Income, Health, and Suicide: Evidence from Individual Panel Data in Korea

Chulhee Lee and Jeongrim Hong

Limited evidence regarding the effects of individual income and health on suicide was presented. We investigated how individual economic status and health conditions (chronic diseases and disabilities) affect the probability of suicidal death through an analysis of micro panel data constructed by the Korean National Health Insurance. The data looked into a sample of one million individuals from 2002 to 2013. Results show that low economic status significantly increases the probability of suicide. Poor health is strongly related to a high risk of suicide. The effects of income are strongly revealed for males. Mental disability exerts a stronger effect on female suicide, whereas other types of disability have more powerful effects on male suicide. Suicide in older people is more strongly influenced by health compared with that in middle-aged people, with the exception of mental disability. Moreover, the effect of the severity of the health condition differs according to health problems, and the effect of a new onset is not as strong as that of a continuing condition of the same type.

Keywords: Suicide, Income, Health, Disease, Disability

JEL Classification: I10, I12, I14

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I. Introduction

Suicide is a major public health concern worldwide and a particularly serious social issue in South Korea. Suicide rates in South Korea experienced a sharp rise during the last 15 years, especially among the elderly. The number of suicidal deaths per 100,000 increased from 7.3 in 1991 to 31.9 in 2011 before it fell slightly to 25.5 in 2016. Particularly, the suicide rate for the population 60 and older jumped from 13.3 in 1991 to 71.1 in 2010 and is currently 47.2.

Numerous studies from multiple disciplines have attempted to investigate the determining factors of suicide.[1] However, research on the issue has been seriously restricted by lack of individual-level data on suicide. Previous studies based on micro data primarily investigated suicide attempts or suicidal thoughts (Goodwin *et al.* 2003; Kim *et al.* 2010; Lee *et al.* 2010; Chen *et al.* 2012). Although the effects of local or national economic conditions measured by unemployment and poverty rates have been examined (Noh 2006; Chang *et al.* 2009; Classen, and Dunn 2012; Phillips 2013; Lee, and Kang 2014), how individual economic status affects the risk of committing suicide is largely unknown.[2]

Limited evidence regarding the effects of individual health problems on suicide for the general population has also been presented although past studies have shown a positive relationship between poor health and suicide (Harris *et al.* 1994; Grabbe *et al.* 1997; Stenager, and Stenager 1998; Stenager *et al.* 1998; Palmier-Claus *et al.* 2012). These studies contained selection bias due to the use of small, clinic-based, selected, or non-representative samples; thus, they could not be applied to the general population.

In addition, although previous studies using a representative database pointed to chronic disease or disability as a determining factor for suicide, little is known about the combined effects of disease and disability in population-based samples. Erlangen and colleagues (2015) examined the association between 39 physical diseases and suicidal

[1] See Chen *et al.* (2012) for a comprehensive survey of recent economics literature on suicide.

[2] The study by Denney *et al.* (2009) is a rare exception that utilizes micro data to investigate the effects of marital status and family size on the probability of suicide in the United States.

deaths in older adults and found that multiple physical diseases increased the risk of suicide. Lee and colleagues (2017) assessed the risk of suicide in relation to disability. Particularly, they examined variations in the risk of suicide for different sexes, ages, and income levels. The results showed that the risk of suicide is higher for people with disability than those without (Lee *et al.* 2017). A gap in the literature lies on the failure of these studies to consider the combined effects of functional limitations and diseases. Kaplan and colleagues (2007) analyzed how suicide risk differentials vary among people with diseases and functional impairments. The drawbacks are as follows: (1) they were unable to examine the effects specific to each disease and (2) their data relied on self-reported surveys.

We fill this gap in the literature by investigating how individual economic status and health affect the probability of suicidal death of Koreans aged 40 and older. This study is based on the analysis of the National Health Insurance Service National Sample Cohort (NHIS-NSC) data, which comprise individual panel data that looked into a sample of approximately one million individuals from 2002 to 2013. These sources provide information on the type of employment (wage earners vs. self-employed workers), income class, type and severity of disability, classifications of diseases, and basic personal characteristics. We can identify the individuals who committed suicide because the deceased in the sample are linked to the Cause of Death Statistics. Given that almost everyone in Korea is covered by the NHIS, the sample is representative of the entire population. The suicide rates by gender, age, and year estimated from the sample are similar to those obtained from the entire population. Using the data, we estimated logit models of the correlates of suicide.

Our results show that low economic status significantly increases the probability of suicide. Poor health is strongly related to a high risk of suicide. The effects of income are strongly revealed for males. Mental disability exerts a stronger effect on female suicide, whereas other types of disability have more powerful effects on male suicide. The positive relationship between health condition and suicide is more strongly observed among the elderly than middle-aged individuals. Moreover, the effect of the severity of the health condition differs according to health problems, and the effect of a new onset is not as strong as that of a continuing condition of the same type.

