

Appendix for “Medical Expenditures over the Life-cycle: Persistent Risks and Insurance”

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1 Lifetime Out-of-pocket Medical Expenditures

In this section, we take into account the details of Japan’s health insurance program and simulate lifetime out-of-pocket (OOP) medical expenditure process across individuals. Lifetime OOP expenditures are not a simple linear transformation of gross expenditures since copay rates depends on age as well as income and expenditure levels of each individual.

1.1 Age-dependent Copay Rates and High-Cost Medical Expense (HCME) Benefits

Based on gross expenditures computed from the NDB, we compute OOP expenditures based on age-dependent copay rates, 30% for adults aged 69 and below, 20% for 70-74 and 10% for 75 and above. OOP expenditures are further adjusted according to High-Cost Medical Expense (HCME) benefits. The maximum copay set by HCME depends on age and annual earnings of each individual. We compute earnings of individuals for each age and gender using the Employment Status Survey (ESS). Using the second order Markov transition matrices of expenditures we computed in [Fukai et al. \(2021\)](#), we simulate lifetime OOP expenditures of many individuals and compute various moments.

Figure 1 compares probability distribution of lifetime gross and OOP medical expenditures. OOP expenditures are significantly lower than gross expenditures and almost no one pays above 15 million yen, with a peak at around 2.5 million.

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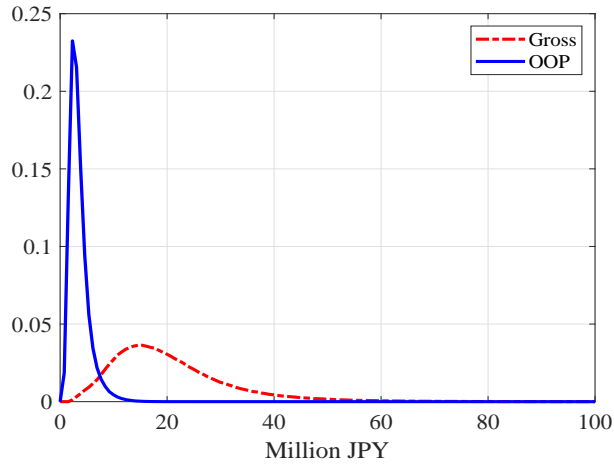


Figure 1: Probability Distribution of Lifetime Medical Expenditures (Males): Gross and Out-of-pocket

Note: The horizontal axis indicates simulated lifetime medical expenditures (gross or out-of-pocket) in million JPY.

Age-dependent copay rates provide significant insurance since coverage rates are high when individuals are old and are more likely to face not only high average expenditures but a large risk of incurring extremely high expenditures. On top of the age-dependent copay rates, HCME benefits provide additional insurance by imposing a ceiling on OOP and providing individuals with a shield against shocks that involve catastrophic expenses. Figure 2 plots probability distribution of OOP expenditures with and without HCME benefits and shows that the right tail of the distribution is thinner with HCME.

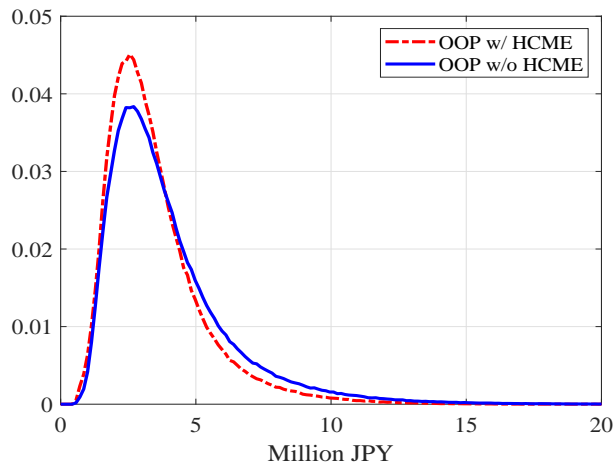


Figure 2: Probability Distribution of Lifetime Medical Expenditures (Males): Out-of-pocket with and without HCME

Note: The horizontal axis indicates simulated lifetime medical expenditures (out-of-pocket with and without HCME) in million JPY.

