44
Requiring long-term care 1	2.99	0.10	2.80	2.99	3.19
Requiring long-term care 2	3.65	0.12	3.43	3.66	3.88
Requiring long-term care 3	4.51	0.15	4.22	4.52	4.79
Requiring long-term care 4	5.25	0.20	4.87	5.25	5.63
Requiring long-term care 5	6.80	0.24	6.34	6.80	7.25
Lagged long-term care expenditures(home care)	−0.03	0.01	−0.04	−0.03	−0.02
Lagged long-term care expenditures(facility care)	−0.04	0.01	−0.05	−0.04	−0.03
Age	0.20	0.11	−0.02	0.20	0.38
Sex	−0.07	0.06	−0.19	−0.07	0.06
Stroke	0.67	0.35	−0.02	0.66	1.36
Hypertension	−0.12	0.16	−0.42	−0.12	0.20
Time dummy					
2006Q3	−0.03	0.44	−1.33	0.03	0.64
2006Q4	−0.20	0.43	−1.51	−0.13	0.46
2007Q1	−0.03	0.42	−1.30	0.03	0.60
2007Q2	0.02	0.41	−1.24	0.07	0.64
2007Q3	0.02	0.40	−1.26	0.07	0.62
2007Q4	−0.07	0.40	−1.32	−0.01	0.51
2008Q1	−0.17	0.40	−1.42	−0.11	0.39
2008Q2	−0.06	0.40	−1.30	−0.01	0.50
2008Q3	−1.18	0.40	−2.41	−1.13	−0.62
2008Q4	0.78	0.40	−0.42	0.83	1.34
2009Q1	−0.11	0.41	−1.34	−0.06	0.48
2009Q2	0.07	0.41	−1.16	0.11	0.67
2009Q3	−0.12	0.42	−1.36	−0.07	0.50
2009Q4	−0.05	0.44	−1.29	−0.00	0.61

(4) Requiring Support 1 and 2; Single equation; Total expenditures

Estimation results for persons requiring support are dramatic. In Tables 7, we restrict the sample to the least severe categories: Requiring Support 1 and 2.

Table 7 Requiring Support 1 and 2 ; Single Equation
(Total long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Lagged care level	0.92	0.15	0.61	0.92	1.21
Age	0.42	0.28	−0.09	0.41	0.94
Sex	−0.32	0.28	−0.86	−0.31	0.20
Lagged long-term care expenditures	−0.10	0.02	−0.14	−0.10	−0.05
Stroke	2.18	1.80	−0.71	2.02	6.09
Hypertension	−0.75	0.44	−1.62	−0.74	0.09
Time dummy					
2006Q3	0.47	0.70	−0.97	0.44	1.95
2006Q4	−0.44	0.66	−1.88	−0.45	0.93
2007Q1	0.33	0.62	−1.02	0.31	1.66
2007Q2	0.02	0.59	−1.35	0.01	1.28
2007Q3	0.15	0.56	−1.18	0.13	1.31
2007Q4	−0.15	0.54	−1.47	−0.14	0.93
2008Q1	−0.02	0.54	−1.35	−0.01	1.05
2008Q2	0.01	0.56	−1.33	0.02	1.08
2008Q3	−1.70	0.59	−3.13	−1.66	−0.62
2008Q4	0.56	0.58	−0.86	0.62	1.59
2009Q1	−0.54	0.62	−2.01	−0.47	0.51
2009Q2	0.03	0.64	−1.49	0.11	1.12
2009Q3	−0.42	0.69	−1.99	−0.32	0.76
2009Q4	−0.73	0.75	−2.39	−0.64	0.55

Table 7 shows the results for the estimation using total care expenditures as an explanatory variable. Even total expenditures exert favorable effects on care levels. This result confirms our hypothesis: the earlier, the better.

(5) Requiring Long-term Care 1 and 2; Single equation; Total expenditures and separated expenditures

As shown in Tables 8 and 9, we picked up slightly more severe categories: Requiring Long-term Care 1 and 2. The coefficient on total expenditures is smaller than that in the case of Requiring Support and virtually the same as the results for the case of all samples. When expenditures are decomposed into two categories, the results for the early stages of frailty are similar to the results for the whole sample including later stages, home care and facility care is effective in preventing aggravating frailty.

Table 8 Requiring Long-term Care 1 and 2 ; Single Equation
(Total long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Lagged care level	1.39	0.13	1.14	1.39	1.66
Age	−0.07	0.38	−0.75	−0.04	0.61
Sex	−0.23	0.15	−0.54	−0.23	0.07
Lagged long-term care expenditures	−0.05	0.01	−0.07	−0.05	−0.03
Stroke	−0.60	0.87	−2.33	−0.60	1.09
Hypertension	0.00	0.48	−0.96	−0.01	0.99
Time dummy					
2006Q3	−0.32	0.82	−2.24	−0.23	1.30
2006Q4	−0.39	0.79	−2.20	−0.32	1.27
2007Q1	−0.47	0.77	−2.22	−0.42	1.27
2007Q2	0.14	0.76	−1.53	0.16	1.98
2007Q3	−0.01	0.75	−1.61	−0.00	1.96
2007Q4	0.21	0.77	−1.35	0.19	2.34
2008Q1	−0.09	0.79	−1.67	−0.11	2.18
2008Q2	0.23	0.83	−1.33	0.17	2.66
2008Q3	−1.71	0.87	−3.33	−1.79	0.84
2008Q4	2.54	0.92	0.92	2.44	5.33
2009Q1	0.49	0.97	−1.16	0.34	3.37
2009Q2	0.55	1.04	−1.15	0.37	3.58
2009Q3	0.33	1.10	−1.46	0.13	3.50
2009Q4	0.50	1.18	−1.41	0.29	3.84

