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Health Impacts on Labor Participation of Elderly Japanese Males

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Abstract

The main object of this study is to investigate the relationship between individuals' health status and labor participation among middle-aged and elderly males in Japan using a unique panel dataset. Our analysis focuses on three types of health indicators based on respondents' medical history in the three years preceding the survey. To adjust for the potential endogeneity of the health variables, we use individuals' body mass index at age 30 and their parents' medical history as instrumental variables. Our empirical results show that a deterioration in health increases the probability of not working and being retired and, moreover, tends to decrease individuals' average working hours per week. Further, splitting our sample, we find that, compared with males under 60 years of age, the work status of males aged 60 or over is significantly more likely to be affected by having one additional illness and suffering from a lifestyle disease than that of under 60s.

Keywords: Labor participation by elderly males, Health indicators, Instrumental variable method, Body mass index at a young age, Parent medical history

JEL Classification Codes: **I10, J14, J26**

1. Introduction

In a graying society, such as that of contemporary Japan, in which the number of persons in the labor force is gradually decreasing, the promotion of labor participation by elderly workers is an important policy issue. In order to effectively address this issue, society needs to critically review the retirement system for the elderly in Japan. One of the most significant causes for the elderly to leave the labor market in Japan appears to be a deterioration of their health. According to the "Survey on Employment Conditions of Elderly Persons in 2004" conducted by the Ministry of Health, Labour and Welfare (MHLW), 29% of elderly males between 55 and 69 years do not work and do not even wish to work due to "poor health," which is the second most commonly cited reason for having retired.

While the negative impact of poor health on labor participation in Japan is well documented (see, e.g., Iwamoto, 2000; Oishi, 2000; and Hamaaki and Noguchi, 2010), empirical evidence on the size of the effect of poor health is inconclusive due to the limited availability of appropriate data on individuals' labor participation and health status. In addition, studies using the limited data available suffer from the endogeneity of health indicators, which has made it difficult to identify the "pure" effects of health status on labor supply. Such endogeneity is often caused by measurement errors, unobserved determinants of health and labor supply, and respondents' "justification behavior," that is, the frequently observed pattern that those not working justify the fact that they are not working or took early retirement by overstating their health problems (Bound, 1991; Kerkhofs and Lindeboom, 1995; Kreider, 1999; Gannon, 2009; Lindeboom and Kerkhofs, 2009). [1]

A potential way to resolve such endogeneity problems is to use more objective indicators of individuals' health status, such as activities of daily living (ADL) indicators. However, as pointed out by Mathiowetz and Lair (1994), as long as such data are self-reported, there still remain possible measurement errors. Moreover, even if we were able to use almost perfectly objective health measures, such as diagnoses extracted from medical charts or health care receipts, which are actually used by Datta Gupta and Larsen (2010) and Christensen and Kallestrup-Lamb (2012), it would still be difficult to avoid the endogeneity issue due to the presence of unobserved heterogeneity that affects both individuals' health and work status (or working hours). To adjust for the statistical bias caused by endogeneity, preceding studies therefore have employed a variety of instrumental variables (IVs) such as mortality information (i.e., the date of death) (Bound, 1991) and parents' health and mortality and respondent's degree of obesity (Dwyer and Mitchell, 1999). Moreover, a different IV approach has also been developed, by Bound et al. (1999), Au et al. (2005) and Disney et al. (2006), for examining a dynamic relation through the lifetime between health status and trajectories of working status. Specifically, they construct a latent variable for health stock as a function of individual characteristics and detailed objective health measures, and use the predicted value of this variable as an instrument to estimate the effect of self-assessed health in the second stage regression of their 2SLS estimation. Overall, these previous studies confirm that poor health (and its decline) has a significant impact on individuals' retirement decisions.

More recent studies make efforts to overcome the endogeneity problem of health measures through a matching method (combined with difference-in-differences estimation). Further, in order to prevent the health impact from being contaminated by an anticipation effect, many studies focus on unexpected changes in health (i.e., highly exogenous changes in health), such as the first onset of myocardial infarction (e.g., stroke, cancer, etc.) and a sudden decline in self-reported health. Especially among the studies analyzing the effect of health status on the labor supply for middle-aged and elderly people, it was found that while the health deterioration tends to significantly reduce the probability of being employed, it does not decrease hours worked (conditional on working), on average (see, e.g., García-Gómez, 2011; Trevisan and Zantomio, 2016; Candon 2018; Lenhart, 2019).

Previous studies focusing on Japan have also attempted to address the endogeneity problem of individuals' health status using a variety of instruments. For instance, Iwamoto (2000) uses the average health status of household members except the respondent himself and the respondent's daily activities (i.e., eating, exercising, and sleeping) for maintaining his own physical and mental health as IVs for the respondent's health status. However, it seems that these instruments do not sufficiently capture any change in health status. Second, Oishi (2000) employs prefecture-level average life expectancy and its square as IVs. However, since these instruments are not significantly correlated with individual's subjective health in the first stage of her IV regression, her results on health effects are not robust. Third, Yuda (2010) uses two dummy variables for fitness habits and

[1] Some studies, however, find little evidence of justification behavior (e.g., Dwyer and Mitchell, 1999; Benitez-Silva et al., 2004) or suggest that the overestimation of health effects due to justification behavior is not very serious. Specifically, Au et al. (2005) find that estimated health effects based on subjective health suffer from attenuation bias rather than justification bias.

participation in sports club activities as IVs. Although those variables are significantly correlated with a subjective health measure, significant parts of the correlation might be accounted for by a reverse causality from the health status to physical activities. Finally, Sato (2016) uses as IVs average hours of sleep per day and the amount of exercise with sweating outside of work during a week.

Against this background, the main purpose of this study is to examine to what extent a deterioration in health influences an individual's decision to participate in the labor market for middle-aged and older males in Japan, carefully adjusting for the endogeneity of health indicators. We do so using the unique panel data from the "Survey on Health and Retirement" conducted from 2008 through 2010 by the National Institute of Population and Social Security Research. Our analysis focuses on the effect of the following three types of health indicators defined on the basis of respondents' medical history in the three years preceding the survey: (1) the number of illnesses, (2) whether or not suffering from a lifestyle disease (high blood pressure, hyperlipidemia, sugar diabetes, and gout), and (3) whether or not suffering from at least one of the "three killer diseases" (cancer or malignant growth, heart disease, stroke or cerebrovascular disease). Since these measures are relatively objective and accurate compared to other subjective measures solely based on respondents' self-assessment, they are less likely to be affected by measurement errors and "justification behavior." In order to control for the remaining sources of endogeneity, which likely derive from omitted variables (i.e., unobserved determinants of health and labor supply), we use the degree of obesity in youth and the parents' medical history as IVs, which were first applied to Japanese data in one of our previous studies, Hamaaki and Noguchi (2010). While the present study employs the same instruments, the focus is somewhat different. Specifically, whereas in Hamaaki and Noguchi (2010) we examine the effect of respondents' life-long medical history on labor supply, this study analyzes the more direct and immediate effects of individuals' health status on labor supply by focusing only on the three years preceding the survey.

Focusing on men only, we examine the effect of the three health indicators mentioned above on the probability of not working, on the probability of having retired, and on the average working hours per week. Second, we conduct this examination for all observations in our sample as well as for subsamples of individuals younger than 60 and individuals aged 60 and above, and compare the extent to which health problems affect individuals' labor status for these two age groups. The opportunity cost of retiring tends to be lower for elderly individuals who, moreover, tend to have lower physical resistance to diseases, and splitting the sample into these two age groups allows us to examine how these factors affect the retirement decision.