Table 1 shows moments of the lifetime OOP expenditures for males and females, with moments for gross expenditures for comparison. Distribution of the OOP without HCME has a higher skewness, consistent with the thick right tail in Figure 2.

Table 1: Moments of Lifetime Medical Expenditures: Gross, OOP with HCME (1) and OOP without HCME (2)

	Male			Female		
	Gross	OOP(1)	OOP(2)	Gross	OOP(1)	OOP(2)
Mean	20.5	3.5	4.0	21.4	3.6	3.9
Std. dev.	10.9	1.8	2.3	10.2	1.6	1.9
Coeff. of var.	0.53	0.52	0.58	0.48	0.46	0.50
Skewness	1.49	1.81	1.92	1.43	1.63	1.73

Note: Mean and standard deviation are in million JPY.

1.2 Alternative Medical Expenditure Process

Table 2 shows moments of lifetime OOP medical expenditures for males and females under alternative assumptions about persistence of expenditure shocks. Probability distributions are displayed in Figure 3. Qualitatively, the differences across specifications are similar to those for gross medical expenditures examined in Fukai et al. (2021).

Table 2: Moments of Lifetime Out-of-pocket Medical Expenditures Under Alternative Processes

	Male				Female			
	M(2)	M(1)	iid	det.	M(2)	M(1)	iid	det.
Mean	3.49	3.54	3.54	3.99	3.57	3.61	3.61	3.93
Std. dev.	1.83	1.50	0.96	0.83	1.63	1.34	0.85	0.65
Coeff. of var.	0.52	0.42	0.27	0.21	0.46	0.37	0.23	0.17
Skewness	1.81	1.04	0.15	-1.22	1.63	0.96	0.07	-1.81

Note: Mean and standard deviation are in million JPY.

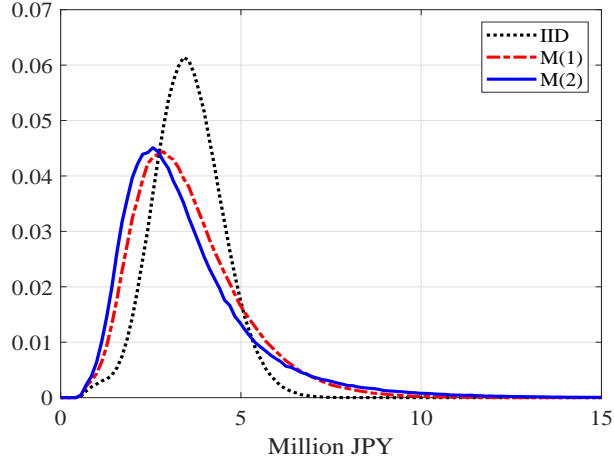


Figure 3: Probability distribution of Lifetime Medical Expenditures under Alternative Processes (Males)

Note: The horizontal axis indicates simulated lifetime medical expenditures in million JPY.

High persistence of bad health shocks in the M(2) specification relative to others is reflected in the higher standard deviation and skewness of lifetime OOP expenditures than those under different specifications. There is not much difference in average expenditures across specifications between M(2) and M(1) processes. The small difference, however, at the macro level conceals different experiences across individuals who face persistent bad health shocks.

To demonstrate such differences, we computed lifetime gross and OOP expenditures for individuals who face a bad health shock for the first time in their lives at different ages, followed by another bad health shock in the next period. Average lifetime gross and OOP expenditures are summarized in Table 3.

Table 3: Lifetime Gross and OOP Expenditures and Persistent Bad Health Shocks

Bad at age	30	40	50	60	70	All
Gross M(2)	24.4	25.5	25.7	26.0	26.3	20.5
Gross M(1)	23.0	23.6	25.3	26.0	26.7	20.7
OOP M(2)	4.67	5.04	5.28	4.88	3.32	3.49
OOP M(1)	4.17	4.47	4.74	4.76	3.48	3.53

Note: Age denotes the age at which individuals received a bad health shock for the first time, followed by another bad shock in the next period. Expenditures are in million JPY.

