It is illegal to post this copyrighted PDF on any website. Sociodemographic Factors, Health Behaviors, and Biological Indicators Associated With Suicide Mortality Among Young Adults in South Korea: A Nationwide Cohort Study Among 15 Million Men and Women

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ABSTRACT

Objective: The role of sociodemographic factors, health behaviors, and biological indicators as potential risk factors for suicide is relatively understudied among young adults. The aim of this study is to explore the association of these variables with the risk of death by suicide among young adults.

Methods: The study population consisted of 15,534,438 individuals aged 20–39 years from the Korean National Health Insurance Service. Sociodemographic factors associated with death by suicide during 2006–2015 were evaluated. 3,396,353 individuals who underwent health examinations between 2002 and 2005 were separately assessed for health behaviors and biological indicators associated with death by suicide. Cox proportional hazards regression analysis was used to determine the hazard ratios (HRs) and 95% confidence intervals (CIs) for suicide mortality according to sociodemographic factors (age, household income, job status, residence, and Charlson comorbidity index score), health behaviors (physical activity, smoking, and alcohol consumption), and biological indicators (blood pressure, total cholesterol level, body mass index, and fasting serum glucose level).

Results: Low household income, self- and non-employment, increased comorbidity, smoking, and normal weight elevated the risk of death by suicide among young adults. While older age was associated with elevated risk for death by suicide among men (adjusted HR [aHR] = 2.11; 95% CI, 2.02–2.20 for men aged 35–39 years), older age reduced the risk for death by suicide among women (aHR = 0.72; 95% CI, 0.69–0.75 for women aged 35–39 years). Elevated blood pressure and fasting serum glucose level were associated with increased risk for death by suicide among men (aHR = 1.16; 95% CI, 1.05–1.28 and aHR = 1.48; 95% CI, 1.26–1.75, respectively). Finally, high total cholesterol levels were associated with increased risk for death by suicide among women (aHR = 1.59; 95% CI, 1.19–2.13)

Conclusions: Sociodemographic factors, health behaviors, and biological indicators were associated with suicide mortality among young adults.

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C uicide has been a critical issue in public health worldwide. Particularly, the rate of suicide in South Korea has been positioned as one of the most noteworthy among Organization for Economy Cooperation and Development (OECD) countries since 2002.¹ In South Korea, deaths from suicide have increased since 1985, with the rate for suicidal deaths being over 30 per 100,000 persons in 2010.² Particularly, suicide mortality has become more prevalent among young adults,³ with rapid increase in total suicide rates being more noticeable among those aged under 45 years.⁴ There are two dimensions of suicide risk factors, personal and social. Both psychiatric and physical disorders, family history of suicide, and psychosocial isolation are possible personal risk factors. Socioeconomic or familial factors such as divorce and unemployment are possible social risk factors.⁵ Most psychiatric disorders such as depression, personality disorders, anxiety disorders, bipolar disorder, alcohol use disorders, other substance use disorders, and schizophrenia are strong risk factors for suicide; of these, depression is definitely the strongest risk factor.⁶ Additionally, physical disorders including chronic diseases, malignancy, and somatic disorders have been reported as risk factors for suicide.⁶

According to a British study⁷ which reported that the suicide rates for men less than 45 years old nearly doubled between 1950 and 1998, risk factors for suicide seem to vary by age. Socioeconomic factors, such as divorce, unemployment, alcohol and substance abuse, decrease in marriage, and income discrepancy, might drive this unfavorable trend in young men.⁷ While the result might be reflected by socioeconomic backgrounds of Western countries so that it could be hard to apply to Asian populations, it seemed to differ from the results of most previous studies focused on increasing suicide rates in elders. Therefore, it is necessary to evaluate risk factors for suicide among young adults, which contributes to the total mortality rate in Korea.



It is illegal to post this copyrighted PDF on any website. population of 15,534,438 young adults. Among them,

Clinical Points

- In light of the increasing societal burden of suicide, the role of sociodemographic factors, health behaviors, and biological indicators as potential risk factors for suicide is relatively understudied among young adults.
- Regular health examinations with information on sociodemographic factors, health behaviors, and biological indicators could help support vulnerable young adults who are at risk for suicide.

Although numerous studies have focused solely on psychiatric risk factors for suicide, the role of sociodemographic factors, health behaviors, and biological indicators as potential risk factors for suicide is relatively understudied. Accordingly, schemes for anticipating suicide risk have targeted mostly psychiatric risk factors instead of health behaviors and biological factors. Recently, a prospective cohort study conducted by Jee et al⁸ showed that some behavioral and cardiovascular risk factors, including smoking, alcohol intake, blood cholesterol, and body mass index (BMI), were related to suicide mortality.⁸ However, the population in Jee and colleagues' study consisted mostly of middle-aged and elderly participants (mean age = 45.0 and 49.4 years for men and women, respectively) and did not include individuals aged 20-29 years. Since young adults aged 20-39 years are at particularly high risk for suicide, identifying nonpsychiatric factors associated with suicide risk may be helpful in designing screening or prevention programs for suicide among young people. This study thus purposed to determine the sociodemographic factors, health behaviors, and biological indicators associated with death by suicide among young people using the database from the Korean National Health Insurance Service (NHIS).

METHODS

Study Population

The NHIS provides compulsory health care for the entire population, resulting in a 97% enrollment rate in South Korea. The NHIS collects data from all hospitals including medication prescriptions, national health screenings, and inpatient and outpatient visits. Among adults aged 20-39 years, the NHIS provides health examinations for employee-insured and self-employed individuals.⁹ The health examination includes a questionnaire self-reported on previous medical records and health behaviors, height, weight, and blood pressure measurements, and blood tests. The NHIS database can be used for research purposes and includes information on the aforementioned data as well as death dates and cause of death data merged from the Statistics Korea database. The NHIS database was used previously by multiple epidemiologic studies, and its validity is described elsewhere.9

From among 15,541,342 participants aged 20-39 years in 2005, 6,904 individuals who died before the index date of January 1, 2006, were excluded, resulting in a study 3,396,353 individuals who underwent health examinations between 2002 and 2005 were separately assessed for factors related to health behavior and cardiovascular risk. All participants were then followed-up from January 1, 2006, to December 31, 2015, or the date of death, whichever came earlier. This study was approved by the Seoul National University Hospital Institutional Review Board (IRB number: 1703-039-836), and the qualification for informed consent was waived as the NHIS database is anonymized according to strict confidentiality guidelines.

Key Variables

Death due to suicide was determined by the cause of death pertaining to the International Classification of Diseases, Tenth Revision (ICD-10), codes for intentional self-harm (X60-X84). Cause of death is determined by the attending physician upon death using the ICD-10 codes. The assessed factors included age (20-24, 25-29, 30-34, and 35-39 years), household income (first, second, third, and fourth quartiles), job status (employed, self-employed, and not employed), residence (capital, metropolitan area, and city/town), and Charlson comorbidity index score (0, 1, and ≥ 2) for the entire study population. Furthermore, among those with health examination data, smoking (never, past, and current smoker), physical activity (0, 1–2, and \geq 3 times per week), alcohol consumption (0, 1, and ≥ 2 times per week), BMI (< 23.0, 23.0–24.9, and \geq 25.0 kg/m²), blood pressure (<120/80, 120/80–139/89, and \geq 140/90 mm Hg), fasting serum glucose level (<100.0, 100.0-125.9, and \geq 126.0 mg/dL), and total cholesterol level (< 200.0, 200.0-239.9, and \geq 240.0 mg/dL) were also assessed. BMI was determined by dividing the weight in kilograms by the height in meters squared. Household income was determined by the insurance premium. Charlson comorbidity index score was determined by assessing major comorbidities during 2002–2005 using an algorithm for calculating the Charlson comorbidity index score from claims data from a previous study.10

Statistical Analysis

To calculate 95% confidence intervals (CIs) and the adjusted hazard ratios (aHRs) for the risk of death by suicide according to sociodemographic factors, health behaviors, and biological indicators, Cox proportional hazards regression analysis was used. For the entire study population, the fully adjusted model included household income and adjustments for age, job status, residence, and Charlson comorbidity index score. Upon evaluation of the risk for death by suicide among young adults with health examination data, the fully adjusted model included additional adjustments for smoking, alcohol consumption, physical activity, blood pressure, BMI, total cholesterol level, and fasting serum glucose level. We defined statistical significance as a P value of <.05 in a 2-sided manner. All analyses were conducted with SAS 9.4 (SAS Institute Inc; Cary, North Carolina), including data collection and statistical analysis.