Our empirical results show that a deterioration of health does affect individuals' decisions on whether to participate in the labor market and how many hours to work. Specifically, both the probability of not working and of having retired tend to be higher for those suffering from one of the three killer diseases in the preceding three years, and their working hours per week tend to be shorter. Further, the magnitude of the health effect of suffering from one of the three killer diseases appears to be considerably larger than that of suffering from one additional illness or suffering from a lifestyle disease. In addition, we find that the instrumented estimates of the health effect are considerably larger than the non-instrumented estimates. This finding suggests that the main cause of the endogeneity in our health indicator is probably omitted variables. Specifically, unobservable determinants of health and labor supply, such as the past employment status and the type of work done in the past, are omitted both from the health and labor supply equations. For example, those who did not work in the past may be in better health since they were not exposed to hard physical labor or hazardous work or did not experience stress. At the same time, they may be less likely to be participating in the labor force on the survey date. Further, we find that the work status of males aged 60 and above is more significantly affected by one additional illness and a history of lifestyle diseases than that of those under 60.

The remainder of the study is organized as follows. Section 2 describes our data. Section 3 descriptively examines the relationship between health status and labor participation using the basic statistics of our dataset. Section 4 then outlines our empirical strategy and discusses the validity of our instrument. Section 5 presents our empirical results, while Section 6 concludes the study.

2. Data description

2.1. Data source and observations to be analyzed

The data used in this study are taken from waves I to III of the "Survey on Health and Retirement" conducted from 2008 through 2010. The survey is conducted annually in March by the National Institute of Population and Social Security Research to examine the effects of middle-aged and older people's health on their retirement behavior and, to this end, targets respondents aged between 45 and 80 at the time of wave I. For the 2008 survey, 2,747 potential respondents were randomly extracted from the 39,311 "monitors" (individuals that had previously agreed to participate in future surveys) of Central Research Services, Inc. (CRS). [2]

Of the 2,747 monitors contacted, 1,074 responded to wave I of the survey (for a response rate of 39%). In wave II (implemented in March 2009), in addition to a follow-up survey of the 1,074 respondents to the first survey, another 578 individuals were randomly chosen from among the CRS monitors. Responses were obtained from 862 wave I respondents (response rate: 80%) and from 257 newly chosen individuals (response rate: 44%). In wave III (March 2010), the 1,119 wave II respondents were contacted again, of which 954 responded (response rate: 85%).

From wave II onward, the "Survey on Health and Retirement" has included questions regarding respondents' spouses' health and work status that are almost identical to those for respondents themselves. Responses regarding spouses' health and work status are available for 937 individuals in wave II (2009) and 798 individuals in wave III (2010). For the purpose of this study, we concentrate on male respondents/spouses, since – as we pointed out in Hamaaki and Noguchi (2010) – female labor participation is more likely than male labor participation to be affected by factors other than health. As a result, our dataset consists of observations for 497 men in wave I, 665 in wave II, and 656 in wave III.

2.2. Health indicators and work status

In this subsection, we describe the primary variables used for our empirical analyses. First, as for individuals' health status, the "Survey on Health and Retirement" asked respondents and their spouses to indicate whether they had suffered from one or more illnesses from a list of 29 illnesses

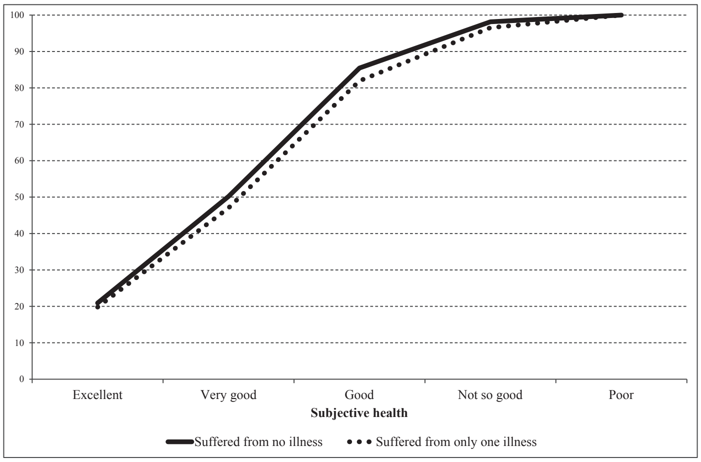
[2] CRS conducts a Monthly Omnibus Survey of individuals randomly selected from the basic resident register. "Monitors" are individuals that have agreed to participate in more detailed surveys in the future. CRS then selects "monitors" for various surveys from municipalities around Japan that are representative of the sex and age structure (in five-year age brackets) of the population overall. The composition of monitors is adjusted regularly so that the sex and age structure is identical to that in the *Population Census*. Survey respondents receive a book voucher worth 500 yen as compensation for participating.

(including "other"). [3] The survey also asked about the age at which individuals had contracted these illnesses. Based on these questions, we construct the following three types of health indicators: (1) the number of illnesses contracted in the three years preceding the survey, (2) a dummy variable for suffering from a lifestyle disease in the preceding three years, and (3) a dummy variable for suffering, in the preceding three years, from at least one of the three killer diseases that are the main cause of death in Japan. Even though the data are solely based on self-reporting (rather than on clinical and/or physiological examinations such as blood tests and cytodiagnosis), these health indicators can be considered to be relatively objective. On the other hand, although it is common in epidemiology to measure people's health in terms of the number of illnesses, since this measure does not take into account the severity of an illness and its effects on physical functions, severe and mild illnesses are weighted equally. Therefore, in order to take the heterogeneity across illnesses in terms of their effect on labor participation into account, we also focus on two specific types of illnesses, namely lifestyle diseases and the three killer diseases.

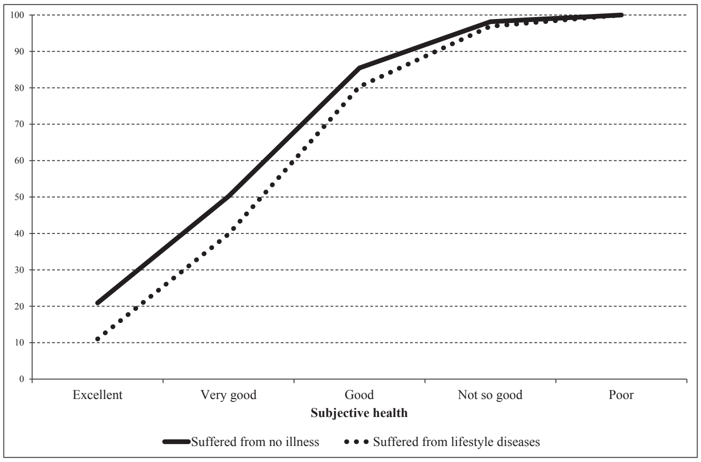
In order to examine whether the incidence of illness affects the labor participation decision through a change in subjective health, we examine the relationship between our objective health indicators and subjective health. For this purpose, we compare the cumulative distribution functions (CDFs) of a subjective health indicator of people with good and with poor objective health. The subjective health indicator is based on a five-grade response to the question: "What is your current health condition?" If, for example, suffering from one of the three killer diseases worsens subjective health, the CDF of those suffering from one of the three killer diseases should be located below that of those not suffering from one of these diseases. Figures 1(a) to 1(c) show the CDFs of subjective health of those suffering from no illness and those suffering from one or more illnesses. In the figures, the CDFs of those suffering from an illness are located below the CDFs of those suffering no illness. In particular, suffering from one of the three killer diseases appears to be associated with a sharp deterioration in individuals' subjective health. This suggests that when people suffer from a severe acute disease, this is likely to result in a greater deterioration in subjective health and hence is more likely to affect individuals' labor participation decisions.