As demonstrated in Fukai et al. (2021), for an individual in bad health in the current period at time t , the probability of staying in bad health in the following period at $t+1$ is higher if the individual was already in bad health in the previous period at time $t-1$. This long persistence of health shocks beyond one period is captured in the M(2) process, but

not in the $M(1)$. As shown in Table 3, those who receive bad shocks for two periods have higher lifetime expenditures under the $M(2)$ process, at least for those who experienced such shocks for the first time before age 60. Recall also that death probability is positively correlated with expenditures especially at older ages and this is reflected in the reversal of lifetime expenditures between $M(1)$ and $M(2)$ at older ages. Those who receive bad shocks in their 60s or 70s, for example, are more likely to die sooner, which offsets the positive effects of more persistent bad health shocks on lifetime expenditures.

2 Alternative Parameter Values

In this section we simulate the model under alternative values of preference parameters and quantify their effects on some of our quantitative results.

Discount Factor: In the baseline, we set the value of discount factor β at 0.9586, or approximately 0.96, to match the level of assets at the peak over the life-cycle. We simulate the baseline model where we set the discount factor at 0.95 and 0.97, and compare the effects of extreme scenarios of no insurance with and without taxes. Results are summarized in Table 4. A higher discount factor leads individuals to save more since they place more weight on future consumption. The effects of an extreme scenario of removing health insurance studied in Fukai et al. (2021), with and without tax adjustment, do not differ much under alternative values of β .

Table 4: Extreme Scenarios: No Health Insurance and Full Insurance under Alternative Discount Factors β

Discount factor β	No tax change		
	0.95	0.96	0.97
Change in avg. savings	+39.2%	+38.3%	+38.3%
Change in avg. consumption	-9.7%	-10.0%	-10.2%
Transfer recipients	6.9%	5.8%	4.4%
	(+222.4%)	(+239.7%)	(+256.5%)
Lump-sum tax (JPY)	—	—	—
Welfare effects			
- All	-9.2%	-10.1%	-11.2%
- Male: low/high	-10.1%/-8.2%	-11.1%/-9.1%	-12.3%/-10.2%
- Female: low/high	-9.2%/-8.6%	-9.9%/-9.5%	-11.0%/-10.5%
Discount factor β	Tax adjusted		
	0.95	0.96	0.97
Change in avg. savings	+53.7%	+51.8%	+50.7%
Change in avg. consumption	+2.8%	+3.4%	+4.2%
Transfer recipients	3.6%	2.8%	1.9%
	(+68.9%)	(+64.1%)	(+54.4%)
Lump-sum tax (JPY)	-227,000	-290,000	-309,000
Welfare effects			
- All	+5.0%	+4.8%	+4.7%
- Male: low/high	+5.0%/+3.4%	+4.8%/+3.1%	+4.7%/+2.8%
- Female: low/high	+6.2%/+3.8%	+6.1%/+3.5%	+6.1%/+3.3%

Note: The middle column is for the baseline, where β is approximately 0.96 (0.9586). The row “Transfer Recipients” indicates the fraction of the population receiving welfare transfers in each experiment. The percentage change in the number of recipients from the baseline model is indicated in parentheses. Lump-sum tax is expressed as an annual tax collected in Japanese yen. A negative number indicates a positive transfer from the government to each individual.

Risk Aversion: Table 5 shows effects of no insurance under different values of risk aversion parameter σ . As shown in the top panel of the table for the case of no tax change, loss of insurance induces more savings in a model with a higher σ and welfare effects are more negative. Since individuals save more to insure themselves against expenditure risks, fewer individuals would be eligible for means-tested transfers. Government expenditures for welfare transfers would be lower with higher risk aversion, and when taxes are adjusted, a larger lump-sum transfer is given to individuals.