Table 9 Requiring Long-term Care 1 and 2 ; Single Equation
(Separated long-term care expenditures)

	mean	sd	2.5%	median	97.5%
Lagged care level	1.41	0.12	1.18	1.41	1.66
Age	0.30	0.33	−0.41	0.38	0.81
Sex	−0.18	0.16	−0.50	−0.18	0.12
Lagged long-term care expenditures(home care)	−0.04	0.01	−0.07	−0.04	−0.02
Lagged long-term care expenditures(facility care)	−0.06	0.01	−0.08	−0.06	−0.03
Stroke	−0.73	0.87	−2.35	−0.76	1.07
Hypertension	0.12	0.48	−0.79	0.11	1.07
Time dummy					
2006Q3	0.07	0.77	−1.26	0.03	2.06
2006Q4	−0.08	0.73	−1.32	−0.11	1.84
2007Q1	−0.24	0.71	−1.46	−0.27	1.63
2007Q2	0.30	0.68	−0.91	0.24	2.15
2007Q3	0.03	0.66	−1.19	−0.00	1.82
2007Q4	0.17	0.66	−1.07	0.13	1.95
2008Q1	−0.22	0.67	−1.55	−0.22	1.49
2008Q2	0.01	0.69	−1.36	−0.00	1.69
2008Q3	−2.03	0.72	−3.49	−2.03	−0.43
2008Q4	2.13	0.78	0.59	2.14	3.78
2009Q1	0.01	0.79	−1.57	0.02	1.66
2009Q2	−0.01	0.84	−1.65	−0.01	1.70
2009Q3	−0.34	0.89	−2.09	−0.30	1.41
2009Q4	−0.25	0.96	−2.09	−0.23	1.62

9. Conclusion

This paper investigated the preventive effects of long-term care expenditures. The notion that long-term care can avoid deterioration of frailty or can ameliorate the condition of the elderly is unique to the Japanese long-term care insurance system, but is potentially important not only for individuals but also for the society through reduced costs. Preventive effects take on more importance when deteriorated conditions tend to entail further deterioration. With the existence of state dependence, preventive care may stave off an avalanche of deteriorated frailty.

State dependence is incorporated into the model by utilizing dynamic panel data. To control endogeneity, or correlation between unobserved heterogeneity and explanatory variables we adopt the estimation method proposed by Wooldridge (2205). We further try to adjust for attrition bias following Albert and Follmann(2003).

Long-term care expenditures are estimated to significantly ameliorate care levels although their magnitude is rather modest. We also confirmed state dependence of care levels. These findings are confirmed even when attrition bias is adjusted for. When expenditures are divided into home and facility care, both categories is effective in prevention of care.

When the sample is restricted to the least severe categories, Requiring Support 1 and 2, preventive effect is stronger than for all the elderly. This result confirms our hypothesis: the earlier, the better.

For slightly more severe categories, Requiring Long-term Care 1 and 2, preventive effect is less marked and virtually the same as the case of all sample.

Appendix: General Description of the Conditions of the Elderly Who Requires Support/Long-term Care

First, "the elderly" is classified into three broad categories, Independent, Requiring Support and Requiring Long-term Care. Then, Requiring Support is divided into two subcategories and Requiring Long-term Care into five.

1. Independent (requiring neither support nor care)
Basic activities of daily living such as walking and standing up can be performed independently and procedural activities of daily living such as taking medicine and making a phone call can be done.

2. Requiring Support
Basic activities of daily living can be performed basically independently but some support is needed for procedural activities of daily living to prevent becoming in need of long-term care.

2-1.Requiring Support 1
Basic activities of daily living can be performed basically independently but some support is needed concerning standing up, getting up, standing on one foot.

2-2.Requiring Support 2
Compared with the Requiring Support 1, the ability to perform basic activities of daily living such as walking, body washing, keeping track of finances and clipping nails has deteriorated but possibly improved.

3. Requiring Long-term Care
Basic activities of daily living cannot be performed independently and long-term care is needed.

3-1. Requiring Long-Term Care 1
The same as Requiring Support 2 but their conditions will remain.

3-2. Requiring Long-Term Care 2

In addition to the condition of the Requiring Long-Term Care 1, care of basic activities of daily living is partially needed concerning wear/pull off trousers, moving, and daily decision making.

3-3. Requiring Long-Term Care 3

Compared with the Requiring Long-Term Care 2, the ability to perform both basic and procedural activities of daily living has deteriorated significantly concerning washing face, grooming one's hair, oral care, urination/defecation and transferring from one place to another and overall long-term care is needed.