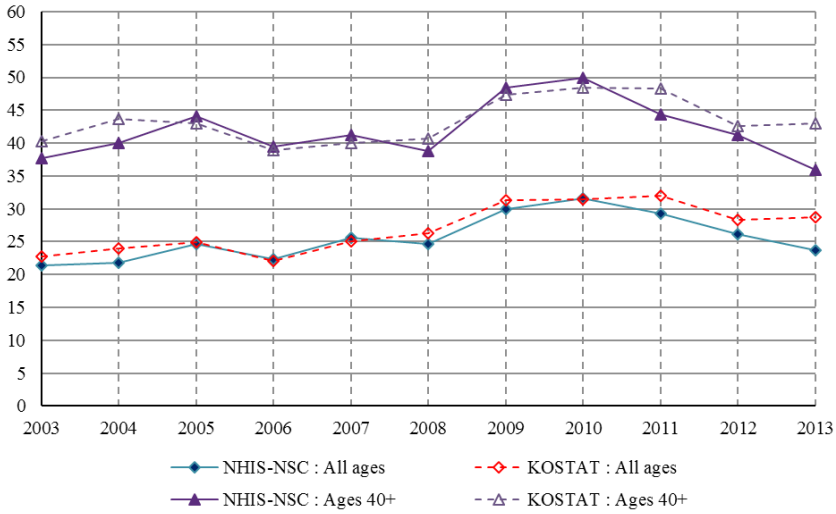

FIGURE 1
NUMBER OF SUICIDAL DEATHS PER 100,000 PERSONS BY AGE

II. Data and Methods

This study is based on the NHIS-NSC (NHIS-2015-2-027) provided by the Korean NHIS. Given that all citizens residing in Korea are required to participate in public health insurance, the NHIS covers nearly the entire population. Approximately 97% of Koreans subscribe to the mandatory National Health Insurance (NHI), and the remaining 3% are the beneficiaries of the Medical Aid Program. Thus, NHIS, the single insurer managed by the government, holds the entire database of health-care utilizations.

The NHIS-NSC data represent individual-level panel data constructed by the NHIS based on stratified random sampling from the national claim database. NHIS-NSC comprises a representative random sample of approximately one million individuals, roughly 2.2% of the entire population in 2002. These data followed the sample for 11 years, up to 2013. These data contain the information of the type of employment (wage workers and the self-employed), income class, type and severity of disability, diagnostic codes (ICD-10) for diseases, medical care costs, the number of days of inpatient and outpatient treatments, and basic personal characteristics.

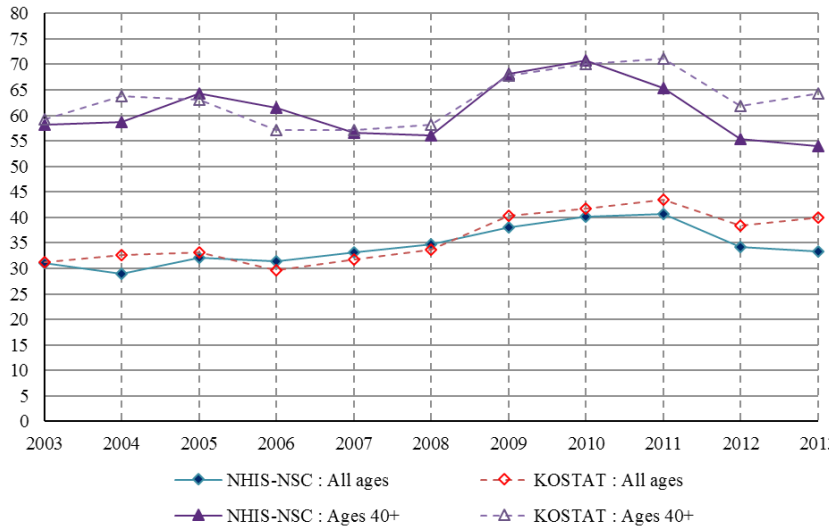

FIGURE 2
NUMBER OF SUICIDAL DEATHS PER 100,000 PERSONS BY SEX AND AGE: MALE

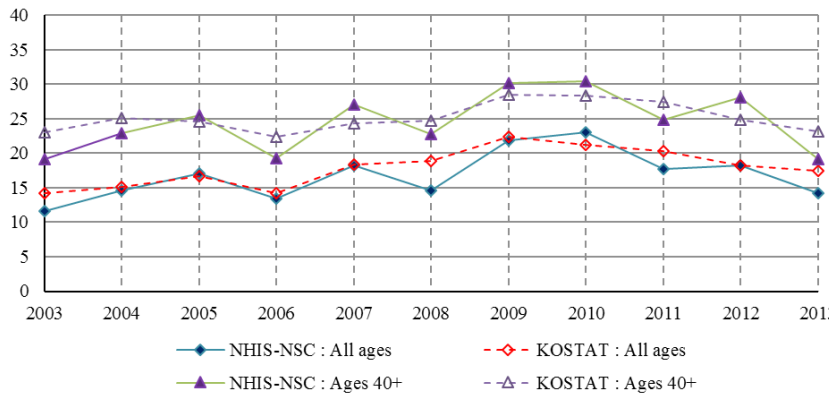

FIGURE 3
NUMBER OF SUICIDAL DEATHS PER 100,000 PERSONS BY SEX AND AGE: FEMALE

The data also provide information on mortality, such as the date and cause of death (ICD-10) by linking the deceased in the sample to the Cause of Death Statistics drawn from the death registration records of the Korean Statistical Information Service. We identified the

people who committed suicide in the sample if the cause of death is recorded as X60-X84 (intentional self-harm). Figures 1–3 depict that the suicide rates by gender, age, and year estimated from the sample are remarkably similar to those obtained from the aggregated statistics for the entire population.