Second, regarding individuals' work status, the "Survey on Health and Retirement" asks survey participants to report their and their spouse's employment status choosing from the following categories: (1) regular employee or civil servant; (2) contract or non-regular employee; (3) temporary employee (agency temp); (4) part-timer; (5) self-employed (own business); employed in agriculture, fishing, or forestry; (6) self-employed; (7) piecework at home; (8) professional job requiring

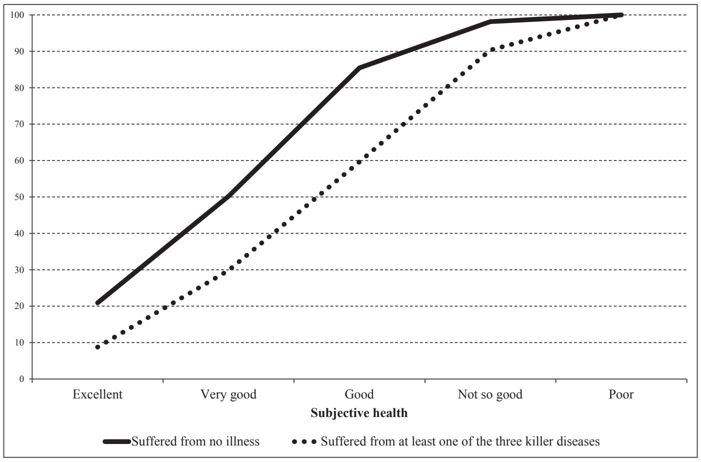
[3] The 29 illnesses are: (1) heart diseases (heart attack and heart failure, heart infarction, valvular heart disease, etc.); (2) high blood pressure; (3) hyperlipidemia; (4) stroke and cerebrovascular disease; (5) cancer and malignant growths (including leukemia and lymphoma; excluding benign skin cancer); (6) sugar diabetes; (7) gout; (8) chronic lung disease (chronic bronchitis, pulmonary emphysema, etc.); (9) asthma; (10) digestive system disorders I (stomach diseases other than cancer such as ulcers); (11) digestive system disorders II (liver diseases other than liver cancer such as hepatitis B and C, cirrhosis of the liver); (12) digestive system disorders III (gall bladder-related diseases); (13) digestive system disorders IV (other or unspecified digestive system disorders); (14) kidney-related diseases; (15) uterine fibroids and ovary-related diseases; (16) thyroid gland-related diseases (Graves' disease, prostatic hyperplasia, etc.); (17) urination problems (incontinence and leakage, urinary hesitancy, ureteral stones); (18) joint diseases (arthritis, rheumatism); (19) hernias, neuralgia; (20) lower back pain, stiff shoulders; (21) femoral neck fracture; (22) osteoporosis; (23) eye diseases (cataract, glaucoma, etc.); (24) ear diseases (deafness, etc.); (25) hay fever, allergies, etc.; (26) Parkinson's disease; (27) skin diseases (including benign skin cancer); (28) mental health problems such as depression; (29) other. It should be noted that the number of categories increased from 21 in wave I to 27 in wave II and finally to 29 in wave III as a result of refinements in the questionnaire by providing separate categories for diseases that made up a large share of the answers given under "other" in the earlier surveys.



(a) CDFs of the subjective health measure of those who suffered from only one illness and those who suffered from no illness



(b) CDFs of the subjective health measure of those who suffered from lifestyle diseases and those who suffered from no illness



(c) CDFs of the subjective health measure of those who suffered from at least one of the three killer diseases and those who suffered from no illness

Figure 1. Comparison of CDFs of subjective health of those suffering from no illness and those suffering from one or more illnesses

qualifications; (9) other; (10) not working. [4] In this study, we group these categories into (1) regular employees; (2)-(4) non-regular employees; (5)-(9) self-employed and other, and (10) not working. Moreover, the survey asked whether respondents and their spouses were looking for work at the time of the survey (from wave II onward) and how many hours per week they currently worked on average. Based on these questions, we create the following three work status variables: "not working" at the time of the survey (1 if (10) was chosen; 0, otherwise); "having retired" at the time of the survey (1 if not working and also not looking for work at the time of the survey; 0, otherwise); and average hours of work per week.

3. Basic statistics

3.1. Individual characteristics

Table 1 shows basic statistics for the main characteristics of the individuals in our dataset for each survey wave. First, the table shows that from wave I to wave III the average age of respondents increased from 61.4 to 63.0 years. At the same time, the share of respondents not working increased from 34.2% to 37.5%, the share of those having retired (i.e., those not working and not looking for work) rose from 31.5% in wave II to 32.8% in wave III, [5] and the average hours of work per week dropped considerably from 33.4 hours in wave I to 25.3 hours in wave III. Taken together, these figures indicate that with advancing age people are more likely to stop working. That being said, the large 7-hour decline in average weekly working hours from 2008 (wave I) to 2009 (wave II) is likely, to a considerable extent, to reflect the impact of the global financial crisis on the labor market for the elderly.

Second, regarding respondents' medical history in the preceding three years, the table shows a gradual deterioration in their health status. Again, to a large extent, this presumably reflects the advancing average age of our survey respondents. In addition, it needs to be pointed out, however, that these figures may be affected by considerable changes in two of the health indicators from 2008 to 2009, namely, the number of illnesses and the share of those who suffered from lifestyle diseases, as a result of revisions in the list of illnesses in the "Survey on Health and Retirement" (see footnote 4 for details). For example, in wave II, "gout" was added as a new item to the list of illnesses, thus increasing the number of illnesses and the share of those who suffered from a lifestyle disease.

Third, let us take a brief look at individual characteristics other than work and health status. The share of married respondents is about 94 to 95% and shows no clear trend. Regarding educational achievement, about 34% of the respondents in our dataset had a university degree. This means that our respondents are better educated than the national average, given that for the age cohorts covered by our survey (those born between 1928 and 1963), the share of those with a university degree ranges from 8.1 to 25.7% percent. [6] Further, the mean of equivalent household wealth, calculated by dividing total household wealth by the square root of the number of household members, ranges from about 20.1 to 21.9 million yen during the three waves. Comparing these figures with the 2009 National Survey of Family Income and Expenditure (NSFIE, conducted by the Ministry of Internal

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[4] Wave I of the survey did not include categories (6) and (8). However, taking respondents and spouses together, there were only 12 individuals in wave II and 15 in wave III that fell into these categories. Given these extremely small numbers, the difference in categories between the waves is unlikely to have any major effect on our results.

[5] Wave I of the "Survey on Health and Retirement" did not ask whether respondents and their spouses were looking for work. We are therefore unable to calculate the share of those having retired.

[6] Figures from the "School Basic Survey," Ministry of Education, Culture, Sports, Science and Technology. Available online (in Japanese) at:
http://www.e-stat.go.jp/SG1/estat/List.do?bid=000001015843&cycode=0.

Table 1. Basic statistics

	Wave I	Wave II	Wave III
Not working	34.2%	34.6%	37.5%
Having retired from the labor market	-	31.5%	32.8%
Average working hours per week	33.4	26.6	25.3
	(22.9)	(23.6)	(23.1)
Health measures			
Number of illnesses in the preceding three years	0.237	1.256	1.712
	(0.516)	(1.785)	(2.063)
Suffered from lifestyle disease in the preceding three years	8.2%	25.7%	32.0%
Suffered from at least one of the three killer diseases in the preceding three years	2.2%	9.5%	13.4%
Age	61.4	62.2	63.0
	(8.99)	(9.237)	(9.097)
Married	95.2%	93.7%	95.4%
University (undergraduate or graduate school) graduate	34.2%	34.9%	34.3%
Household wealth (100,000 yen, gross value)	371.0	342.8	334.6
	(337.0)	(343.5)	(338.0)
Equivalent household wealth (100,000 yen, gross value)	218.8	205.0	201.2
	(212.1)	(213.2)	(213.9)
Hourly market wage (by prefecture, 1,000 yen)	1.937	1.897	1.856
	(0.575)	(0.487)	(0.546)
Number of observations	497	665	656

Note 1: Values in parentheses show standard deviations, shown only for continuous variables.
Note 2: "Survey on Health and Retirement" did not ask whether or not respondents and/or spouses were seeking work in the first wave. We could not therefore obtain the ratio of "having retired" for the year 2008. We also had to exclude some observations with missing variables from the calculation and therefore the entire number of samples for these ratios are 651 and 625 in waves II and III, respectively.
Note 3: The descriptive statistics for working hours in waves I, II, and III are based on 415, 656, and 644 observations, respectively, since observations with missing values were dropped.
Note 4: Regardless of respondents and/or spouses' working status, we impute aggregated hourly market wages by prefecture, industry, and size of firms, based on the "Basic Survey on Wage Structure" conducted by MHLW at each survey year. Hourly market wage is an exogenous variable, calculated by (scheduled cash earnings/(scheduled hours worked+actual number of overtime hours worked)).