The total number of deaths from suicide was 37,812: 23,624 for men and 14,188 for women. Table 1 shows the detailed population characteristics of the study. The study population consisted of 7,954,632 and 7,579,806 men and women, respectively. There was a higher proportion of those who were employed among men (38.0%) compared to that among women (23.6%). The majority of men and women had Charlson comorbidity index scores of 0 (83.9% for men and 77.0% for women). Among participants who underwent health examinations, there were 2,204,965 men and 1,191,388 women. While most men (53.2%) were current smokers, the majority of women (94.1%) were never smokers. The majority of men (54.9%) had blood pressure within 120/80 and 139/89 mm Hg, while most women (62.3%) had blood pressure < 120/80 mm Hg.

The results of the risk for death by suicide according to sociodemographic factors are shown in Table 2. Among 3 groups-total, those who did not undergo health examination, and those who underwent health examination-the association between suicide risk and each sociodemographic factor seemed to be consistent, but the risk for death by suicide according to age was varied. Among men who did not undergo health examination, increasing age was related to elevated risk for death by suicide (aHR = 2.29; 95% CI, 2.19-2.39 for men aged 35-39 years), whereas it was associated with reduced risk for death by suicide (aHR=0.85; 95% CI, 0.75-0.97 for men aged 35-39 years) among those who underwent health examination. Among women overall, increasing age was associated with reduced risk for death by suicide (aHR = 0.72; 95% CI, 0.69-0.75 for women aged 35-39 years), and its association was preserved regardless of whether or not women underwent health examination. Compared to those within the lowest quartile of household income, young adults within the highest quartile of household income had reduced risk for death by suicide among both women (aHR = 0.61; 95% CI, 0.58-0.64) and men (aHR = 0.52; 95% CI, 0.50-0.54). Compared to employed men, those who were self-employed (aHR = 1.56;95% CI, 1.50-1.62) and not employed (aHR = 2.33; 95% CI, 2.25-2.41) had increased risk for death by suicide. Similarly, women who were self-employed (aHR = 3.52); 95% CI, 3.30-3.76) and not employed (aHR = 2.02; 95% CI, 1.92-2.13) had elevated risk for death by suicide compared to employed women. Finally, a Charlson comorbidity index score of ≥ 2 was related to increased risk for death by suicide for both women (aHR = 1.53; 95% CI, 1.44-1.63) and men (aHR=1.27; 95% CI, 1.19-1.34).

Table 3 depicts the risk of death by suicide according to health behaviors and biological indicators among young adults. Compared to never smokers, current smokers were associated with elevated risk for death by suicide among both men (aHR=1.79; 95% CI, 1.65–1.94) and women (aHR=2.66; 95% CI, 2.16–3.29). Obesity (BMI \geq 25.0 kg/m²) was associated with reduced risk of death by suicide for both men (aHR=0.68; 95% CI, 0.63–0.74) and women

Table 1. Descriptive Characteris	tics of the Stud	y Population ^a
Characteristic	Men	Women
	(n=7,954,032)	(n=7,579,800)
Age, y		1 (00 705 (22 4)
20-24	1,780,001 (22.5)	1,098,785 (22.4)
25-29	1,009,129 (23.3)	1,779,454 (25.5)
30-34	2,113,730 (20.0)	2,017,229 (20.0)
Household income quartile	2,103,772 (27.3)	2,004,000 (27.0)
1st (lowest)	2 031 145 (25 5)	1 904 919 (25 1)
2nd	1.989.051 (25.0)	1,776,989 (23,4)
3rd	2,018,414 (25.4)	1,964,123 (25.9)
4th (highest)	1,916,022 (24.1)	1,933,775 (25.5)
Job status		,,
Employed	3,023,331 (38.0)	1,785,758 (23.6)
Self-employed	1,545,709 (19.4)	623,272 (8.2)
Not employed	3,385,511 (42.6)	5,170,776 (68.2)
Residence		
Capital	1,818,001 (22.9)	1,753,335 (23.1)
Metropolitan area	2,076,372 (26.1)	2,018,228 (26.6)
City/town	4,060,259 (51.0)	3,808,243 (50.2)
Charlson comorbidity index score		
0	6,674,279 (83.9)	5,836,509 (77.0)
1	968,545 (12.2)	1,316,651 (17.4)
≥2	311,808 (3.9)	426,646 (5.6)
No. of people who underwent health examinations	2,204,965	1,191,388
Smoking		
Never smoker	759,025 (34.4)	1,121,398 (94.1)
Past smoker	272,575 (12.4)	29,031 (2.4)
Current smoker	1,173,365 (53.2)	40,959 (3.4)
Physical activity, times per week		
None	1,033,408 (46.9)	821,880 (69.0)
1-2	817,161 (37.1)	249,342 (20.9)
3 or more	354,396 (16.1)	120,166 (10.1)
Alconol consumption, times per week	E06 1E1 (27 0)	(FE 221 (FE 0)
1	590,151 (27.0) 640 101 (20.0)	240 014 (20 2)
	040,101 (29.0)	549,014 (29.5) 197 042 (15 7)
Body mass index kg/m ²	900,713 (43.9)	107,045 (15.7)
< 23 0	894 960 (40 6)	940 271 (78 9)
23.0-24.9	553 068 (25 1)	138 848 (11 7)
> 25.0	756 937 (34 3)	112 268 (9.4)
Blood pressure, mm Ha	, 50,557 (51.5)	112,200 (5.1)
<120/80	629,494 (28,5)	742.725 (62.3)
120/80-139/89	1,209,613 (54,9)	403.487 (33.9)
≥140/90	365,858 (16.6)	45,176 (3.8)
Fasting serum glucose level, mg/dL	,	-, -, -, -, -, -, -, -, -, -, -, -, -, -
<100.0	1,751,021 (79.4)	1,061,519 (89.1)
100.0–125.9	399,295 (18.1)	120,665 (10.1)
≥126.0	54,649 (2.5)	9,204 (0.8)
Total cholesterol level, mg/dL		. ,
< 200.0	1,456,351 (66.0)	963,639 (80.9)
200.0–239.9	578,940 (26.3)	190,833 (16.0)
≥240.0	169,674 (7.7)	36,916 (3.1)
^a Values are shown as n (%) unless other	wise noted.	