The analyses provided below are based on the pooled sample of individuals aged 40 and older who are included in the NHIS-NSC. Variables pertaining to economic status were created using the information on income class determined by the NHI to assess the amount of health insurance fee (11 categories in total, including the recipients of medical aid allowances and 10 income classes) and the type of employment (wage earners and self-employed workers). In this study, dummy variables for 11 groups reclassified by income quintile and employment type (medical aid, wage worker quintiles 1 to 5, and self-employed worker quintiles 1 to 5) were constructed and used as the indices of economic status.[3]

Two different measures of health conditions are available from the data. First, the "disease records" allow us to determine if a person is treated for a particular disease. We considered five serious chronic diseases that are potentially associated with high suicide risks based on previous studies. These diseases include cancers, Parkinson's diseases, strokes, renal failures, and mood disorders, including depression (Stenager, and Stenager 2000; Hughes and Kleepsies 2001; Fiske *et al.* 2008; McClatchey *et al.* 2017).[4] Second, the "qualification records" report the type and severity of disability for handicapped individuals. The current data classify disabilities into eight categories, namely, physical, cerebral, sight, hearing, cognitive, mental, kidney, and others. We considered all of these eight types of disability in the regression analyses. Personal characteristics contained in the data are limited, with only gender, age, and province of residence available. Table 1 presents the definition of the variables used in analysis.

[3] For both plans covering subscribers' dependent family members including the spouse and the children, the family members of a given household belong to the same household income bracket.

[4] A person who is simply suspected of having a disease may have been assigned the diagnostic code for the disease even if it was revealed to be a false alarm. Therefore, we consider a person having a particular disease in a given year if they received medical treatment twice or more for the disease in that year.

TABLE 1
DEFINITION OF VARIABLES USED IN THE STUDY

Variable	Definition
Dependent variable	
Suicidal death (ICD X60-X84)	=1 if the person committed suicide, =0 otherwise
Independent variable	
Disease	
Cancer (ICD C00-C97)	=1 if the person is a cancer patient, =0 otherwise
Parkinson's disease (ICD G20-22)	=1 if the person is a Parkinson's disease patient, =0 otherwise
Stroke (ICD I60-I64)	=1 if the person is a stroke patient, =0 otherwise
Renal failure (ICD N17-19)	=1 if the person is a renal failure patient, =0 otherwise
Mood disorder (ICD F30-F39)	=1 if the person is a mood disorder patient, =0 otherwise
Disability	
Physical	=1 if the person is physically disabled, =0 otherwise
Cerebral	=1 if the person has a cerebral paralysis, =0 otherwise
Sight	=1 if the person is visually impaired, =0 otherwise
Hearing	=1 if the person is hearing-impaired, =0 otherwise
Cognitive	=1 if the person is cognitively disabled, =0 otherwise
Mental	=1 if the person is mentally disabled, =0 otherwise
Kidney	=1 if the person has a kidney impairment, =0 otherwise
Other	=1 if the person has other disabilities, =0 otherwise
Income	
Medical aid	Medical aid beneficiaries (the poorest)
Wage worker quintiles 1–5	Income quintiles by wage workers (income Q5: the richest)
Self-employed worker quintiles 1–5	Income quintiles by the self-employed (income Q5: the richest)
Control variable	
Age	Dummy variable for each of 5-year age groups
Gender	=1 if the person is male, = 0 otherwise
Household head	=1 if the person is a household head, = 0 otherwise

TABLE 2
DESCRIPTIVE STATISTICS

	Mean	SD
Suicides per 100,000 people	42.410	2,058.923
Disease		
Cancer	0.024	0.154
Parkinson's disease	0.002	0.045
Stroke	0.016	0.127
Renal failure	0.004	0.061
Mood disorder	0.015	0.122
Disability		
Physical	0.046	0.209
Cerebral	0.008	0.091
Sight	0.008	0.090
Hearing	0.008	0.091
Cognitive	0.002	0.048
Mental	0.002	0.050
Kidney	0.002	0.045
Other	0.003	0.053
Income		
Medical aid	0.046	0.209
Wage worker quintile 1	0.091	0.287
Wage worker quintile 2	0.082	0.274
Wage worker quintile 3	0.087	0.282
Wage worker quintile 4	0.114	0.318
Wage worker quintile 5	0.190	0.392
Self-employed worker quintile 1	0.048	0.214
Self-employed worker quintile 2	0.061	0.239
Self-employed worker quintile 3	0.077	0.267
Self-employed worker quintile 4	0.090	0.287
Self-employed worker quintile 5	0.114	0.317
Age dummy		
40–44	0.199	0.399
45–49	0.190	0.392
50–54	0.162	0.368
55–59	0.122	0.327
60–64	0.097	0.297
65–69	0.083	0.276
70–74	0.066	0.247
75–79	0.042	0.201
80–84	0.024	0.152
85+	0.015	0.121
Gender	0.480	0.500
Household head	0.521	0.500
Observations	4,944,632	

We used data from 2003 to 2013, excluding 2002 in which no death record was found. Table 2 reports the descriptive statistics for the analysis. The sample size is 4,944,632, and the average suicide rate for aged 40 and older is 42.4 per 100,000. People who were treated with chronic diseases included in this study are 6.1%, and individuals with disabilities are 7.9%. Medical aid allowances, wage workers, and the self-employed are 4.6%, 56.4%, and 39%, respectively.