Affairs and Communications) to check the national representativeness of our data shows that the mean of equivalent household wealth in our survey is much smaller than the weighted average of equivalent household wealth for two-or-more person households with a household head aged 40–49 years, 50–59 years, 60–69 years, or 70 and above (36.5 million yen). We suspect that the difference may be due to different survey methodologies for real assets. While the NSFIE estimates the value of real assets, including houses and residential land, utilizing information on dwelling structures and areas of land, our survey does not separately inquire about the current value of real assets, but asks about the value of total household assets, including financial assets, houses, and residential land. This means that while respondents to our survey may have quite accurate knowledge of the current value of their financial assets, this is not necessarily the case for their real assets. Respondents may mainly report the value of financial assets, and not knowing exactly the value of real assets would thus result in an underestimation of household assets.

Table 2. The relationship between suffering from illnesses and working status

Panel 2-1. Suffering from illnesses and the probability of "not working"

		The probability of "not working"					
Health measures	Age	50-59		60-69		70-	
Suffered from at least one illness in the preceding three years	Suffered	5.6%		42.2%		78.4%	
	Not	5.7%		40.0%		75.7%	
Suffered from lifestyle disease in the preceding three years	Suffered	5.1%		35.8%		76.7%	
	Not	5.6%		40.2%		74.9%	
Suffered from at least one of the three killer diseases in the preceding three years	Suffered	23.1%	***	42.5%		94.4%	***
	Not	5.1%		40.2%		74.9%	

Panel 2-2. Suffering from illnesses and the probability of "having retired from the labor market"

		The probability of "having retired from the labor market"					
Health measures	Age	50-59		60-69		70-	
Suffered from at least one illness in the preceding three years	Suffered	2.4%		36.3%		77.2%	*
	Not	2.8%		36.3%		69.6%	
Suffered from lifestyle disease in the preceding three years	Suffered	3.8%		31.3%		75.4%	
	Not	2.1%		35.3%		69.8%	
Suffered from at least one of the three killer diseases in the preceding three years	Suffered	7.7%	*	38.2%		96.2%	***
	Not	2.1%		35.3%		69.8%	

Panel 2-3. Suffering from illnesses and average working hours per week

		Average working hours per week					
Health measures	Age	50-59		60-69		70-	
Suffered from at least one illness in the preceding three years	Suffered	46.3		35.2	*	25.1	*
	Not	45.9		38.6		32.0	
Suffered from lifestyle disease in the preceding three years	Suffered	44.2	*	32.4	***	28.3	
	Not	46.2		38.3		28.8	
Suffered from at least one of the three killer diseases in the preceding three years	Suffered	38.3	**	33.7	*	20.0	
	Not	46.2		38.3		28.8	

Note 1: For panels 2-1 and 2-2, the asterisks ***,**, * indicate statistical significance at the 1%, 5%, and 10% significance levels of the null hypothesis that the probability of "Not" minus that of "Suffered" is negative.
Note 2: For panel 2-3, the asterisks ***,**, * indicate statistical significance at the 1%, 5%, and 10% significance levels of the null hypothesis that the average working hours per week of "Not" minus that of "Suffered" is positive.

3.2. The relationship between suffering from an illness and work status

Table 2 shows cross tabulations for the relationship between suffering from an illness in the preceding three years (i.e., suffering from at least one illness, suffering from a lifestyle disease, and suffering from one of the three killer diseases) and variables on the work status at the time of the survey for 10-year age brackets. In order to separate the effect of lifestyle diseases from that of the three killer diseases, we restrict the sample of respondents to those who did not suffer from one of the three killer diseases in the preceding three years when analyzing the effect of lifestyle diseases on the probability of not working and of having retired. Similarly, when examining the effect of contracting one of the three killer diseases, we restrict our sample to those not suffering from a lifestyle disease in the preceding three years.

To start with, in panels (a) and (b) of Table 2 we look at the effect of a deterioration in health on the extensive margin of labor supply (i.e., whether individuals work and participate in the labor

Table 3. The relationship between suffering from illnesses and the continuation of work

The probability of working status and average working hours per week at wave III (in 2010), conditional on working at wave I (in 2008)		(A) The probability of "not working"		(B) The probability of "having retired from the labor market"	(C) Average working hours per week	
Suffering from at least one illness during the period from wave I to wave III	Suffered	10.4%		4.5%	41.4	
	Not	8.7%		5.3%	40.8	
Suffering from lifestyle diseases during the period from wave I to wave III	Suffered	11.6%		2.4%	40.1	
	Not	9.2%		5.3%	41.2	
Suffering from the three killer diseases during the period from wave I to wave III	Suffered	21.4%	*	0.0%	33.3	*
	Not	9.0%		5.1%	41.3	

Note 1: For column (A), the asterisk * indicates statistical significance at the 10% significance level of the null hypothesis that the probability of “Not” minus that of “Suffered” is negative
Note 2: For column (B), the asterisk * indicates statistical significance at the 10% significance level of the null hypothesis that the average working hours per week of “Not” minus that of “Suffered” is positive.

market). The panels show that while suffering from a lifestyle disease does not increase the probability of not working or having retired, and in some cases, in fact, decrease these probabilities, suffering from one of the three killer diseases significantly increases these probabilities. The observed negative correlation between suffering from a lifestyle disease and the probability of not working or having retired may be due to reverse causality, i.e., the fact that working (longer hours) increases the likelihood of contracting a lifestyle disease.

Next, panel (c) of Table 2 compares the average working hours per week between those who had contracted an illness and those who had not. In this panel, we excluded those working zero hours from the calculation in order to focus on the intensive margin of labor supply (i.e., how much individuals work, conditional upon the fact that they were in work). We find a significant negative correlation between hours worked and deterioration in health.

3.3. The relationship between suffering from an illness and continuing to work

Table 3 shows cross tabulations for the relationship between suffering from an illness and continuing to work from wave I to wave III. In this tabulation, we focus only on those who had a job during wave I of the survey. Therefore, the figures in columns (A) and (B) show the probability of transitioning from working to not working and from working to having retired during our observation period. Further, column (C) presents the average working hours per week of those who remained in the labor market throughout the period.

Starting with column (A), this shows a significantly positive correlation between the incidence of the three killer diseases and the probability of transitioning from working to not working during the observation period. This suggests that contracting a severe acute disease is likely to negatively affect participation in the labor market. On the other hand, we do not observe a significant effect in the case of suffering from at least one illness or from a lifestyle disease. Next, column (B) shows that no significant correlation is observed between contracting an illness and the decision to retire. This suggests that retirement is the result of a long-term decision-making process and is not influenced by a newly diagnosed disease. Finally, column (C) suggests that if workers suffer from one of the three killer diseases, they are likely to decrease their working hours. In contrast, there is little change in hours worked if people suffer from an additional illness or a lifestyle disease.

In sum, contracting a severe acute disease appears to significantly decrease individuals' labor supply. However, the results of the descriptive analysis here are likely to be biased due to endogeneity of the health status. We address this issue in the next two sections to examine the effects of health on individuals' labor supply in a standard econometric framework.

4. Empirical strategy

4.1. Empirical specifications

This section describes our empirical model for examining the effects of health on individuals' work status and working hours. In order to address the problem of potential endogeneity in our health indicators, we estimate a labor participation function using the following IV probit and recursive bivariate probit models: [7]

$$y_{it} = \begin{cases} 1 & (if\ \ y_{it}^* = \alpha h_{it} + X_{1,it}\beta + \varepsilon_{it} > 0) \\ 0 & (if\ \ y_{it}^* = \alpha h_{it} + X_{1,it}\beta + \varepsilon_{it} \le 0) \end{cases}$$

$$h_{it} = X_{1,it}\gamma + X_{2,i}\delta + \nu_{it} \tag{1}$$

where y_{it} is a dichotomous variable which takes one if individual *i* is not working (or has retired) at time *t* and zero otherwise. Further, h_{it} stands for individual *i*'s health status in year *t*. $X_{1,it}$ is a vector of individual *i*'s characteristics other than health status at time *t*, such as age, marital status, the hourly market wage in the prefecture where the individual lives, educational attainment, and equivalent household wealth, as well as year dummies. $X_{2,i}$ is a vector of IVs to identify α in the above model. The two error components, ε_{it} and ν_{it}, are allowed to correlate, that is, $\mathrm{Cov}(\varepsilon_{it}, \nu_{it} \mid X_{1,it},\ X_{2,i}) = \rho$.