(aHR=0.64; 95% CI, 0.50–0.81) compared to non-obesity. Men with blood pressure \geq 140/90 mm Hg had increased risk for death by suicide (aHR=1.16; 95% CI, 1.05–1.28) compared to those with blood pressure < 120/80 mm Hg. Compared to men with fasting serum glucose levels of < 100.0 mg/dL, those with fasting serum glucose levels of 100.0–125.9 (aHR=1.12; 95% CI, 1.03–1.21) and \geq 126.0 mg/dL (aHR=1.48; 95% CI, 1.26–1.75) had increased risk for death by suicide. Finally, women with total cholesterol levels of \geq 240.0 mg/dL (aHR=1.59; 95% CI, 1.19–2.13) had increased risk for death by suicide compared to women with cholesterol levels of < 200.0 mg/dL. We calculated C statistics

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It is illogal to post this copyrighted PDE on any we Table 2. Adjusted Hazard Ratios (95% Cls) for the Effect of Sociodemographic Factors on Death by Suicide^a

		Men			Women	
		Did Not Undergo Health	Underwent Health		Did Not Undergo Health	Underwent Health
Variable	Total	Examination	Examination	Total	Examination	Examination
Age, y						
20–24	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
25–29	1.40 (1.34–1.46)	1.44 (1.38–1.50)	0.65 (0.67-0.75)	0.98 (0.94-1.03)	1.02 (0.97-1.07)	0.71 (0.60-0.83)
30–34	1.79 (1.72–1.87)	1.94 (1.86–2.03)	0.70 (0.61-0.80)	0.79 (0.75-0.83)	0.80 (0.76-0.83)	0.76 (0.63-0.91)
35–39	2.11 (2.02-2.20)	2.29 (2.19–2.39)	0.85 (0.75-0.97)	0.72 (0.69-0.75)	0.71 (0.68-0.75)	0.92 (0.77-1.10)
Household income, quartile						
1st (lowest)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
2nd	0.77 (0.75-0.80)	0.77 (0.74-0.80)	0.84 (0.77-0.92)	0.74 (0.70-0.77)	0.73 (0.69-0.76)	0.96 (0.81-1.13)
3rd	0.63 (0.61-0.65)	0.66 (0.63-0.68)	0.63 (0.57-0.69)	0.65 (0.62-0.68)	0.64 (0.61-0.67)	0.78 (0.66-0.93)
4th (highest)	0.52 (0.50-0.54)	0.54 (0.52-0.57)	0.48 (0.44-0.54)	0.61 (0.58-0.64)	0.61 (0.58-0.64)	0.69 (0.58-0.82)
Job status						
Employed	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Self-employed	1.56 (1.50-1.62)	1.34 (1.27–1.40)	0.99 (0.85-1.15)	3.52 (3.30-3.76)	2.95 (2.72-3.20)	2.29 (1.76-2.99)
Not employed	2.33 (2.25-2.41)	2.00 (1.91-2.10)	2.13 (1.80-2.52)	2.02 (1.92-2.13)	1.67 (1.55–1.79)	1.94 (1.51-2.50)
Residence						
Capital	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Metropolitan area	1.12 (1.07-1.16)	1.13 (1.09–1.18)	1.05 (0.96-1.16)	1.08 (1.03-1.13)	1.08 (1.03-1.13)	1.12 (0.95-1.33)
City/town	1.19 (1.15–1.23)	1.21 (1.16–1.25)	1.14 (1.05–1.24)	1.04 (0.99-1.08)	1.04 (0.99-1.08)	1.03 (0.89-1.21)
Charlson comorbidity index score						
0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
1	1.05 (1.01-1.10)	1.08 (1.03-1.12)	1.01 (0.92-1.10)	1.12 (1.07–1.17)	1.12 (1.07–1.17)	1.14 (0.98-1.32)
≥2	1.27 (1.19–1.34)	1.32 (1.23–1.40)	1.10 (0.96–1.27)	1.53 (1.44–1.63)	1.54 (1.44–1.64)	1.43 (1.13–1.80)
3 4 15 7 11 1 75 1 1 7 1			C. 11 .			

^aAdjusted hazard ratios calculated by Cox proportional hazards regression after adjustments for age, household income, job status, residence, and Charlson comorbidity index score.

Table 3. Adjusted Hazard Ratios (95% CIs) for the Effect of Health Behaviors and Cardiovascular Risk Factors on Death by Suicide Among Those Who Underwent Health Examinations^a

		Men			Women	
Variable	Unadjusted	Age-Adjusted	Fully Adjusted ^b	Unadjusted	Age Adjusted	Fully Adjusted ^b
Smoking						
Never smoker	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Past smoker	0.99 (0.88-1.12)	1.02 (0.90-1.15)	1.07 (0.94–1.13)	2.48 (1.90-3.23)	2.54 (1.95-3.31)	2.22 (1.69-2.90)
Current smoker	1.84 (1.71–1.98)	1.83 (1.70–1.97)	1.79 (1.65–1.94)	3.42 (2.81-4.16)	3.35 (2.75-4.09)	2.66 (2.16-3.29)
Physical activity, times per week						
None	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
1–2	0.99 (0.93-1.07)	1.01 (0.94–1.08)	1.01 (0.94-1.08)	1.01 (0.87–1.17)	0.99 (0.85-1.15)	0.98 (0.85-1.14)
3 or more	1.00 (0.92-1.10)	1.01 (0.92–1.11)	1.06 (0.97-1.16)	1.03 (0.85-1.26)	0.97 (0.80-1.19)	0.97 (0.79-1.19)
Alcohol consumption, times per week						
None	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
1	0.91 (0.84-1.00)	0.93 (0.85-1.02)	0.85 (0.77-0.93)	1.11 (0.96–1.28)	1.11 (0.96–1.28)	1.07 (0.93-1.24)
2 or more	1.19 (1.10–1.28)	1.19 (1.11–1.29)	1.00 (0.92-1.08)	1.78 (1.54–2.07)	1.80 (1.55–2.10)	1.47 (1.25-1.72)
Body mass index, kg/m ²						
<23.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
23.0–24.9	0.78 (0.72-0.84)	0.76 (0.70-0.83)	0.78 (0.72-0.85)	0.84 (0.69-1.02)	0.78 (0.64-0.96)	0.75 (0.61-0.92)
≥ 25.0	0.68 (0.64-0.74)	0.70 (0.65–0.75)	0.68 (0.63-0.74)	0.76 (0.60-0.95)	0.72 (0.57-0.91)	0.64 (0.50-0.81)
Blood pressure, mm Hg						
< 120/80	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
120/80–139/89	1.01 (0.95–1.09)	1.00 (0.93-1.08)	1.03 (0.96-1.11)	0.92 (0.81-1.05)	0.94 (0.83-1.07)	0.95 (0.84-1.08)
≥ 140/90	1.17 (1.07–1.29)	1.11 (1.01–1.22)	1.16 (1.05-1.28)	0.90 (0.64-1.25)	0.89 (0.64-1.24)	0.89 (0.64-1.25)
Fasting serum glucose level, mg/dL						
< 100.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
100.0–125.9	1.16 (1.07–1.25)	1.13 (1.04–1.22)	1.12 (1.03-1.21)	1.23 (1.02–1.47)	1.20 (0.99–1.44)	1.18 (0.98-1.42)
≥126.0	1.62 (1.38–1.90)	1.59 (1.35–1.87)	1.48 (1.26–1.75)	1.49 (0.84–2.63)	1.33 (0.73–2.41)	1.28 (0.70-2.32)
Total cholesterol level, mg/dL						
< 200.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
200.0–239.9	0.89 (0.83-0.96)	0.88 (0.81–0.95)	0.93 (0.86–0.99)	0.97 (0.82–1.14)	1.00 (0.85–1.18)	1.03 (0.87–1.22)
≥240.0	1.02 (0.91–1.15)	1.04 (0.93–1.17)	1.10 (0.98–1.24)	1.41 (1.05–1.89)	1.48 (1.10–1.98)	1.59 (1.19–2.13)

^aHazard ratio calculated by Cox proportional hazards regression.

^bFully adjusted model includes adjustments for age, household income, job status, residence, Charlson comorbidity index score, smoking, physical activity, alcohol consumption, body mass index, blood pressure, fasting serum glucose level, and total cholesterol level.

It is illegal to post this copy to see how well all the combined risk factors discriminate the high suicide risk group (0.629 for men, 0.631 for women) from those with lower risk.