We conducted logistic regressions for the correlates of the probability of suicide among middle- and old-aged individuals in Korea, focusing on the effects of economic status and health conditions. Our baseline logit model employed in the estimations is given as follows:

$$y_i^* = \alpha + \beta H_i + \gamma Z_i + \eta X_i + \delta_t + \theta_s + \varepsilon_i \tag{1}$$

$$y_i = \begin{cases} 1 \ if \ \ y_i^* > 0 \\ 0 \ otherwise \end{cases} \tag{2}$$

In Equation (1), y_i^* is a latent variable. We did not observe y_i^* but rather y, which takes on values 0 or 1 according to Equation (2). We can derive Equation (3) by using Equations (1) and (2).

$$prob(y_i = 1) = prob(\alpha + \beta H_i + \gamma Z_i + \eta X_i + \delta_t + \theta_s + \varepsilon_i > 0) \tag{3}$$

$$= \frac{\exp(\alpha + \beta H_i + \gamma Z_i + \eta X_i + \delta_t + \theta_s)}{1 + \exp(\alpha + \beta H_i + \gamma Z_i + \eta X_i + \delta_t + \theta_s)}$$

In Equation (3), $prob(y_i = 1)$ denotes the probability of suicide; H, health conditions; Z, economic status; X, personal characteristics; δ, year fixed effect; θ, province fixed effect; and ε, error term.

III. Baseline Regression Results

We employed six models with different health conditions while incorporating economic status. We controlled only chronic diseases as a measure of health, with variables on personal characteristics in Model 1 and disabilities in Model 3. Model 5 considers diseases and disabilities to estimate the association between health and suicide. We added income class in Models 2, 4, and 6 as a dummy variable to Models 1, 3, and 5, respectively, to investigate the effects of economic

TABLE 3
MARGINAL EFFECT ON 100,000 SUICIDAL DEATHS

	(1)	(2)	(3)	(4)	(5)	(6)
Disease						
Cancer	15.754***	18.130***			15.893***	18.166***
	(4.530)	(4.537)			(4.567)	(4.569)
Parkinson's disease	47.865***	49.646***			42.361***	45.750***
	(8.628)	(8.692)			(8.819)	(8.820)
Stroke	6.149	7.000			2.063	3.899
	(5.321)	(5.316)			(5.487)	(5.466)
Renal failure	16.825*	15.480			−3.981	−0.792
	(10.107)	(10.086)			(16.075)	(14.941)
Mood disorder	84.648***	87.232***			83.215***	86.168***
	(3.654)	(3.687)			(3.680)	(3.706)
Disability						
Physical			23.150***	17.910***	22.068***	16.254***
			(3.303)	(3.325)	(3.303)	(3.323)
Cerebral			28.546***	23.142***	24.801***	18.139***
			(6.192)	(6.214)	(6.545)	(6.514)
Sight			8.389	3.270	8.412	2.712
			(8.233)	(8.231)	(8.222)	(8.214)
Hearing			15.204**	11.974*	13.239*	9.848
			(6.761)	(6.742)	(6.794)	(6.762)
Cognitive			23.868	1.294	21.171	-3.758
			(16.121)	(16.514)	(15.974)	(16.380)
Mental			73.119***	50.246***	58.901***	36.234***
			(9.083)	(9.489)	(0.9151)	(9.326)
Kidney			45.109***	39.021***	47.369**	37.601**
			(11.837)	(11.830)	(18.863)	(17.530)
Other			16.386	9.770	11.030	3.227
			(12.357)	(12.350)	(12.500)	(12.492)
Income						
Medical aid		80.935***		57.948***		68.970***
		(8.951)		(7.892)		(8.583)
Wage worker Q1		7.102*		6.775*		7.138*
		(4.090)		(4.072)		(4.116)
Wage worker Q2		0.928		0.855		0.920
		(3.915)		(3.912)		(3.939)
Wage worker Q3						
Wage worker Q4		−2.738		−2.697		−2.817
		(3.377)		(3.382)		(3.396)

TABLE 3
(CONTINUED)

	(1)	(2)	(3)	(4)	(5)	(6)
Wage worker Q5		−8.058***		−7.137**		−8.138***
		(3.046)		(3.072)		(3.064)
Self-employed worker Q1		65.237***		62.706***		62.438***
		(7.598)		(7.427)		(7.462)
Self-employed worker Q2		52.521***		51.598***		52.168***
		(6.596)		(6.534)		(6.602)
Self-employed worker Q3		28.696***		28.607***		28.693***
		(5.229)		(5.222)		(5.252)
Self-employed worker Q4		13.022***		13.394***		13.340***
		(4.536)		(4.558)		(4.580)
Self-employed worker Q5		−1.006		−0.054		−0.849
		(3.755)		(3.807)		(3.788)

Note: (a) The number of observation is 4,944,632. (b) Age dummy, gender, household head, province dummy, and year dummy are included in each regression but omitted from the table. (b) Standard errors are adjusted for clustering at the individual level and reported in parentheses. (d) *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

status on suicide. All regression coefficients reported in the tables are multiplied by 100,000 such that they convey changes in suicide rates in the number of suicidal deaths per 100,000 persons.