Table 5: Extreme Scenarios: No Health Insurance and Full Insurance under Alternative Risk Aversion Parameter σ

Risk Aversion Parameter σ	No tax change		
	2	3	4
Change in avg. savings	+16.0%	+38.3%	+48.4%
Change in avg. consumption	-9.1%	-10.0%	-10.5%
Transfer recipients	9.4%	5.8%	3.7%
	(+251.0%)	(+239.7%)	(+255.2%)
Lump-sum tax (JPY)	—	—	—
Welfare effects			
- All	-4.4%	-10.1%	-16.5%
- Male: low/high	-4.7%/-4.0%	-11.1%/-9.1%	-18.4%/-15.1%
- Female: low/high	-4.5%/-4.2%	-9.9%/-9.5%	-15.7%/-15.7%
Risk Aversion Parameter σ	Tax adjusted		
	2	3	4
Change in avg. savings	+33.6%	+51.8%	+60.9%
Change in avg. consumption	+1.7%	+3.4%	+4.6%
Transfer recipients	5.7%	2.8%	1.5%
	(+111.3%)	(+64.1%)	(+44.2%)
Lump-sum tax (JPY)	-244,000	-290,000	-321,000
Welfare effects			
- All	+1.6%	+4.8%	+8.5%
- Male: low/high	+1.8%/+1.0%	+4.8%/+3.1%	+7.9%/+5.0%
- Female: low/high	+2.2%/+1.1%	+6.1%/+3.5%	+10.7%/+6.0%

Note: The row “Transfer Recipients” indicates the fraction of the population receiving welfare transfers in each experiment. The percentage change in the number of recipients from the baseline model is indicated in parentheses. Lump-sum tax is expressed as an annual tax collected in Japanese yen. A negative number indicates a positive transfer from the government to each individual.

3 Calibration of Frailty Index

In this section we explain how we calibrated the frailty index used to introduce correlation between health status and earnings in [Fukai et al. \(2021\)](#).

Data Description: We use the Japanese Study of Aging and Retirement (JSTAR) to study the correlation between health and labor force participation. JSTAR is a panel survey of elderly people aged 50 and over, conducted by the Research Institute of Economy, Trade and Industry (RIETI), Hitotsubashi University and The University of Tokyo.

The survey has been conducted every two years since 2007. The survey is designed to ensure maximum comparability with preceding surveys such as the Health and Retirement Study (HRS). Although the survey includes some questions about medical expenditures, we found that they are not comparable to those of the NDB. Therefore, we instead computed an objective measure of health status: “the frailty index” from JSTAR, following the method of Hosseini et al. (2021). Hosseini et al. (2021) obtained the frailty index using not only PSID but also HRS, and we can calculate a frailty index using a similar construction method. We use the data between 2007 and 2013.¹

Construction of Frailty Index: Following the strategy taken in Hosseini et al. (2021), we use 37 variables that take a value between 0 and 1 and calculate the frailty index by summing up all variables with equal weight and then normalizing them to a value between 0 and 1. These variables mainly consist of activities of daily living (ADL)/Instrumental ADL (IADL) variables, past and present disease-related variables, cognitive variables, and health care utilization (outpatient visits, etc.).

- ADL/IADL variables (Difficulties in following activities): Eating using tableware by yourself; putting on and taking off stockings, socks and shoes; getting into and out of bed; using the toilet; bathing by yourself; walking around the room; walking 100 meters; making a phone call without help; managing money;² shopping for daily necessities; boiling water in a kettle; getting up from a chair after sitting continuously for a long time; squatting or kneeling; lifting or carrying an object weighing 5kg or more; taking medicine without help; taking one step up the stairs without using the handrail; picking up a small object such as a one-yen coin from a desktop with your fingers; raising your arms above your shoulder; pushing or pulling a large object such as a chair or sofa; going out using public transformation.
- Past and present disease variables (ever had any of the following conditions): High blood pressure; diabetes; cancer or other malignant tumor (including leukemia, lymphoma; excluding benign skin cancer); chronic lung disease (chronic bronchitis, emphysema, etc.; excluding lung cancer); heart disease (angina, heart failure, cardiac infarction, heart valve disease, etc); stroke; joint disorder; asthma; other serious, chronic conditions (liver disease, parkinson’s, etc.); BMI ≥ 30 ; has ever smoked.