Supplementary Tables 1 and 2 depict the multivariate and univariate Cox proportional hazards regression models for suicide among those who underwent health examinations. In the univariate Cox proportional model, individuals who were unemployed, current smokers, and moderate to heavy alcohol drinkers had elevated risk for death by suicide. In the multivariate Cox proportional model, those who were unemployed and past/current smokers had elevated risk for suicide mortality. Overweight to obese individuals tended to have lower risk of death by suicide compared to normal-weight individuals. Among men, participants with higher serum glucose levels and higher blood pressure had increased risk for death by suicide, and among women, those with higher total cholesterol levels had increased risk for death by suicide. To determine whether the risk factors for suicide investigated in our study had the similar magnitude of association with death from unknown causes (5,287 men, 1,406 women), we analyzed the association with death from unknown causes according to sociodemographic factors, health behaviors, and cardiovascular risk factors, and the results were similar to those for the association with suicide (Supplementary Tables 3 and 4). The baseline characteristics-distribution of age, sex, household income, job status, residence, and comorbidity-were different between those who underwent health screening and those who did not undergo health screening among young adults aged 20 to 39 years (Supplementary Table 5). In addition, the risk of suicide among people who underwent health screening was lower than among those who did not undergo health screening (Supplementary Table 6).

DISCUSSION

We have shown that sociodemographic factors, health behaviors, and biological indicators were associated with risk of death by suicide in this nationwide cohort study consisting of more than 15 million young adults aged 20–39 years. We confirmed the expected associations of smoking, comorbidities, low household income, self- or non-employment, and normal weight with elevated suicide mortality risk. As noted, we calculated C statistics to see how well all the combined risk factors discriminate the high suicide risk group (0.629 for men, 0.631 for women) from those with lower risk. Thus, our findings that sociodemographic and health behavior/status risk factors for suicide should be interpreted with caution.

Sociodemographic Factors

Age. Previous studies^{3,11} have shown that increasing age was associated with elevated suicide rates in South Korea. In our study, however, this association varied by sex and whether one underwent health screening or not. According to the results of our study, age was positively related with

chted PDF on any website. Suicide risk in men, but negatively related with suicide risk in women. Although the reason for this discrepancy is not clear, conventional masculinity is a major psychosocial stress for male vulnerability, promoting maladaptive coping strategies such as emotional unexpressiveness and reluctance to seek help.¹² Among women, but not among men, parents with children were less likely to commit suicide compared to those without children.¹³ Interestingly, men who underwent health screening tended to have decreased suicide risk with aging, but those who did not undergo health screening did not (Table 2). We assumed that this result was due to unmeasured social factors, eg, education level, job security, willingness of subsequent health care utilization. Therefore, future studies that take into consideration marriage-related factors such as presence of children and marital status and social factors such as job security, education level, and continuity of health care are needed to examine this association in more detail.

Employment and household income. Many studies have suggested that unemployed men have higher suicide rates than do employed men, while female suicide rates have shown inconsistent findings according to employment status.¹⁴⁻¹⁶ A study¹⁷ showed that poor environment of employment protection was related to increased suicide rates as well as unemployment among all of the studied populations. In a retrospective cohort study,¹⁸ the risk of suicide increased as socioeconomic position according to insurance premium levels decreased. In our study, selfemployed women, interestingly, showed higher risk of suicide mortality compared to employed women. We assumed that there was an issue of job insecurity in this finding. The association between self-employment and suicide could depend on characteristics of "self-employment." The meaning of self-employment is somewhat ambiguous because it includes both dependent and independent status. One study¹⁹ showed that employees with insecure work were more likely to have suicide attempts (OR = 1.52; 95% CI, 1.02-2.27) and suicidal ideation (OR=1.41; 95% CI, 1.28-1.55) compared to employees with secure work. According to another study,¹⁷ which investigated the relationship between employment stability and suicide among young adults in 20 OECD countries from 1994 to 2010, poor employment protection rather than unemployment itself was associated with increased suicide risk. The association between self-employment and suicide could also be inconsistent depending on sex. Korean cultural expectations about a feminine role in unpaid work in the household and paid employment might deserve to lesser expectations in the field of labor.²⁰ Further studies are required to determine the association between dynamic aspects of employment and age- and sex-specific suicide mortality.

Health Behavior Factors

Cigarette smoking and alcohol intake. Smoking has previously been found to be possibly related with an increased risk of completed suicide.²¹ In addition, the effect of cigarette smoking on completed suicide appeared to be dose-dependent.²¹ There are a couple of plausible theories:

It is illegal to post this copy smoking reduces the levels of brain serotonin, which could be protective against risk of suicide,²² and nicotine may dysregulate the hypothalamic-pituitary-adrenal axis, which might be related to increased suicide risk.^{23,24}

One study²⁵ found that alcohol use disorder significantly increased the risk of suicidal ideation and suicide attempt as well as completed suicide. A prompt dose-dependent effect of alcohol on the central nervous system may explain the recognized dose-response relationship between alcohol consumption and suicidal behavior. As compared to lower doses, higher alcohol doses seem to produce more powerful effects on cognitive states and mood that have a causal relationship in suicidal behavior.²⁶⁻²⁸

Biological Indicators

BMI. A recent review²⁹ found a significant inverse association between completed suicide and obesity, which is in line with our study results; obesity (BMI $\ge 25.0 \text{ kg/m}^2$) was associated with reduced risk of death by suicide for both men (aHR 0.68; 95% CI, 0.63-0.74) and women (aHR 0.64; 95% CI, 0.50-0.81) compared to non-obese individuals. In a previous large prospective cohort study,⁸ being underweight was associated with higher risk of suicide in both men and women. Although the mechanisms for this association are not clear, previous studies³⁰⁻³⁵ suggest that some biological factors relative to increasing BMI could contribute to lower risk of suicide: serotonin and tryptophan levels in brain, fatty acid, impaired insulin sensitivity, carbohydrate intake, and cholesterol metabolism. However, there is inconsistent evidence about the relationship between suicide mortality and BMI. Per a review from the United States,³⁶ obese individuals were found to be at an increased risk of suicide, although the review did not consider different age groups or different suicide categories such as completed suicide, attempted suicides, or suicidal thoughts. A couple of previous studies^{37,38} showed that higher BMI was associated with higher suicide among women but not men. The causal nature of association between BMI and suicide is therefore still unclear, and further study of the relationship may yield more evidence about the mechanism.

Blood pressure. To our knowledge, only a few studies have explored the relationship between blood pressure and suicide risk, and findings between them are inconsistent. Previous studies from Asia⁸ and Europe³⁹ have shown that there was no association between blood pressure and suicide risk. Otherwise, low systolic blood pressure was associated with increased suicide risk according to Finnish Helsinki Heart Study.³⁰ In contrast, two previous studies^{40,41} showed that high blood pressure led to increased risk for suicide, which is in line with the results among men from our study. Although the biological mechanism for the relationship between blood pressure and its effects on suicide is not well established, high blood pressure may induce cerebrovascular damage and consequent functional or cognitive decline, which would then increase the risk of death by suicide.⁴¹ In Taiwan, there was a reverse J-shaped relationship with increased suicide risk among those with extremely high systolic blood pressure.⁴²

ghted PDF on any website. Total cholesterol. Findings about the relationship between total cholesterol and suicide mortality are inconsistent. A couple of studies from other countries^{43,44} showed positive association of high total cholesterol level with increased suicide attempts and risk of suicide, which is in line with the results among women from our study. A plausible mechanism is that high serum cholesterol is associated with low levels of polyunsaturated fatty acids, and this reduction of omega-3-polyunsaturated fatty acids could result in increasing suicide risk.⁴³ Also, a study⁴⁵ whose findings were about depression, not completed suicide, showed that decreased intake of polyunsaturated fatty acids might contribute to increasing rates of depression. However, there is increasing evidence of an association of low cholesterol with suicide death. A previous meta-analysis⁴⁶ found the association between low cholesterol levels and increased suicide risk. Similarly, some studies in Korea^{8,47,48} showed that those who attempted suicide had lower cholesterol levels. On the other hand, other studies^{49,50} showed that there was no evidence for association between serum cholesterol and suicide. Therefore, more studies are required to clarify the relationship between serum cholesterol concentration and suicide risk.