Table 3 presents the results of the baseline regressions conducted for the entire pooled sample. The results indicate that low economic status significantly increases the probability of suicide. Within each employment type, suicide rate is generally high among individuals in low income quintiles. The results also suggest that the self-employed (including family members) are at higher risks of committing suicide than wage earners in the same income class. Compared with wage earners in the middle income quintile (the control group), for example (Model 6), the suicide rates of the self-employed in the first, second, and middle income quintiles are higher by 62, 52, and 29 per 100,000, respectively. Only wage workers in the top income quintile are significantly less likely to commit suicide than those in the control group.

The baseline results also show that poor health conditions tend to increase the probability of suicide. The diseases strongly associated with increased risk of suicide include cancers, Parkinson's diseases,

and mood disorders (including depression). The types of disability that are positively related to the probability of suicide are physical disability, cerebral paralysis, mental disorder, and kidney impairment. The magnitudes of the effects are large. The suicide rate among cancer patients is higher than that of people without the condition by 18 per 100,000. Having Parkinson's disease also increases the suicide rate by approximately 46 per 100,000. In addition, the suicide rate among individuals suffering from mood disorder is higher by 86 per 100,000 compared with those without such a disorder. In the case of disabilities, the suicide rates for those with physical disability, cerebral paralysis, mental disorder, and kidney impairment are higher than those without by 16, 18, 36, and 38, respectively, per 100,000.

Particularly, the marginal effect of disability on suicide is weaker in the models taking into account income class than models without, and this finding can be explained as follows. People with disabilities are likely to experience economic difficulties because they suffer severe constraints in their capability for mental or physical activities. Given the relationship between economic status and suicide, the effects in the models that do not control income are overestimated due to the mixed causes of income and disability.

Table 4 provides the results of regression analysis conducted separately by gender. The results suggest that the effect of income on suicide is pronounced for males. The magnitudes of the estimated coefficients for those receiving medical aid and the self-employed in the lowest income quintile are approximately five times larger for males than for females. If the higher overall suicide rates among males compared with females (60 per 100,000 for males compared with 25 per 100,000 for females) are considered, male suicide remains more responsive to economic status.

Gender disparities in the relationship between health and suicide differ according to the types of health problems. Chronic diseases, including cancers, Parkinson's diseases, and mood disorders, significantly increase the probability of suicide regardless of gender, and the estimated marginal effect is approximately two times higher for males than for females. Mental disability exerts a stronger effect on female suicide, whereas other types of disability (physical, cerebral, hearing, and kidney) have more powerful effects on male suicide.

Table 5 reports the results carried out separately for two age groups (40 to 59 and 60 and older). The patterns of the effect of income on

TABLE 4
MARGINAL EFFECT ON 100,000 SUICIDAL DEATHS BY GENDER

	(1)		(2)	
	Male		Female	
	$\partial y/\partial x$	S. E.	$\partial y/\partial x$	S. E.
Disease				
Cancer	25.832***	7.777	11.973**	5.131
Parkinson's disease	67.700***	16.249	25.561***	8.455
Stroke	4.028	9.401	3.685	5.948
Renal failure	3.692	23.093	-8.458	26.161
Mood disorder	121.313***	6.988	52.515***	3.533
Disability				
Physical	24.663***	5.502	6.367	4.145
Cerebral	24.351**	10.789	11.257	7.893
Sight	9.823	12.927	−10.246	12.486
Hearing	25.415**	10.549	−13.135	11.195
Cognitive	−3.519	25.819	−9.835	25.082
Mental	22.857	19.266	40.383***	7.775
Kidney	60.877**	26.594	2.252	36.925
Other	6.680	19.008	−8.812	24.953
Income				
Medical aid	122.901***	17.015	23.365***	7.165
Wage worker Q1	14.132**	6.725	−1.708	4.693
Wage worker Q2	2.890	6.313	−2.279	4.660
Wage worker Q3				
Wage worker Q4	−2.210	5.435	−2.927	4.203
Wage worker Q5	−11.400**	4.906	−4.091	3.796
Self-employed worker Q1	110.240***	14.241	20.716***	6.592
Self-employed worker Q2	104.864***	12.650	8.947	5.984
Self-employed worker Q3	59.782***	9.856	5.243	5.282
Self-employed worker Q4	33.474***	8.479	−0.568	4.808
Self-employed worker Q5	5.329	6.706	−3.260	4.308
N	2,371,724		2,572,908	