The reason for adding the prefecture-level hourly market wage is to control for individuals' opportunity cost of not working or retiring from the labor market. Specifically, we use the average hourly market wage for all industries and firm sizes of the prefecture where an individual lives using the MHLW's "Basic Survey on Wage Structure" for each survey year, regardless of whether a respondent (or his spouse) works. The hourly market wage is calculated as follows: scheduled cash earnings/(scheduled hours worked + overtime hours worked). The hourly market wage gradually decreased from 1,937 in wave I to 1,856 yen wave III, which probably reflects the weakening of the economy as a result of the global financial crisis.

To estimate the determinants of average working hours per week, we employ a standard censored Tobit model, i.e.:

$$WH_{it} = \begin{cases} WH_{it}^* & (if\ \ WH_{it}^* = \alpha h_{it} + X_{3,it}\beta + \varepsilon_{it} > 0) \\ 0 & (if\ \ WH_{it}^* = \alpha h_{it} + X_{3,it}\beta + \varepsilon_{it} \le 0) \end{cases}$$

$$h_{it} = X_{3,it}\gamma + X_{2,i}\delta + \nu_{it} \tag{2}$$

where WH_{it} stands for individual *i*'s average working hours per week. $X_{3,it}$ is a vector of individual *i*'s characteristics at time *t*, consisting of the variables contained in $X_{1,it}$ and two additional variables: (1) a dummy variable which takes one if individual *i* was a regular employee or public servant at the survey date; and (2) a dummy variable which takes one if individual *i* fell into

[7] To confirm the robustness of our results, we also conduct linear probability estimations using two-stage least squares (2SLS).

one of the following employment categories at the survey date: self-employed (own business); employed in agriculture, fishing, or forestry; self-employed; piecework at home; professional job requiring qualifications; or other.

4.2. Instrumental variables (IVs)

In order to address the endogeneity of the health indicators in equations (1) and (2), we employ the body mass index (BMI) at age 30 and the parents' medical history as IVs ($X_{2,i}$). The BMI is a standard measure of the degree of obesity and is calculated by dividing a person's weight (kg) by the squared height (m). The BMI at age 30 is calculated from a respondent's present height (i.e., it is assumed that his height has not changed since age 30) and his weight at age 30. The epidemiological literature suggests that overweight and obesity in young adulthood and middle age are associated with subsequent higher morbidity and disability (Taylor and Østbye, 2001; Ferraro et al., 2002; Stenholm et al., 2007), and therefore higher medical expenditure in old age (Daviglus et al., 2004; Daviglus, 2005). We therefore expect that respondents with a high BMI at age 30 are more likely to have lifestyle-related and/or other diseases in old age. Moreover, the BMI at age 30 would be exogenous if the degree of obesity is to a large extent genetically determined. In fact, Comuzzie and Allison (1998) summarized that "40 to 70% of the variation in obesity-related phenotypes, such as body mass index (BMI), sum of skinfold thickness, fat mass, and leptin levels, is heritable." However, it must be noted that people's lifestyle and their personality traits also appear to contribute to obesity. If that is the case, our instrument, the BMI at age 30, might be correlated with unobservable disturbances.

The other IV we use is parents' medical history, with which we expect individuals' health to be correlated due to shared genes. Parents' medical history refers to illnesses that respondents' parents and/or their spouses' parents had suffered up to the time of the survey date. To instrument the number of illnesses and suffering from a lifestyle disease, we use dummies indicating whether parents had contracted a lifestyle disease. On the other hand, we use dummies indicating whether parents had contracted one of the three killer diseases to instrument whether respondents had contracted one of these diseases. In both cases, we construct separate dummies indicating whether one of the parents only or both parents have a history of contracting one of the two types of diseases and use these as IVs.

5. Empirical results

5.1. Results for the entire sample

Table 4 reports the effects of one additional illness contracted in the preceding three years on the probability of not working (Panel 4-1) and having retired from the labor market (Panel 4-2) at the time of the survey (see Table A1 in Appendix for the two-stage least squares coefficients of the all explanatory variables). In both panels, columns (A) and (B) show the results of a simple probit and OLS estimation based on the assumption that the health status is exogenous. On the other hand, columns (C) and (D) show the results based on an IV probit model and a two-stage least squares (2SLS) model to adjust for potential endogeneity of the health indicators. Standard errors in all estimations are adjusted to account for possible correlation within a cluster (i.e., within an individual). [8]

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[8] The estimated standard errors in Tables 5, 6, and 7 are also adjusted to account for possible correlation within an individual, except in the case of the bivariate probit model. In the bivariate probit model, the standard errors are estimated by 200 bootstrap replications instead of clustering the standard errors by individual.

Table 4. The effects of the number of illnesses in the preceding three years

Panel 4-1. The effects of the number of illnesses in the preceding three years on the probability of "not working"

Dependent variable=Working status (Not working=1; Working=0)	(A) Probit	(B) OLS	(C) IV estimation: IV Probit		(D) IV estimation: 2SLS
	Marginal Effect	Coefficient	Coefficient	Marginal Effect	Coefficient
Number of illnesses in the preceding three years	0.017 **	0.019 **	0.411 ***	0.099 ***	0.109 *
	(0.007)	(0.008)	(0.137)	(0.038)	(0.062)
Health status equation (coefficients of IVs)					
BMI at age 30	—	—	0.060 ***	—	0.059 ***
			(0.021)		(0.023)
Parents' medical history of lifestyle diseases					
Both parents			0.480 **		0.469 **
	—	—	(0.218)	—	(0.236)
Either father or mother			0.247 **		0.269 **
			(0.119)		(0.12)
Test for weak identification					
F statistics of excluded instruments	—	—	—	—	4.69
Test of over-identification					
p-value of Hansen J statistic	—	—	—	—	0.7777
R^2/Pseudo R^2	0.374	0.414	—	—	—
Wald Chi^2/F-value	341.09 ***	104.44 ***	435.19 ***	—	77.82 ***
Number of observations			1818		

Panel 4-2. The effects of the number of illnesses in the preceding three years on the probability of "having retired from the labor market"

Dependent variable=Working status (Having retired from the labor market=1; Working or Seeking work=0)	(A) Probit	(B) OLS	(C) IV estimation: IV Probit		(D) IV estimation: 2SLS
	Marginal Effect	Coefficient	Coefficient	Marginal Effect	Coefficient
Number of illnesses in the preceding three years	0.014 **	0.017 **	0.251	0.053	0.060
	(0.006)	(0.008)	(0.162)	(0.036)	(0.044)
Health status equation (coefficients of IVs)					
BMI at age 30	—	—	0.077 ***	—	0.076 **
			(0.029)		(0.030)
Parents' medical history of lifestyle diseases					
Both parents			0.664 **		0.650 *
	—	—	(0.333)	—	(0.343)
Either father or mother			0.349 **		0.368 **
			(0.163)		(0.160)
Test for weak identification					
F statistics of excluded instruments	—	—	—	—	4.71
Test of over-identification					
p-value of Hansen J statistic	—	—	—	—	0.7002
R^2/Pseudo R^2	0.399	0.424	—	—	—
Wald Chi^2/F-value	216.77 ***	82.03 ***	241.79 ***	—	73.79 ***
Number of observations			1276		

Note: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level. Columns (A) and (C) report the average marginal effect.

The IV estimations show that having one additional illness raises the probability of not working by about 10-11 percentage points. On the other hand, although the coefficients in the estimations for retiring from the labor market are also positive, they are not significant. However, in both Panels 4-1 and 4-2 the magnitude of the effects in the IV estimations is larger than in the non-instrumented estimations in columns (A) and (B). This is probably because IV estimation mitigates downward bias in these estimates due to omitted variables which affect health status and labor supply behavior. Next, looking at the coefficients on the instruments, these indicate that individuals with a higher BMI at age 30 are more likely to suffer from illness in old age. Further, if parents have a history of lifestyle diseases, respondents are likely to contract more illnesses. In the test of overidentification, the null hypothesis that the IVs are not correlated with the error term of the labor force participation function (ε_{it}) cannot be rejected.