Fasting serum glucose level. Diabetes was associated with increased risk of suicide according to a previous meta-analysis.⁵¹ There is evidence from an observational study⁵² suggesting that people with diabetes experience an increased risk of suicide. High levels of glycated hemoglobin or hemoglobin A1c were associated with depression and suicidal behaviors.⁵³ Hemoglobin A1c levels were positively correlated with cardiovascular disease and increased cardiovascular risk among healthy, non-diabetic Korean adults, and these levels resulted in increased suicide mortality as well.⁵³ In our study, higher serum glucose level was significantly related to increased suicide risk in men, but not in women. The discrepancy in our results according to sex might be due to the smaller sample size of women with impaired fasting glucose or diabetes compared to men.

As noted, the baseline characteristics distribution of age, sex, household income, job status, residence, and comorbidity were different between those who underwent health screening and those who did not undergo health screening among young adults aged 20 to 39 years, and the risk of suicide among people who underwent health screening was lower than among those who did not undergo health screening. We assumed that this difference might be due to the net effect of health screening and unmeasured baseline factors. Health screening can effectively reduce mortality and morbidity in certain diseases. A major mechanism of the effect of health screening in young adults may be the increased awareness of risk factors such screening affords. Screening could itself contribute to the promotion of health, motivating individuals to receive medical attention and change behavior.⁵⁴ As noted previously in the literature,⁵⁵ health screening in Korea increased adherence to diabetes medication and weight control for participants. It is unclear whether health screening could further lead to to lower

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It is illegal to post this copy risk of suicide, so more studies are needed to reinforce our findings. Unmeasured baseline factors such as psychological status and education levels might drive the discrepancy in the current study. As discussed previously, our database does not include information about psychological status for participants. We did not have information on the education level for participants either, an important social determinant since health literacy could be associated with the willingness to improve lifestyle.⁵⁶

Our study was based on a study population of young adults aged 20-39 years, a group that has not been extensively investigated previously. Furthermore, we evaluated sociodemographic factors, health behaviors, and biological indicators rather than psychiatric risk factors. However, the study has several limitations. First, due to lack of data, we were not able to apply some well-known suicide risk factors (eg, psychiatric disorders, previous experience of suicidal attempts or familial history of suicide, socioeconomic factors, marital status, presence of children). Further studies investigating various dimensions of suicide risk factors with reliable data are required. Second, since the unknown causes of 6,693 deaths (5,287 for men and 1,406 for women) could include death by suicide, suicide events might be underestimated. Further studies investigating various dimensions of suicide risk factors with reliable data are required. Third, due to the multiple tests in our model, a possible inflation of type I error rate may have occurred. Fourth, the validity of suicide mortality in death records in Korea was not able to be determined. Upon death, the attending physician is required to name the cause of death according to ICD-10 codes. Nonetheless, future studies that determine the validity of suicide mortality are needed.

In conclusion, we found that smoking, comorbidity, low household income, self- or non-employment, and normal

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weight were associated with elevated risk for death by suicide among men and women aged 20-39 years. Our study provides evidence of risk factors associated with suicide mortality based on real-world data from a nationwide cohort of young adults. Since suicide is the most common cause of death among young adults and the proportion of suicide among young adults is increasing, suicide prevention programs that identify young adults at risk for suicide based on the results from our study could be of public health value. There are several strategies to prevent suicide mortality based on previous reports. First, increasing access to appropriate health care in the community is necessary to prevent suicide mortality. Through regular health checkups with information on sociodemographic factors, health behaviors, and biological indicators, we could support those at risk for suicide. For example, the Japanese public health insurance system covers almost all citizens and provides annual opportunities for regular health checkups to the entire population. This system could be used as an exemplary community-based suicide prevention program.⁵⁷ Second, sensitivity and specificity of current suicide risk screens should be improved to cover various risk factors for suicide in health care systems.⁵⁸ Third, education intervention for general practitioners to identify people at risk for suicide may be a first step for suicide prevention. According to a systematic review,⁵⁹ suicide prevention programs based on health care services aimed at general practitioners could result in early diagnosis and improved clinical interventions for vulnerable young adults, which ultimately could reduce suicide risk in the future. In light of the increasing social burden of suicide, future studies are needed to investigate the underlying mechanisms in the association of sociodemographic factors, health behaviors, and biological indicators with death by suicide.

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Supplementary Material

- Article Title: Sociodemographic Factors, Health Behaviors, and Biological Indicators Associated With Suicide Mortality Among Young Adults in South Korea: A Nationwide Cohort Study Among 15 Million men and Women
- Author(s): Yoosun Cho, MD; Seulggie Choi, MD; Kyuwoong Kim, BSc; and Sang Min Park, MD, PhD, MPH
- DOI Number: https://doi.org/10.4088/JCP.19m13037

List of Supplementary Material for the article

- 1. <u>Table 1</u> Hazard ratios calculated by univariate Cox proportional hazards regression for suicide according to sociodemographics, health behaviors, and health status among those who underwent health examinations
- 2. <u>Table 2</u> Hazard ratios calculated by multivariate Cox proportional hazards regression for suicide according to sociodemographics, health behaviors, and health status among those who underwent health examinations
- 3. <u>Table 3</u> Hazard ratios for the effect of sociodemographic factors on death from unknown causes
- 4. <u>Table 4</u> Hazard ratios for the effect of health behaviors and cardiovascular risk factors on death from unknown causes among those who underwent health examinations
- 5. <u>Table 5</u> Descriptive characteristics of the study population according to health screening examinations
- 6. <u>Table 6</u> Hazard ratios for suicide according to health screening examinations

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1 Supplementary Table 1. Hazard ratios calculated by univariate Cox proportional hazards regression for suicide according to sociodemographics, health behaviors, and

health status among those who underwent health examinations.

	Hazard ratio (95% confidence interval)		
	Men	Women	
Age, years			
20-24	1.00 (reference)	1.00 (reference)	
25-29	0.60 (0.52-0.68)	0.70 (0.59-0.82)	
30-34	0.60 (0.52-0.68)	0.75 (0.63-0.89)	
35-39	0.69 (0.61-0.78)	0.96 (0.81-1.14)	
Household income		, , , , , , , , , , , , , , , , , , ,	
1 st quartile (lowest)	1.00 (reference)	1.00 (reference)	
2 nd quartile	0.81 (0.75-0.89)	0.88 (0.74-1.03)	
3 rd quartile	0.63 (0.57-0.69)	0.72 (0.61-0.85)	
4 th quartile (highest)	0.48 (0.43-0.53)	0.61 (0.52-0.72)	
Job status		, , , , , , , , , , , , , , , , , , ,	
Employed	1.00 (reference)	1.00 (reference)	
Self-employed	1.12 (0.96-1.30)	2.73 (2.12-3.53)	
Not employed	2.33 (1.97-2.75)	2.04 (1.59-2.62)	
Residence			
Capitol	1.00 (reference)	1.00 (reference)	
Metropolitan area	1.13 (1.02-1.24)	1.17 (0.98-1.38)	
City/town	1.22 (1.12-1.33)	1.09 (0.93-1.27)	
Charlson comorbidity index			
0	1.00 (reference)	1.00 (reference)	
1	0.99 (0.91-1.08)	1.15 (0.99-1.34)	
≥2	1.09 (0.95-1.26)	1.47 (1.16-1.85)	
Smoking			
Never smoker	1.00 (reference)	1.00 (reference)	
Past smoker	1.02 (0.90-1.15)	2.52 (1.93-3.28)	
Current smoker	1.82 (1.69-1.96)	3.36 (2.76-4.09)	
Physical activity, times per week			
None	1.00 (reference)	1.00 (reference)	
1-2	1.01 (0.93-1.08)	0.99 (0.85-1.14)	
3 or more	1.02 (0.93-1.12)	0.98 (0.80-1.20)	