Note: (a) Age dummy, household head, province dummy, and year dummy are included in each regression but omitted from the table. (b) Standard errors are adjusted for clustering at the individual level. (c) *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

suicide are similar to those reported in Table 3, regardless of age group. People who received medical aid are most likely to commit suicide, and self-employed workers are at particularly higher risks of committing suicide compared with wage earners in the same income quintiles. As

Table 5
Marginal Effect on 100,000 Suicidal Deaths by Age

	(1)		(2)	
	Aged 40 to 59		Aged 60 and older	
	$\partial y/\partial x$	S. E.	$\partial y/\partial x$	S. E.
Disease				
Cancer	19.844***	5.766	21.414**	8.645
Parkinson's disease	57.833***	16.509	66.259***	14.860
Stroke	−14.922	12.803	11.214	9.033
Renal failure	19.785	18.665	22.611	31.754
Mood disorder	74.615***	4.020	114.747***	7.661
Disability				
Physical	10.541***	3.798	24.148***	6.829
Cerebral	0.567	10.914	33.793***	11.337
Sight	−12.703	12.703	15.237	14.518
Hearing	4.024	11.828	17.243	11.571
Cognitive	−21.960	15.976	48.810	38.326
Mental	17.982**	7.945	41.699	32.590
Kidney	1.647	22.020	84.349**	37.209
Other	10.597	12.914	−12.176	27.323
Income				
Medical aid	83.861***	12.327	62.693***	15.548
Wage worker Q1	1.847	3.874	20.564**	10.230
Wage worker Q2	3.169	3.911	−4.096	9.254
Wage worker Q3				
Wage worker Q4	−1.476	3.572	−7.198	7.516
Wage worker Q5	−9.698***	3.075	−10.471	6.957
Self-employed worker Q1	56.072***	8.421	75.107***	15.786
Self-employed worker Q2	48.373***	6.529	42.651***	14.383
Self-employed worker Q3	22.434***	4.850	37.022***	13.270
Self-employed worker Q4	5.957	3.946	38.255***	13.554
Self-employed worker Q5	−2.214	3.502	3.969	9.831
N	3,326,230		1,618,402	

Note: (a) Age dummy, gender, household head, province dummy, and year dummy are included in each regression but omitted from the table. (b) Standard errors are adjusted for clustering at the individual level. (c) *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

for the effects of health, the association between health and suicide is more strongly observed among older people than middle-aged individuals. Suicide in the elderly is more strongly influenced by disease

compared with that in middle-aged people. The effects of having major disabilities, such as physical disability, cerebral paralysis, and kidney impairment, are more powerful for the elderly than for the middle-aged, with the exception of mental disability.

IV. Additional Results on the Effects of Health

A. Differences by Severity

We performed additional regressions to investigate how the effects of health on the probability of suicide differ by the severity of the health condition. On the one hand, people suffering from a serious disability or disease are likely to commit suicide because of low chances of survival, poor quality of life, and great economic difficulties associated with the physical problem. On the other hand, severe functional limitations imposed by serious disabilities or chronic conditions may restrict suicidal thoughts or attempts.

The NHIS-NSC data classify each case of disability into two ratings (first and second degrees) depending on its severity. We defined first-degree conditions as "severe" disabilities. For chronic diseases, determining the seriousness of each condition is less straightforward. As a crude proxy for severity, we utilized the information on the distinction between inpatient and outpatient treatments. We assumed that a chronic condition treated with hospitalization is more serious than the same type of condition handled only with outpatient visits. This assumption is not entirely justifiable given that hospitalization decisions can be influenced by a variety of factors other than the seriousness of the condition.

We added to the baseline model the interaction term between each of the health conditions and dummy variable that indicates if the condition is serious ("severe" for disabilities and "inpatient" for diseases). The coefficients for the original variables on health show the effects of "milder" conditions on the probability of suicide, whereas the coefficients for the interaction terms show how the effects of more serious disabilities and diseases differ from those of milder conditions. Table 6 reports the results.

The effect of the severity of the health condition on suicide varies according to diseases. In the cases of cancer, the conditions treated with hospitalization tend to exert stronger effects on the probability