Table 5 reports the effect of suffering from a lifestyle disease in the preceding three years on the probability of not working (Panel 5-1) and of having retired (Panel 5-2). Before we discuss the estimation results, it should be noted that while column (C) reports the average treatment effect (ATE) of suffering from a lifestyle disease, column (D) reports the weighted average of local average treatment effects (LATE). As shown by Imbens and Angrist (1994), the 2SLS coefficient can be interpreted as a weighted average of local average treatment effects, which is generally different from the value of the ATE. Columns (C) and (D) show that while suffering from a lifestyle disease significantly raises the probability of not working, it does not have any significant effect on the probability of being retired. Next, comparing the results in Tables 4 and 5, a notable difference is that while the health effects in the probit and OLS estimations are statistically significant in Table 4, this is not the case in Table 5. A possible explanation is that if past labor participation increases the likelihood of suffering from a lifestyle disease due to, for example, irregular hours and poor sleep, and it also decreases the probability of not working at the survey date, the coefficients in columns (A) and (B) may be underestimated as a result of omitting the variable pertaining to past labor participation.

Table 6 shows the effect of suffering from at least one of the three killer diseases in the preceding three years on the probability of not working (Panel 6-1) and of having retired (Panel 6-2). Column (C) in both panels shows that suffering from one of the three killer diseases raises the probability of not working and of being retired by about 24 and 35 percentage points, respectively. The magnitude of these effects is larger than that in Tables 4 and 5, implying that contracting one of the three killer diseases has a major impact on individuals' ability or desire to remain in the labor market.

However, in both panels of Table 6, the F-statistic for the test for weak identification is substantially smaller than 10, the rule-of-thumb value indicating whether IVs satisfy the relevance condition, suggesting that our instruments may be weak. At least a partial explanation may be preventive action by individuals whose parents have a history of suffering from severe illness such as one of the three killer diseases. That is, such individuals may be particularly aware of various health risks and take extra care to avoid them and stay healthy. Such preventive action would weaken the correlation of the incidence of these diseases between individuals and their parents. Thus, weak instruments may be one reason why the health effect is not significant in the 2SLS estimations in Panels 6-1 and 6-2.

Next, Table 7 shows the marginal effects of the three health status indicators on weekly working hours (see Table A2 in the Appendix for the IV Tobit coefficients and the marginal effects of all explanatory variables). The marginal effects are calculated as the effect of a deterioration in health on the actual hours worked, $\mathrm{E}(WH_i \mid WH_i > 0, h_{it} = 1) - \mathrm{E}(WH_i \mid WH_i > 0, h_{it} = 0)$. The result in column (A) shows that the marginal effect of having one additional disease on weekly working hours is not significant. On the other hand, columns (B) and (C) show that contracting a

Table 5. The effects of suffering from lifestyle diseases in the preceding three years

Panel 5-1. The effects of suffering from lifestyle diseases on the probability of "not working"

Dependent variable= Working status (Not working=1; Working=0)	(A) Probit		(B) OLS		(C) IV estimation: Bivariate Probit				(D) IV estimation: 2SLS	
	Marginal Effect		Coefficient		Coefficient		ATE		Coefficient	
Suffered from lifestyle disease in the preceding three years	0.015		0.013		0.801	***	0.193	***	0.341	*
	(0.027)		(0.029)		(0.251)		(0.064)		(0.204)	
Health status equation (coefficients of IVs)										
BMI at age 30	—		—		0.064	***	—		0.018	***
					(0.011)				(0.005)	
Parents' medical history of lifestyle diseases										
Both parents	—		—		0.359	**	—		0.097	*
					(0.121)				(0.052)	
Either father or mother	—		—		0.305	***	—		0.090	***
					(0.075)				(0.029)	
Test for weak identification										
F statistics of excluded instruments	—		—		—		—		8.31	
Test of over-identification										
p-value of Hansen J statistic	—		—		—		—		0.604	
R^2/Pseudo R^2	0.369		0.410		—		—		—	
Wald Chi^2/F-value	337.42	***	101.13	***	—		—		82.87	***
Number of observations					1818					

Panel 5-2. The effects of suffering from lifestyle diseases on the probability of "having retired from the labor market"

Dependent variable= Working status (Having retired from the labor market=1; Working or Seeking work=0)	(A) Probit		(B) OLS		(C) IV estimation: Bivariate Probit				(D) IV estimation: 2SLS	
	Marginal Effect		Coefficient		Coefficient		ATE		Coefficient	
Suffered from lifestyle disease in the preceding three years	0.014		0.013		0.628		0.139		0.202	
	(0.027)		(0.029)		(0.466)		(0.103)		(0.161)	
Health status equation (coefficients of IVs)										
BMI at age 30	—		—		0.066	***	—		0.022	***
					(0.015)				(0.006)	
Parents' medical history of lifestyle diseases										
Both parents	—		—		0.417	***	—		0.132	*
					(0.14)				(0.069)	
Either father or mother	—		—		0.330	***	—		0.111	***
					(0.088)				(0.036)	
Test for weak identification										
F statistics of excluded instruments	—		—		—		—		8.38	
Test of over-identification										
p-value of Hansen J statistic	—		—		—		—		0.5929	
R^2/Pseudo R^2	0.394		0.419		—		—		—	
Wald Chi^2/F-value	219.57	***	80.15	***	—		—		74.29	***
Number of observations					1276					

Note: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level. Column (A) reports the average marginal effect.

Table 6. The effects of suffering from at least one of the three killer diseases in the preceding three years

Panel 6-1. The effects of suffering from the three killer diseases on the probability of "not working"

Dependent variable= Working status (Not working=1; Working=0)	(A) Probit	(B) OLS	(C) IV estimation: Bivariate Probit		(D) IV estimation: 2SLS
	Marginal Effect	Coefficient	Coefficient	ATE	Coefficient
Suffered from the three killer diseases in the preceding three years	0.118 ***	0.140 ***	1.024 *	0.243 *	0.789
	(0.037)	(0.044)	(0.591)	(0.137)	(0.490)
Health status equation (coefficients of IVs)					
BMI at age 30	—	—	0.051 ***	—	0.006 *
			(0.017)		(0.003)
Parents' medical history of three killer diseases					
Both parents	—	—	0.301 **	—	0.038
			(0.132)		(0.029)
Either father or mother	—	—	0.358 ***	—	0.051 **
			(0.100)		(0.02)
Test for weak identification					
F statistics of excluded instruments	—	—	—	—	2.99
Test of over-identification					
p-value of Hansen J statistic	—	—	—	—	0.7896
R^2/Pseudo R^2	0.3767	0.4165	—	—	—
Wald Chi^2/F-value	349.58 ***	108.30 ***	—	—	77.28 ***
Number of observations			1818		

Panel 6-2. The effects of suffering from the three killer diseases on the probability of "having retired from the labor market"

Dependent variable= Working status (Having retired from the labor market=1; Working or Seeking work=0)	(A) Probit	(B) OLS	(C) IV estimation: Bivariate Probit		(D) IV estimation: 2SLS
	Marginal Effect	Coefficient	Coefficient	ATE	Coefficient
Suffered from the three killer diseases in the preceding three years	0.091 ***	0.114 ***	1.560 ***	0.350 **	0.375
	(0.033)	(0.044)	(0.801)	(0.173)	(0.361)
Health status equation (coefficients of IVs)					
BMI at age 30	—	—	0.055 ***	—	0.008 **
			(0.017)		(0.004)
Parents' medical history of three killer diseases					
Both parents	—	—	0.314 **	—	0.048
			(0.138)		(0.035)
Either father or mother	—	—	0.332 ***	—	0.065 **
			(0.111)		(0.026)
Test for weak identification					
F statistics of excluded instruments	—	—	—	—	3.42
Test of over-identification					
p-value of Hansen J statistic	—	—	—	—	0.5523
R^2/Pseudo R^2	0.3999	0.4249	—	—	—
Wald Chi^2/F-value	219.51 ***	84.31 ***	— ***	—	75.44 ***
Number of observations			1276		

Note: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level. Column (A) reports the average marginal effect.