Alcohol consumption, times per week		
None	1.00 (reference)	1.00 (reference)
1	0.92 (0.85-1.01)	1.10 (0.95-1.26)
2 or more	1.19 (1.10-1.28)	1.79 (1.54-2.07)
Body mass index, kg/m ²		
<23.0	1.00 (reference)	1.00 (reference)
23.0-24.9	0.76 (0.70-0.82)	0.81 (0.66-0.99)
≥25.0	0.69 (0.64-0.75)	0.74 (0.59-0.94)
Blood pressure, mmHg		
<120/80	1.00 (reference)	1.00 (reference)
120/80-139/89	0.99 (0.93-1.07)	0.95 (0.83-1.08)
≥140/90	1.10 (1.00-1.21)	0.91 (0.66-1.27)
Fasting serum glucose, mg/dL		
<100.0	1.00 (reference)	1.00 (reference)
100.0-125.9	1.12 (1.04-1.22)	1.21 (1.01-1.46)
≥126.0	1.60 (1.36-1.88)	1.36 (0.75-2.46)
Total cholesterol, mg/dL		
<200.0	1.00 (reference)	1.00 (reference)
200.0-239.9	0.87 (0.81-0.94)	1.00 (0.85-1.18)
≥240.0	1.03 (0.92-1.16)	1.46 (1.09-1.95)

Hazard ratio calculated by univariate Cox proportional hazards regression.

9 Supplementary Table 2 Hazard ratios calculated by multivariate Cox proportional hazards regression for suicide according to sociodemographics, health behaviors,

and health status among those who underwent health examinations.