¹For our research purpose, we don’t use the data of seven cities from the 2011 survey because there are not enough variables to calculate the frailty index. The seven cities are: Adachi, Kanazawa, Shirakawa, Sendai, Takikawa, Tosu and Naha.

²This variable is calculated using the following three questions: paying bills, making deposits in and withdrawals from your bank or postal account, and filling out documentation such as pension forms. We sum these three variables and normalize them to a value between 0 and 1, with 1 meaning that individuals can’t do these activities.

- Cognitive variables (ever had any of the following conditions): Dementia; depression or emotional disorder.
- Health care utilization: Outpatient visit; inpatient visit; formal home care utilization; institutional long-term care utilization.

Using the frailty index, we define health status by dividing it into four categories using ten-year age groups. Then, we compute the correlation between health status and labor force participation by gender and age, and estimate the health-dependent labor force participation by gender, age, skill, and marital status. Since the JSTAR does not cover individuals below age 50, we extrapolate our estimates for younger age groups by using [Hosseini et al. \(2020\)](#)'s estimation results from the PSID and assuming that non-participation rates by health status will decline at the same speed as [Hosseini et al. \(2020\)](#).

4 More on NDB

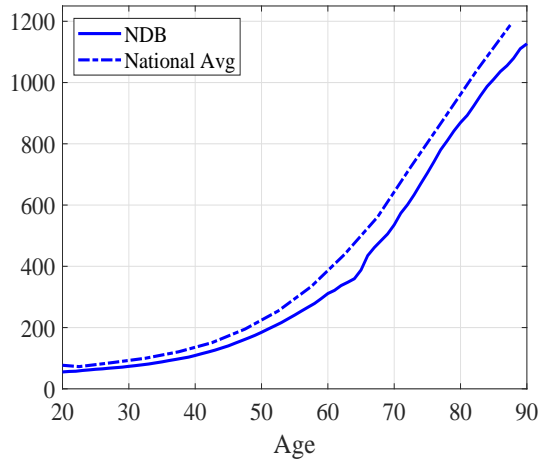
4.1 Life-cycle Profiles

To demonstrate the comprehensiveness of the NDB, Figure 4 shows that the life-cycle profiles of medical expenditures are in line with the national data reported by the Ministry of Health, Labour and Welfare.³ As discussed in the data section of [Fukai, Ichimura, Kitao, and Mikoshiba \(2021\)](#), there are differences in covered items between the NDBs and the national medical expenses, which explains the difference in the two profiles.

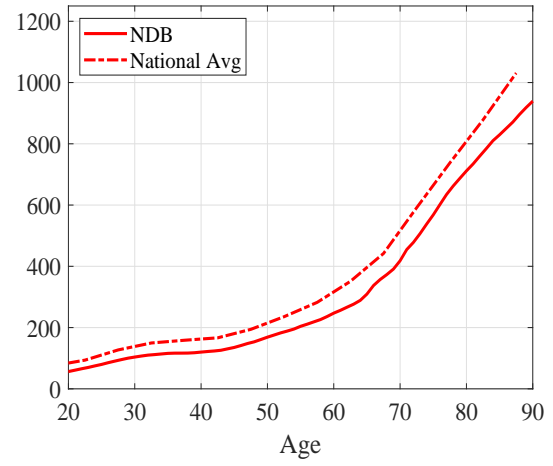
³The data is from the Estimates of National Medical Care Expenditure in 2015.

<https://www.mhlw.go.jp/toukei/list/37-21.html> (in Japanese)

<https://www.mhlw.go.jp/english/database/db-hss/enmce.html> (in English)



(a) Male



(b) Female

Figure 4: Annual Medical Expenditures: NDB and National Data (in 1,000 JPY)

References

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