TABLE 6

MARGINAL EFFECT ON 100,000 SUICIDAL DEATHS: INTERACTED WITH SEVERITY OF HEALTH STATUS

	(1)		(2)	
	$\partial y/\partial x$	S. E.	$\partial y/\partial x$	S. E.
Disease				
Cancer	−12.720	7.872	−9.661	7.864
Cancer * inpatient	53.852***	9.462	51.695***	9.459
Parkinson's disease	35.439***	10.570	38.689***	10.601
Parkinson's disease * inpatient	22.319	17.908	23.196	17.812
Stroke	−4.190	6.768	−1.633	6.757
Stroke * inpatient	18.277*	10.891	15.994	10.871
Renal failure	−9.413	17.706	−6.069	16.659
Renal failure * inpatient	6.980	21.072	8.291	20.921
Mood disorder	78.695***	3.826	81.664***	3.852
Mood disorder * inpatient	47.132***	8.607	45.034***	8.598
Disability				
Physical	19.912***	3.563	15.118***	3.564
Physical * severe	14.876*	8.360	7.429	8.407
Cerebral	25.096***	9.236	19.511**	9.191
Cerebral * severe	−0.724	12.230	−2.600	12.214
Sight	6.161	9.503	1.471	9.502
Sight * severe	10.132	18.637	5.450	18.594
Hearing	14.782**	7.369	12.711*	7.330
Hearing * severe	−10.934	18.727	−17.123	18.733
Cognitive	36.249*	21.140	13.611	21.493
Cognitive * severe	−30.542	32.185	−33.337	32.324
Mental	58.176***	14.102	39.550***	14.154
Mental * severe	−7.464	18.165	−12.730	18.186
Kidney	−438.041***	14.752	−443.319***	14.097
Kidney * severe	490.879***	20.733	485.302***	20.535
Other	14.434	13.692	7.331	13.723
Other * severe	−14.369	32.947	−18.259	32.901
Income				
Medical aid			67.892***	8.523
Wage worker Q1			7.262*	4.118
Wage worker Q2			0.971	3.938
Wage worker Q3				
Wage worker Q4			−2.712	3.397
Wage worker Q5			−8.023***	3.065
Self-employed worker Q1			61.639***	7.415
Self-employed worker Q2			51.816***	6.577
Self-employed worker Q3			28.498***	5.235
Self-employed worker Q4			13.262***	4.569
Self-employed worker Q5			−0.781	3.788

Note: (a) The number of observations is 4,944,632. (b) Age dummy, gender, household head, province dummy, and year dummy are included in each regression but omitted from the table. (c) Standard errors are adjusted for clustering at the individual level. (d) *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

of suicide than those treated with outpatient visits, and only the coefficient for interaction term is significantly positive. By contrast, patients with Parkinson's disease are significantly likely to commit suicide only when they received outpatient treatment. Mood disorder increases the probability of suicide irrespective of its severity. Having a mild mental condition increases the probability of suicide by 82 per 100,000. However, suffering a severe mental disorder exerts relatively weak effects: the estimated coefficient for the interaction term is almost half that of the estimated effect of a mild mental disease. For other diseases, no statistically significant differences between the effects of severe and mild are observed.

For disabilities, in general, the estimated parameters of the interaction terms are statistically insignificant, and mild disabilities exert strong effects on the probability of suicide. Physical, cerebral, and mental disabilities increase the probability of suicide only when it is rated second degree. An exception is kidney impairment, which increases the probability of suicide only if it is rated first degree and actually decreases when rated second degree.

B. Differences by the Timing of Onset

We also conducted regression analyses to determine if the effect of a new onset of disease or disability on suicide differs from that of a continuing condition. Such an investigation is relevant for the issue of mechanism by which poor health leads to a high risk of suicide. A possible pathway is psychological shock caused by being diagnosed of a serious disease or being disabled. Another probable channel is severe hardships (*e.g.*, physical pain, emotional distress, and economic difficulties) associated with suffering chronic conditions or disability. These two explanations are not mutually exclusive. The relative explanatory powers of the two hypotheses can also differ by the type of health condition. If psychological shock is a major mechanism of the observed effects of health on suicide, then a new onset of health problem is likely to exert strong effects on the probability of suicide.

The NHIS-NSC data contain information on the date of disability registration. We utilized the registered year as a new onset of disability. By contrast, the currently available data do not allow us to determine when a patient was first diagnosed with a certain disease. We could only observe whether or not the person received medical treatments

TABLE 7

MARGINAL EFFECT ON 100,000 SUICIDAL DEATHS: INTERACTED WITH NEW ONSET OF HEALTH STATUS

	(1)		(2)	
	$\partial y/\partial x$	S. E.	$\partial y/\partial x$	S. E.
Disease				
Cancer	13.865**	5.758	17.306***	5.762
Cancer * new	8.697	9.311	5.859	9.313
Parkinson's disease	44.100***	10.768	48.619***	10.830
Parkinson's disease * new	−12.639	20.123	−16.433	20.182
Stroke	−0.412	7.141	3.025	7.111
Stroke * new	6.190	11.029	2.725	11.016
Renal failure	23.144*	12.185	21.869*	12.144
Renal failure * new	−17.336	22.463	−17.281	22.456
Mood disorder	85.453***	4.424	88.615***	4.470
Mood disorder * new	−7.550	6.460	−9.012	6.472
Disability				
Physical	21.341***	3.505	15.081***	3.518
Physical * new	−49.484**	24.509	−46.804*	24.499
Cerebral	26.321***	6.984	18.673***	6.936
Cerebral * new	−8.738	20.014	−7.151	19.999
Sight	4.001	9.222	-2.114	9.216
Sight * new	29.154	25.688	30.791	25.706
Hearing	13.544*	7.276	9.908	7.238
Hearing * new	−7.363	25.315	−6.093	25.311
Other	15.774	12.929	7.159	12.910
Other * new	−13.227	43.947	−12.539	43.967
Income				
Medical aid			77.951***	9.372
Wage worker Q1			6.178	4.302
Wage worker Q2			0.275	4.114
Wage worker Q3				
Wage worker Q4			−4.949	3.511
Wage worker Q5			−8.238**	3.211
Self-employed worker Q1			70.800***	8.303
Self-employed worker Q2			53.923***	7.117
Self-employed worker Q3			28.553***	5.554
Self-employed worker Q4			12.745***	4.812
Self-employed worker Q5			−2.902	3.924