MenWomenAge, years1.00 (reference) $20-24$ 1.00 (reference) $25-29$ $0.67 (0.58-0.77)$ $0.76 (0.64-0.90)$ $30-34$ $0.73 (0.64-0.84)$ $0.85 (0.71-1.03)$ $35-39$ $0.90 (0.79-1.03)$ $1.11 (0.93-1.34)$ Household income 1^{st} quartile (lowest) 1.00 (reference) 2^{nd} quartile $0.84 (0.77-0.92)$ $0.95 (0.80-1.12)$ 3^{rd} quartile $0.66 (0.60-0.72)$ $0.80 (0.67-0.95)$ 4^{th} quartile (highest) $0.52 (0.47-0.57)$ $0.71 (0.59-0.84)$ Job statusEmployed 1.00 (reference) 1.00 (reference)Self-employed $1.00 (reference)$ $-$ Capitol 1.00 (reference) $-$ Charlson comorbidity index 0 $ 1.12 (1.03-1.22)$ $ 2nd$ using $2nd$		Hazard ratio (95% confidence interval)		
Age, yearsI.00 (reference)1.00 (reference)20-241.00 (reference)1.00 (reference)25-290.67 (0.58-0.77)0.76 (0.64-0.90)30-340.73 (0.64-0.84)0.85 (0.71-1.03)35-390.90 (0.79-1.03)1.11 (0.93-1.34)Household income11st quartile (lowest)1.00 (reference)1st quartile (lowest)1.00 (reference)3rd quartile0.84 (0.77-0.92)0.95 (0.80-1.12)3rd quartile0.66 (0.60-0.72)0.80 (0.67-0.95)4th quartile (highest)0.52 (0.47-0.57)0.71 (0.59-0.84)Job status1.00 (reference)1.00 (reference)Employed1.00 (reference)1.00 (reference)Self-employed1.00 (reference)1.00 (reference)Self-employed1.00 (reference)1.86 (1.42-2.43)Not employed2.05 (1.73-2.43)1.84 (1.43-2.36)ResidenceCapitol1.00 (reference)-Metropolitan area1.01 (0.92-1.12)-City/town1.12 (1.03-1.22)-Charlson comorbidity index-1.00 (reference)0-1.00 (reference)1.43 (1.13-1.80)Smoking-1.00 (reference)Never smoker1.00 (reference)1.00 (reference)Past smoker1.00 (reference)1.00 (reference)Past smoker1.79 (1.65-1.94)2.64 (2.14-3.25)Alcohol consumption, times per week1.00 (reference)1.00 (reference)		Men	Women	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Age, years			
25-29 $0.67 (0.58-0.77)$ $0.76 (0.64-0.90)$ 30-34 $0.73 (0.64-0.84)$ $0.85 (0.71-1.03)$ 35-39 $0.90 (0.79-1.03)$ $1.11 (0.93-1.34)$ Household income $1.00 (reference)$ $1.00 (reference)$ 2^{nd} quartile (lowest) $1.00 (reference)$ $0.95 (0.80-1.12)$ 3^{rd} quartile (lighest) $0.66 (0.60-0.72)$ $0.80 (0.67-0.95)$ 4^{th} quartile (highest) $0.52 (0.47-0.57)$ $0.71 (0.59-0.84)$ Job status $ -$ Employed $1.00 (reference)$ $1.00 (reference)$ Self-employed $1.00 (reference)$ $1.00 (reference)$ Residence $ -$ Capitol $1.00 (reference)$ $-$ Metropolitan area $1.01 (0.92-1.12)$ $-$ City/town $1.12 (1.03-1.22)$ $-$ Charlson comorbidity index $ 1.43 (1.13-1.80)$ Smoking $ 1.00 (reference)$ $-$ Never smoker $1.00 (reference)$ $1.00 (reference)$ Past smoker $1.00 (reference)$ $1.00 (reference)$ Alcohol consumption, times per week $1.00 (reference)$ $1.00 (reference)$	20-24	1.00 (reference)	1.00 (reference)	
$\begin{array}{c ccccc} 30.34 & 0.73 & (0.64-0.84) & 0.85 & (0.71-1.03) \\ 35-39 & 0.90 & (0.79-1.03) & 1.11 & (0.93-1.34) \\ \\ Household income & & & & \\ 1^{st} quartile & (lowest) & 1.00 & (reference) & 1.00 & (reference) \\ 2^{nd} quartile & 0.84 & (0.77-0.92) & 0.95 & (0.80-1.12) \\ 3^{rd} quartile & 0.66 & (0.60-0.72) & 0.80 & (0.67-0.95) \\ 4^{th} quartile & (highest) & 0.52 & (0.47-0.57) & 0.71 & (0.59-0.84) \\ Job status & & & & \\ Employed & 1.00 & (reference) & 1.00 & (reference) \\ Self-employed & 1.00 & (reference) & 1.00 & (reference) \\ Self-employed & 2.05 & (1.73-2.43) & 1.84 & (1.43-2.36) \\ Residence & & & \\ Capitol & 1.00 & (reference) & - \\ Metropolitan area & 1.01 & (0.92-1.12) & - \\ City/town & 1.12 & (1.03-1.22) & - \\ Charlson comorbidity index & & & \\ 0 & - & 1.00 & (reference) \\ 1 & - & 1.14 & (0.98-1.33) \\ \ge 2 & - & 1.43 & (1.13-1.80) \\ Smoking & & & \\ Never smoker & 1.00 & (reference) & 1.00 & (reference) \\ Past smoker & 1.12 & (1.03-1.22) & 2.19 & (1.68-2.87) \\ Current smoker & 1.79 & (1.65-1.94) & 2.64 & (2.14-3.25) \\ Alcohol consumption, times per week \\ None & 1.00 & (reference) & 1.00 & (reference) \\ \end{array}$	25-29	0.67 (0.58-0.77)	0.76 (0.64-0.90)	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	30-34	0.73 (0.64-0.84)	0.85 (0.71-1.03)	
Household income1.00 (reference)1.00 (reference) 1^{st} quartile (lowest)1.00 (reference)1.00 (reference) 2^{nd} quartile0.84 (0.77-0.92)0.95 (0.80-1.12) 3^{rd} quartile0.66 (0.60-0.72)0.80 (0.67-0.95) 4^{th} quartile (highest)0.52 (0.47-0.57)0.71 (0.59-0.84)Job statusEmployed1.00 (reference)1.00 (reference)Self-employed1.00 (o.86-1.16)1.86 (1.42-2.43)Not employed2.05 (1.73-2.43)1.84 (1.43-2.36)ResidenceCapitol1.00 (reference)-Metropolitan area1.01 (0.92-1.12)-City/town1.12 (1.03-1.22)-Charlson comorbidity index0-1.00 (reference)1-1.43 (1.13-1.80)SmokingNever smoker1.00 (reference)1.00 (reference)Past smoker1.12 (1.03-1.22)2.19 (1.68-2.87)Current smoker1.79 (1.65-1.94)2.64 (2.14-3.25)Alcohol consumption, times per weekNone1.00 (reference)1.00 (reference)	35-39	0.90 (0.79-1.03)	1.11 (0.93-1.34)	
1^{st} quartile (lowest)1.00 (reference)1.00 (reference) 2^{nd} quartile0.84 (0.77-0.92)0.95 (0.80-1.12) 3^{rd} quartile0.66 (0.60-0.72)0.80 (0.67-0.95) 4^{th} quartile (highest)0.52 (0.47-0.57)0.71 (0.59-0.84)Job statusEmployed1.00 (reference)1.00 (reference)Self-employed1.00 (o.86-1.16)1.86 (1.42-2.43)Not employed2.05 (1.73-2.43)1.84 (1.43-2.36)ResidenceCapitol1.00 (reference)-Metropolitan area1.01 (0.92-1.12)-City/town1.12 (1.03-1.22)-Charlson comorbidity index0-1.00 (reference)11.00 (reference)1.43 (1.13-1.80)SmokingNever smoker1.00 (reference)1.00 (reference)Past smoker1.12 (1.03-1.22)2.19 (1.68-2.87)Current smoker1.79 (1.65-1.94)2.64 (2.14-3.25)Alcohol consumption, times per weekNone1.00 (reference)1.00 (reference)	Household income			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	1 st quartile (lowest)	1.00 (reference)	1.00 (reference)	
$\begin{array}{c ccccc} 3^{\rm rd} quartile & 0.66 (0.60-0.72) & 0.80 (0.67-0.95) \\ 4^{\rm th} quartile (highest) & 0.52 (0.47-0.57) & 0.71 (0.59-0.84) \\ \hline Job status & & & & \\ Employed & 1.00 (reference) & 1.00 (reference) \\ \hline Self-employed & 1.00 (0.86-1.16) & 1.86 (1.42-2.43) \\ \hline Not employed & 2.05 (1.73-2.43) & 1.84 (1.43-2.36) \\ \hline Residence & & & \\ \hline Capitol & 1.00 (reference) & - \\ \hline Metropolitan area & 1.01 (0.92-1.12) & - \\ \hline City/town & 1.12 (1.03-1.22) & - \\ \hline Charlson comorbidity index & & \\ \hline 0 & - & 1.00 (reference) \\ \hline 1 & - & 1.14 (0.98-1.33) \\ \geq 2 & - & 1.43 (1.13-1.80) \\ \hline Smoking & & \\ \hline Never smoker & 1.00 (reference) & 1.00 (reference) \\ \hline Past smoker & 1.79 (1.65-1.94) & 2.64 (2.14-3.25) \\ \hline Alcohol consumption, times per week \\ \hline None & 1.00 (reference) & 1.00 (reference) \\ \hline \end{array}$	2 nd quartile	0.84 (0.77-0.92)	0.95 (0.80-1.12)	
4^{th} quartile (highest)0.52 (0.47-0.57)0.71 (0.59-0.84)Job status	3 rd quartile	0.66 (0.60-0.72)	0.80 (0.67-0.95)	
Job status I.00 (reference) I.00 (reference) Employed 1.00 (0.86-1.16) 1.86 (1.42-2.43) Not employed 2.05 (1.73-2.43) 1.84 (1.43-2.36) Residence - - Capitol 1.00 (reference) - Metropolitan area 1.01 (0.92-1.12) - City/town 1.12 (1.03-1.22) - Charlson comorbidity index - 1.00 (reference) 1 - 1.00 (reference) 1 - 1.00 (reference) 2 - 1.00 (reference) 1 - 1.00 (reference) 1 - 1.00 (reference) 1 - 1.43 (1.13-1.80) Smoking - 1.00 (reference) Never smoker 1.00 (reference) 1.00 (reference) Past smoker 1.12 (1.03-1.22) 2.19 (1.68-2.87) Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25) Alcohol consumption, times per week - - None 1.00 (reference) 1.00 (refere	4 th quartile (highest)	0.52 (0.47-0.57)	0.71 (0.59-0.84)	
Employed 1.00 (reference) 1.00 (reference)Self-employed 1.00 ($0.86-1.16$) 1.86 ($1.42-2.43$)Not employed 2.05 ($1.73-2.43$) 1.84 ($1.43-2.36$)Residence-Capitol 1.00 (reference)-Metropolitan area 1.01 ($0.92-1.12$)-City/town 1.12 ($1.03-1.22$)-Charlson comorbidity index-0- 1.00 (reference)1- 1.14 ($0.98-1.33$) ≥ 2 - 1.43 ($1.13-1.80$)Smoking- 1.00 (reference)Never smoker 1.00 (reference) 1.00 (reference)Past smoker 1.12 ($1.03-1.22$) 2.19 ($1.68-2.87$)Current smoker 1.79 ($1.65-1.94$) 2.64 ($2.14-3.25$)Alcohol consumption, times per week- 1.00 (reference)None 1.00 (reference) 1.00 (reference)	Job status			
Self-employed $1.00 (0.86-1.16)$ $1.86 (1.42-2.43)$ Not employed $2.05 (1.73-2.43)$ $1.84 (1.43-2.36)$ Residence-Capitol $1.00 (reference)$ -Metropolitan area $1.01 (0.92-1.12)$ -City/town $1.12 (1.03-1.22)$ -Charlson comorbidity index-0- $1.00 (reference)$ 1- $1.14 (0.98-1.33)$ ≥ 2 - $1.43 (1.13-1.80)$ Smoking- $1.00 (reference)$ Never smoker $1.00 (reference)$ $1.00 (reference)$ Past smoker $1.12 (1.03-1.22)$ $2.19 (1.68-2.87)$ Current smoker $1.79 (1.65-1.94)$ $2.64 (2.14-3.25)$ Alcohol consumption, times per week- $1.00 (reference)$ None $1.00 (reference)$ $1.00 (reference)$	Employed	1.00 (reference)	1.00 (reference)	
Not employed $2.05 (1.73-2.43)$ $1.84 (1.43-2.36)$ Residence-Capitol $1.00 (reference)$ -Metropolitan area $1.01 (0.92-1.12)$ -City/town $1.12 (1.03-1.22)$ -Charlson comorbidity index- $1.00 (reference)$ 0- $1.00 (reference)$ 1- $1.14 (0.98-1.33)$ ≥ 2 - $1.43 (1.13-1.80)$ Smoking- $1.00 (reference)$ Never smoker $1.00 (reference)$ $1.00 (reference)$ Past smoker $1.12 (1.03-1.22)$ $2.19 (1.68-2.87)$ Current smoker $1.79 (1.65-1.94)$ $2.64 (2.14-3.25)$ Alcohol consumption, times per week- $1.00 (reference)$ None $1.00 (reference)$ $1.00 (reference)$	Self-employed	1.00 (0.86-1.16)	1.86 (1.42-2.43)	
Residence1.00 (reference)-Capitol 1.00 (reference)-Metropolitan area 1.01 (0.92-1.12)-City/town 1.12 (1.03-1.22)-Charlson comorbidity index $-$ 0- 1.00 (reference)1- 1.14 (0.98-1.33) ≥ 2 - 1.43 (1.13-1.80)Smoking $ 1.00$ (reference)Never smoker 1.00 (reference) 1.00 (reference)Past smoker 1.12 (1.03-1.22) 2.19 (1.68-2.87)Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25)Alcohol consumption, times per week $ 1.00$ (reference)None 1.00 (reference) 1.00 (reference)	Not employed	2.05 (1.73-2.43)	1.84 (1.43-2.36)	
Capitol $1.00 (reference)$ $-$ Metropolitan area $1.01 (0.92-1.12)$ $-$ City/town $1.12 (1.03-1.22)$ $-$ Charlson comorbidity index $ 1.00 (reference)$ 0 $ 1.00 (reference)$ 1 $ 1.14 (0.98-1.33)$ ≥ 2 $ 1.43 (1.13-1.80)$ Smoking $ 1.43 (1.13-1.80)$ Never smoker $1.00 (reference)$ $1.00 (reference)$ Past smoker $1.12 (1.03-1.22)$ $2.19 (1.68-2.87)$ Current smoker $1.79 (1.65-1.94)$ $2.64 (2.14-3.25)$ Alcohol consumption, times per week $ 1.00 (reference)$ None $1.00 (reference)$ $1.00 (reference)$	Residence			
Metropolitan area $1.01 (0.92-1.12)$ -City/town $1.12 (1.03-1.22)$ -Charlson comorbidity index $1.00 (reference)$ 0- $1.00 (reference)$ 1- $1.14 (0.98-1.33)$ ≥ 2 - $1.43 (1.13-1.80)$ Smoking $1.00 (reference)$ Never smoker $1.00 (reference)$ 1.12 (1.03-1.22) $2.19 (1.68-2.87)$ Current smoker $1.79 (1.65-1.94)$ 2.64 (2.14-3.25)Alcohol consumption, times per week $1.00 (reference)$ None $1.00 (reference)$	Capitol	1.00 (reference)	-	
$\begin{array}{c cccc} City/town & 1.12 (1.03-1.22) & - \\ \hline Charlson comorbidity index & & & \\ \hline 0 & - & 1.00 (reference) \\ \hline 1 & - & 1.14 (0.98-1.33) \\ \geq 2 & - & 1.43 (1.13-1.80) \\ \hline Smoking & & & \\ \hline Never smoker & 1.00 (reference) & 1.00 (reference) \\ \hline Past smoker & 1.00 (reference) & 1.00 (reference) \\ \hline Past smoker & 1.12 (1.03-1.22) & 2.19 (1.68-2.87) \\ \hline Current smoker & 1.79 (1.65-1.94) & 2.64 (2.14-3.25) \\ \hline Alcohol consumption, times per week \\ \hline None & 1.00 (reference) & 1.00 (reference) \\ \hline \end{array}$	Metropolitan area	1.01 (0.92-1.12)	-	
Charlson comorbidity index Image: matrix of the system 0 - 1.00 (reference) 1 - 1.14 (0.98-1.33) ≥ 2 - 1.43 (1.13-1.80) Smoking - 1.43 (1.13-1.80) Never smoker 1.00 (reference) 1.00 (reference) Past smoker 1.00 (reference) 2.19 (1.68-2.87) Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25) Alcohol consumption, times per week - - None 1.00 (reference) 1.00 (reference)	City/town	1.12 (1.03-1.22)	-	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Charlson comorbidity index			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0	-	1.00 (reference)	
≥2 - 1.43 (1.13-1.80) Smoking	1	-	1.14 (0.98-1.33)	
Smoking I.00 (reference) Never smoker 1.00 (reference) Past smoker 1.12 (1.03-1.22) Current smoker 1.79 (1.65-1.94) Alcohol consumption, times per week Instrument None 1.00 (reference)	≥2	-	1.43 (1.13-1.80)	
Never smoker 1.00 (reference) 1.00 (reference) Past smoker 1.12 (1.03-1.22) 2.19 (1.68-2.87) Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25) Alcohol consumption, times per week None 1.00 (reference) 1.00 (reference)	Smoking			
Past smoker 1.12 (1.03-1.22) 2.19 (1.68-2.87) Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25) Alcohol consumption, times per week None 1.00 (reference) 1.00 (reference)	Never smoker	1.00 (reference)	1.00 (reference)	
Current smoker 1.79 (1.65-1.94) 2.64 (2.14-3.25) Alcohol consumption, times per week None 1.00 (reference) 1.00 (reference)	Past smoker	1.12 (1.03-1.22)	2.19 (1.68-2.87)	
Alcohol consumption, times per week1.00 (reference)None1.00 (reference)1.00 (reference)	Current smoker	1.79 (1.65-1.94)	2.64 (2.14-3.25)	
None1.00 (reference)1.00 (reference)	Alcohol consumption, times per week			
	None	1.00 (reference)	1.00 (reference)	