Table 7. The effects of health staus on average working hours per week

Health status preceding three years	Number of illnesses		Suffering from lifestyle diseases		Suffering from the three killer diseases	
Dependent variable=Average working hours per week	(A)		(B) IV Tobit		(C)	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Health status	-6.295	-4.008	-20.808	-11.761 *	-79.403	-25.163 ***
	(4.837)	(3.084)	(13.892)	(6.876)	(51.241)	(8.720)
Referece: Non-IV Tobit estimate of health status	-1.447 ***	-0.959 ***	-3.741 ***	-2.422 ***	-7.563 ***	-4.641 ***
	(0.409)	(0.270)	(1.441)	(0.909)	(2.613)	(1.477)
Health status equation (coefficients of IVs)						
BMI at age 30	0.067 ***	—	0.020 ***	—	0.008 ***	—
	(0.021)		(0.005)		(0.003)	
Parents' medical history						
Lifestyle diseases						
Both parents	0.403	—	0.093	—	—	—
	(0.286)		(0.058)			
Either father or mother	0.223	—	0.077 *	—	—	—
	(0.174)		(0.041)			
Three killer diseases						
Both parents	—	—	—	—	0.015	—
					(0.028)	
Either father or mother	—	—	—	—	0.030	—
					(0.025)	
Wald Chi²	1270.250 ***	—	1271.15 ***	—	760.26 ***	—
Number of observations	1715					

Note 1: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level.
Note 2: Marginal effects are calculated by E(WH|WH>0, h=1)-E(WH|WH>0, h=0).

lifestyle disease or one of the three killer diseases on average decreases weekly working hours by approximately 12 and 25 hours, respectively. Thus, the size of health effects is largest for the three killer diseases, followed by lifestyle diseases, while that of one additional illness is not significant. This ranking is consistent with the results in Figures 1(a) to (c). Based on these regression results, we can conclude that suffering from a lifestyle disease and especially suffering from one of the three killer diseases are significant health factors preventing male workers in Japan from staying in the labor market. Once individuals contract one of these diseases, the probability that they will leave the labor force increases and the hours worked per week significantly declines even for those who stay in the labor market.

5.2. Results for the split sample (those under 60 versus those 60 and older)

Next, we estimate equations (1) and (2) dividing our sample into those under 60 years of age and those 60 years of age and older. Age 60 is the most common retirement age in Japan. Individuals' health status may have a different impact on the labor supply of these different age groups. Apart from having, due to age, lower physical resistance to a deterioration in health, individuals in the older age group in Japan are more likely to be non-regular workers earning a relatively low wage, and thus their opportunity cost of retiring is lower than that for the younger age group.

Tables 8-1 and 8-2 show the effects of one additional illness and of suffering from a lifestyle disease on the probability of not working and on working hours per week, respectively, for the two age groups. [9] It should be noted that we do not examine the effects of the three killer diseases here, because the low F-statistic for the IVs in column (D) of Table 6 suggests that our instruments may be weak. Table 8-1 indicates that for those under 60, having one additional illness has no significant effect on the probability of not working and working hours per week, while for those aged 60 and over, the probability of not working increases significantly, although there also does not appear to be any significant effect on the working hours per week. Thus, at least with regard to the probability of not working, we find that the impact of one additional illness differs between the two age groups.

Next, Table 8-2 shows the effects of contracting a lifestyle disease and indicates that the ATEs on the probability of not working are significant. Specifically, contracting a lifestyle disease increases the probability by 22 percentage points for the younger age group, while for the older age group it raises it by 34 percentage points. Further, suffering from a lifestyle disease significantly decreases the working hours per week for the older age group, namely by about 19 hours. In contrast, no significant effect can be observed for the younger age group. Thus, our results suggest that the effect of suffering from a lifestyle disease on work status and working hours per week differs between the younger and the older age group. This difference is likely due to differences between the two groups in individuals' physical resistance to a deterioration in health and the different opportunity costs of not working.

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[9] In this subsection, we do not analyze the effects of health on the probability of being retired from the labor market. The reason is that we do not have sufficient observations for this variable using a split sample, since data for wave I are not available due to the questionnaire not asking whether individuals had retired. Our analysis is therefore confined to the effects of health on the probability of not working and on working hours per week.

Table 8-1. Results of split sample estimation: The effects of the number of illnesses in the preceding three years on working status and working hours (under 60 versus 60 and older)

Age group	Under 60					60 and older				
Dependent variables	Not working			Average working hours per week		Not working			Average working hours per week	
	(A) IV Probit		(B) 2SLS	(C) IV Tobit		(D) IV Probit		(E) 2SLS	(F) IV Tobit	
	Coefficient	Marginal Effect	Coefficient	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Coefficient	Marginal Effect
Number of illnesses	0.516 **	0.066	0.029	1.888	1.858	0.378 **	0.118 **	0.157	-20.630	-7.592
	(0.216)	(0.052)	(0.038)	(3.228)	(3.176)	(0.173)	(0.053)	(0.113)	(16.065)	(5.871)
Health status equation (coefficients of IVs)										
BMI at age 30	0.056 **	—	0.048 *	0.047	—	0.064 **	—	0.065 *	0.072 *	—
	(0.027)		(0.027)	(0.029)		(0.032)		(0.034)	(0.039)	
Parents' medical history of lifestyle diseases										
Both parents	0.492 **	—	0.526 **	0.475 *	—	0.445	—	0.432	0.088	—
	(0.227)		(0.232)	(0.266)		(0.310)		(0.347)	(0.350)	
Either father or mother	0.427 ***	—	0.454 ***	0.478 ***	—	0.141	—	0.137	0.076	—
	(0.145)		(0.140)	(0.136)		(0.169)		(0.182)	(0.159)	
Test for weak identification										
F statistics of excluded instruments	—	—	6.70	—	—	—	—	1.87	—	—
Test of over-identification										
p-value of Hansen J statistic	—	—	0.406	—	—	—	—	0.987	—	—
Wald Chi^2/F-value	110.43 ***	—	2.48 ***	78.42 ***	—	234.41 ***	—	23.07 ***	281.43 ***	—
Number of observations	721			710		1097			1005	

Note 1: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level.
Note 2：Marginal effects are calculated by E(WH|WH>0, h=1)-E(WH|WH>0, h=0).

Table 8-2. Results of split sample estimation: The effects of suffering from lifestyle diseases on working status and working hours (under 60 versus 60 and older)

Age group	Under 60					60 and older				
Dependent variables	Not working			Average working hours per week		Not working			Average working hours per week	
	(A)		(B)	(C)		(D)		(E)	(F)	
	Bivariate Probit		2SLS	IV Tobit		Bivariate Probit		2SLS	IV Tobit	
	Coefficient	ATE	Coefficient	Coefficient	Marginal Effect	Coefficient	ATE	Coefficient	Coefficient	Marginal Effect
Suffering from lifestyle diseases	1.410 **	0.219 *	0.158	6.759	6.671	1.110 ***	0.338 ***	0.487	-61.448	-18.565 *
	(0.563)	(0.124)	(0.155)	(14.409)	(14.270)	(0.341)	(0.099)	(0.343)	(40.639)	(10.397)
Health status equation (coefficients of IVs)										
BMI at age 30	0.074 ***	—	0.019 **	0.017 *	—	0.054 ***	—	0.016 **	0.021 ***	—
	(0.021)		(0.008)	(0.009)		(0.016)		(0.007)	(0.006)	
Parents' medical history of lifestyle diseases										
Both parents	0.304	—	0.094	0.079	—	0.342 **	—	0.095	0.042	—
	(0.259)		(0.094)	(0.099)		(0.151)		(0.065)	(0.079)	
Either father or mother	0.349 ***	—	0.098 **	0.110 ***	—	0.253 ***	—	0.087 **	0.054	—
	(0.119)		(0.042)	(0.04)		(0.093)		(0.040)	(0.054)	
Test for weak identification										
F statistics of excluded instruments	—	—	4.27	—	—	—	—	4.09	—	—
Test of over-identification										
p-value of Hansen J statistic	—	—	0.561	—	—	—	—	0.811	—	—
Wald Chi^2/F-value	—	—	2.43 ***	78.23 ***	—	—	—	24.86 ***	353.95 ***	—
Number of observations	721			710		1097			1005	

Note 1: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level.
Note 2：Marginal effects are calculated by $E(WH|WH>0, h=1)-E(WH|WH>0, h=0)$.