Note: (a) The number of observations is 4,450,816. (b) Age dummy, gender, household head, province dummy, and year dummy are included in each regression but omitted from the table. (c) Standard errors are adjusted for clustering at the individual level. (d) *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

for the illness in a given year. Accordingly, we had to determine if an observed case of disease is a new onset in an arbitrary manner. We regarded the disease observed in a given year as a new onset if the condition has not been present for the previous two years.[5]

Similar to the above regressions concerning differences by severity, we added to the baseline model an interaction term between each of the health conditions and dummy variable; this term indicates if the condition is a new onset ("new").[6] The coefficients for the original variables on health show the effects of continuing conditions on the probability of suicide, whereas the coefficients for the interaction terms show how the effect of a new onset differs from that of a continuing condition. Table 7 reports the results.

The results indicate that psychological shock, if any, is not a major pathway by which disease or disability increases the probability of suicide. All of the estimated parameters of the interaction terms for chronic diseases and disabilities are statistically insignificant at the 5 percent level.

V. Conclusion

Growing concerns about the considerably high suicide rates in Korea, especially among older people, have elicited increased scholarly attention to the socioeconomic determinants of suicide. The problem is that limited evidence has been provided with regard to the effects of individual income and health on suicide. We investigated how individual economic status (measured by income class and employment type) and health conditions (major chronic diseases and disabilities) affect the probability of the suicide of the middle-aged and elderly populations in Korea. Our analyses are based on the NHIS-NSC data that looked into a sample of one million individuals from 2002 to 2013.

Our results demonstrate that income is negatively related to the

[5] This method is subject to measurement errors. For instance, a person may not receive medical treatments for more than two years after a disease is first detected. In another example, a cancer can reoccur several years after it was announced cured.

[6] Cognitive disability, mental disorder, and kidney impairment were excluded from the regression because the results cannot be estimated due to the absence of suicidal deaths in the registered year for these disabilities.

probability of suicide. Since Hamermesh and Soss (1974) proposed the economic theory of suicide, which suggests that individuals decide to commit suicide when their discounted expected lifetime utility falls below a certain threshold, economists have hypothesized that income is an important factor for understanding suicidal behavior. Increased income is associated with the high standards of living, many resources to be spent to cope with desperate times, and possibly great satisfaction in life (Burr *et al.* 1994). The economic theory of suicide predicts that high income is likely to be related to high utility, thereby decreasing the probability of committing suicide (Chen *et al.* 2012). In addition, the indirect channel through which low income leads to a high risk of suicide can be explained from a sociological point of view. Financial stress can strain relationships among household members by increasing the probability of domestic violence, substance abuse, and divorce (Bowlus, and Seitz 2006). Considering the positive relationship of societal discord and suicide, low income can have at least an indirect effect on suicide risk.

Poor health emerges as a strong predictor of suicide risks. The health conditions that significantly increase the probability of suicide include three categories of chronic diseases (cancers, Parkinson's disease, and mood disorder) and four types of disabilities (physical, cerebral, mental, and kidney). Mental disability exerts a stronger effect on female suicide, whereas the other types of disability have more powerful effects on male suicide. The association between health condition and suicide is more strongly observed among older people than middle-aged individuals. Moreover, the effect of the severity of the health condition differs according to health problems, and the effect of a new onset is not as strong as that of a continuing condition of the same type.

We suggest possible mechanisms by which poor health leads to a high risk of suicide. First, chronic pain associated with specific forms of disease or disability can lead individuals with poor health to suicide (Goodwin *et al.* 2003; Ilgen *et al.* 2010; Khazem *et al.* 2015). Second, disability or diagnosis of a severe physical disease may constitute an acutely stressful life event (Hawton, and van Heeringen 2009; Erlangsen *et al.* 2015). Finally, poor health can relay stress onto caregivers (Emanuel *et al.* 2000; Duberstein *et al.* 2004; Lönnqvist 2016). Functional deterioration may force an increased dependence for help, and feelings of perceived burdensomeness and disconnectedness from society increase the risk of suicide (Kjølseth *et al.* 2009; Bryan *et*

al. 2012; Erlangsen *et al.* 2015).

Our results cannot be interpreted as causal effects of income and health on suicide. We were unable to fully take into account the potential heterogeneity across individuals. For instance, people with genetic or personal traits associated with a high risk of committing suicide can be less productive in the labor market or likely to suffer chronic diseases. In addition, our analyses are subject to potential bias arising from endogeneity. Utilizing exogenously driven variations in income or health would have been helpful but could not be attempted in this study. Despite these drawbacks, this study is significant as it establishes how the measures of economic status and health are related to the probability of suicide based on a large and representative sample of individuals. Our results help determine which population group is particularly vulnerable to the risk of suicide. Our study also suggests that reducing the prevalence of chronic diseases can have a positive externality of decreasing the suicide rate of middle- and old-aged people.

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