3-4. Requiring Long-Term Care 4

In addition to the condition of the Requiring Long-Term Care 3, capabilities of movement have deteriorated and dietary intake and communication become difficult so that daily living is difficult without long-term care.

3-5. Requiring Long-Term Care 5

Capabilities of movement have deteriorated further from the Requiring Long-Term Care 4 and swallowing and memorization/understanding become difficult so that daily living is almost impossible without long-term care.

References

Albert, Paul and Dean Follmann. (2003) A Random Effects Transition Model for Longitudinal Binary Data With Informative Missingness. *Statistica Neerlandica*. vol. 57, no. 1, pp. 100–111.

Chamberlain, Gary. (1980) Analysis of Covariance with Qualitative Data. *Review of Economic Studies*. vol.47, pp.225-238.

Contoyannis, Paul, Jones Andrew and Nigel Rice. (2004) The Dynamics of Health in the British Household Panel Survey. *Journal of Applied Econometrics, J. Appl. Econ*. vol. 19, PP. 473–503.

Daniels, Michael and Joseph Hogan. (2008) *Missing Data in Longitudinal Studies: Strategies for Bayesian Modeling and Sensitivity Analysis*. Chapman and Hall/CRC.

Gelman, Andrew, and Jennifer Hill. (2007) *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge University Press.

Heiss, Florian, Axel Borsch-Supan, Michael Hurd and David Wise. (2009) Pathways to Disability: Prediting Health Trajectories. In David Cutler and David Wise (eds.) Health at Older Ages: The Causes and Consequences of Declining Disability among the Elderly. *University of Chicago Press*.

Heiss, Florian, Steven Venti and David Wise. (2014) The Persistence and Heterogeneity of Health Among Older Americans. *NBER Working Paper*. No. 20306.

Jones, A.M., Rice, N., Contoyannis, P., & Jones, A.M. (ed) (2006a) The Dynamics of Health. In Andrew Jones, ed. *The Elgar Companion to Health Economics*. pp. 17-25. Edward Elgar.

Jones, Andrew, Xander Koolman and Nigel Rice. (2006b) Health-Related Non-Response in the British Household Panel Survey and European Community Household Panel: Using Inverse-Probability-Weighted Estimators in Non-Linear

Models. *J. R. Statist. Soc. A.* vol.169, Part3, pp.543-569.

Levine, Deborah, et al. (2014) Functional Disability and Cognitive Impairment after Hospitalization for Myocardial Infarction and Stroke. *Circulation Cardiovascular Quality and Outcomes*. vol. 7. pp. 863-871.

Martina, Stephen, Nigel Riceb and Peter Smith. (2008) Does Health Care Spending Improve Health Outcomes? Evidence from English Programme Budgeting Data. *Journal of Health Economics*. vol. 27, pp.826–842.

Mundlak, Yair. (1978) On the Pooling of Time Series and Cross Section Data. *Econometrica*. vol. 46, issue 1, pp. 69-85.

Shinkai, shouji, Hiroto Yoshida, Yoshinori Fujiwara, Hidenori Amano, Tarou Fukaya, Sanyun Ri, Naoki Watanabe, Shuuichirou Watanabe, Osamu Kumagai, Mariko Nishi, Hiroshi Murayama, Yuu Taniguchi, Youko Kousa, Hiromi Ooba, Yumiko Shimizu, Yuu Taniguchi, Taduru Okabe and Natsumi Hoshikawa, Yumiko Tsuchiya. (2013) Experience and Accomplishments of the Ten Years of Preventive Long-Term Care Activity in Kusatsu-cho. *Journal of the Japanese Society of Public Health*. vol. 60, no.9, pp.596-605.

Spiegelhalter, David, Keith Abrams and Jonathan Myles. (2004) *Bayesian Approaches to Clinical Trials and Health-Care Evaluation*. John Wiley & Sons.

Tajika, Eiji, and Jun Kikuchi. (2005) Effects of the Long-Term Care Insurance to Sustain or Improve Elderly's Long-term Care Level. *The Quarterly of Social Security Research*. vol.41, no.3, pp.248-262. (In Japanese)

Wooldridge, Jeffrey. (2000) A Framework for Estimating Dynamic, Unobserved Effects Panel Data Models with Possible Feedback to Future Explanatory Variables. *Economics Letters*. vol.68, pp.245-250.

Wooldridge, Jeffrey. (2002) *Econometric Analysis of Cross Section and Panel Data*. MIT Press.

Wooldridge, Jeffrey. (2005) Simple Solutions to the Initial Conditions Problem in

Dynamic, Nonlinear Panel Data Models with Unobserved Heterogeneity. *Journal of Applied Econometrics*. vol. 20, Issue 1, pp. 39–54.

Yuda, Michio, Wataru Suzuki, Ryouko Morozumi and Yasushi Iwamoto. (2013) Effects of the Introduction of Preventive Long-Term Care Benefits on the Care Level of the Requiring Help. *The Quarterly of Social Security Research*. vol.49, no.3, pp. 310-325. (In Japanese)