6. Conclusion

Over the last two decades or so, slow economic growth and rapid population aging have placed a growing burden on government finances and have imposed increasing strains on the social security system. Therefore, in order to counter the gradual decrease in the working age population and to ensure the financial sustainability of the social security system (pensions in particular), the government has adopted various labor market and social security policies to encourage older people to remain in the labor market for longer periods of time. For example, the MHLW has started to require employers to continue employing workers after they have reached the retirement age, and the government has begun to gradually raise the pensionable age for the Employees' Pension Insurance system from 60 to 65 years for males beginning in 2013. These policies provide older workers with economic incentives to postpone the timing of retirement. However, these measures appear to overlook health-related reasons for the elderly leaving the labor market, which may be considerably more important than economic reasons.

Against this background, the present study, using a unique panel dataset on health and retirement, quantitatively examined the effects of a deterioration in health on the probability of not working and of retiring as well as on working hours per week, employing IV estimation. Focusing on observations for males, our empirical results show that a deterioration in health increases the probability of not working and of being retired and, moreover, tends to decrease working hours per week. In particular, contracting one of the three killer diseases appears to have a substantial negative effect on individuals' ability or desire to continue working. Further, splitting the sample into two age groups, we find that one additional illness or contracting a lifestyle disease are more likely to have a negative effect on the work status and hours worked for those age 60 and over than for those under 60.

Our results thus suggest that contracting a severe acute disease potentially prevents middle-aged or older male workers from remaining in the labor market and may force them to at least temporarily decrease their working hours, possibly resulting in financial difficulties for themselves and their families, if they are the major breadwinner. This implies that preventive health care, and in particular preventing the three killer diseases, which are often caused by individuals' lifestyles at a relatively young age, represents another key policy that would help people to remain in the labor market for longer. A first important step in this direction would be for policy makers to conduct a cost-benefit analysis taking into account preventive health care, health care in old age, and the contribution of the elderly in the labor market.

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Appendix. Estimation results for Tables 4, 5 and 6

Table A1. Effects of all explanatory variables on the probability of "not working" and on the probability of "having retired from the labor market"

Estimation method	2SLS					
Dependent variable	Working status (Not working=1; Working=0)			Working status (Having retired from the labor market=1; Working or Seeking work=0)		
Health status in the preceding three years	Number of illnesses	Suffering from lifestyle diseases	Suffering from the three killer diseases	Number of illnesses	Suffering from lifestyle diseases	Suffering from the three killer diseases
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Health status	0.109 *	0.341 *	0.789	0.060	0.202	0.375
	(0.062)	(0.204)	(0.49)	(0.044)	(0.161)	(0.361)
Age	-0.68 ***	-0.707 ***	-0.723 ***	-0.828 ***	-0.857 ***	-0.89 ***
	(0.154)	(0.146)	(0.149)	(0.159)	(0.154)	(0.15)
Age squared	0.011 ***	0.011 ***	0.012 ***	0.013 ***	0.014 ***	0.014 ***
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
Age cubed	-0.0000567 ***	-0.0000586 ***	-0.0000595 ***	-0.0000682 ***	-0.0000705 ***	-0.0000729 ***
	(0.0000138)	(0.0000131)	(0.0000135)	(0.0000142)	(0.0000138)	(0.0000135)
Married	-0.015	-0.078	-0.073	0.025	-0.011	-0.021
	(0.083)	(0.061)	(0.055)	(0.071)	(0.057)	(0.053)
University graduate or higher	0.009	0.01	0.016	0.012	0.011	0.018
	(0.029)	(0.029)	(0.028)	(0.028)	(0.029)	(0.027)
Equivalent wealth	0.00000672	-0.0000322	-0.0000464	-0.0000231	-0.0000504	-0.0000588
	(0.0000673)	(0.00007)	(0.0000637)	(0.0000706)	(0.0000716)	(0.0000678)
Hourly market wage	-0.016	-0.007	-0.006	-0.011	-0.002	-0.002
	(0.026)	(0.027)	(0.025)	(0.031)	(0.032)	(0.029)
Year dummy for 2010 (Wave 3)	-0.17 *	-0.093 *	-0.096 *	-0.030	-0.015	-0.016
	(0.092)	(0.052)	(0.056)	(0.022)	(0.014)	(0.017)
Year dummy for 2009 (Wave 2)	-0.129 **	-0.08 **	-0.076 **	-	-	-
	(0.064)	(0.039)	(0.038)	-	-	-
Number of observations		1818			1276	
F-value	77.82 ***	82.87 ***	77.28 ***	73.79 ***	74.29 ***	75.44 ***

Note: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level.

Appendix. Estimation results for Table 7

Table A2. Effects of all explanatory variables on average working hours per week

Health status in the preceding three years	Number of illnesses		Suffering from lifestyle diseases		Suffering from the three killer diseases	
Dependent variable=Average working hours per week	(A)		(B) IV Tobit		(C)	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Health status	-6.295	-4.008	-20.808	-11.761 *	-79.403	-25.163 ***
	(4.837)	(3.084)	(13.892)	(6.876)	(51.241)	(8.72)
Age	13.641	8.686	11.518	7.391	13.119	7.328
	(10.232)	(6.52)	(10.555)	(6.773)	(12.359)	(6.907)
Age squared	-0.197	-0.125	-0.158	-0.102	-0.177	-0.099
	(0.17)	(0.108)	(0.176)	(0.113)	(0.207)	(0.116)
Age cubed	0.001	0.001	0.001	0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Married	-3.326	-2.189	-0.267	-0.172	-1.275	-0.719
	(5.808)	(3.947)	(3.964)	(2.557)	(4.789)	(2.732)
University graduate or higher	2.358	1.514	2.296	1.485	2.312	1.300
	(1.667)	(1.08)	(1.635)	(1.067)	(2.085)	(1.18)
Equivalent wealth	-0.008 **	-0.005 **	-0.006 *	-0.004 *	-0.003	-0.002
	(0.004)	(0.002)	(0.003)	(0.002)	(0.005)	(0.003)
Hourly market wage	1.808	1.151	1.178	0.756	1.836	1.025
	(1.78)	(1.133)	(1.765)	(1.132)	(2.1)	(1.173)
Regular employee or public servant	27.695 ***	19.222 ***	29.605 ***	20.796 ***	24.365 ***	14.601 ***
	(2.823)	(2.005)	(2.39)	(1.695)	(4.421)	(2.792)
Self-employed (own business); employed in agriculture, fishing, or forestry; self-employed; piecework at home; professional job requiring qualifications, or other	34.678 ***	26.691 ***	36.164 ***	28.171 ***	31.541 ***	20.824 ***
	(2.711)	(2.28)	(2.314)	(1.95)	(4.375)	(3.28)
Year dummy for 2010 (Wave 3)	6.139	3.976	2.052	1.324	4.945	2.794
	(6.95)	(4.581)	(3.41)	(2.215)	(5.227)	(2.989)
Year dummy for 2009 (Wave 2)	3.094	1.986	0.509	0.327	2.036	1.143
	(4.66)	(3.018)	(2.466)	(1.587)	(3.444)	(1.942)
Wald Chi^2	1270.25 ***	—	1271.15 ***	—	760.26 ***	—
Number of observations			1715			

Note 1: Standard errors are shown in parentheses. The asterisks, ***, **, * indicate statistical significance at the 1%, 5%, and 10% significance level.
Note 2：Marginal effects for health status are calculated by E(*WH*|*WH*>0, *h*=1)-E(*WH*|*WH*>0, *h*=0).