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1	0.85 (0.78-0.93)	1.07 (0.93-1.24)
2 or more	1.00 (0.92-1.08)	1.46 (1.24-1.71)
Body mass index, kg/m ²		
<23.0	1.00 (reference)	1.00 (reference)
23.0-24.9	0.78 (0.72-0.85)	0.74 (0.61-0.91)
≥25.0	0.68 (0.63-0.74)	0.63 (0.50-0.79)
Blood pressure, mmHg		
<120/80	1.00 (reference)	-
120/80-139/89	1.03 (0.96-1.11)	-
≥140/90	1.16 (1.05-1.28)	-
Fasting serum glucose, mg/dL		
<100.0	1.00 (reference)	1.00 (reference)
100.0-125.9	1.12 (1.03-1.21)	1.19 (0.99-1.43)
≥126.0	1.50 (1.28-1.77)	1.27 (0.80-2.32)
Total cholesterol, mg/dL		
<200.0	-	1.00 (reference)
200.0-239.9	-	1.03 (0.87-1.21)
≥240.0	-	1.58 (1.18-2.12)

12 Hazard ratio calculated by multivariate Cox proportional hazards regression.

Adjusted variables included age, household income, job status, area of residence, smoking, alcohol intake, body mass index, blood pressure, and fasting serum glucose 13

for men and age, household income, job status, Charlson comorbidity index, smoking, alcohol intake, body mass index, fasting serum glucose, and total cholesterol for 14 15 women.

18	Supplementary	Table 3. Hazard ratios for the effect of sociodemographic factors on death from unknown causes.

	Adjusted hazard ratio (95% confidence interval)					
		Men		Women		
	Total	Did not undergo	Underwent health	Total	Did not undergo	Underwent health
	10tai	health examination	examination	10ta1	health examination	examination
Age, years						
20-24	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
25-29	1.77 (1.58-1.98)	1.67 (1.48-1.88)	1.59 (0.98-2.58)	1.35 (1.12-1.63)	1.38 (1.13-1.68)	0.99 (0.51-1.94)
30-34	3.71 (3.34-4.12)	3.88 (3.48-4.33)	1.97 (1.23-3.16)	1.71 (1.44-2.03)	1.77 (1.48-2.11)	0.93 (0.44-1.94)
35-39	6.95 (6.27-7.70)	7.42 (6.67-8.24)	3.42 (2.14-5.44)	2.05 (1.74-2.43)	2.10 (1.76-2.49)	1.46 (0.73-2.93)
Household income						
1 st quartile (lowest)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
2 nd quartile	0.66 (0.62-0.71)	0.66 (0.61-0.71)	0.73 (0.60-0.89)	0.63 (0.55-0.73)	0.63 (0.55-0.73)	0.62 (0.34-1.15)
3 rd quartile	0.49 (0.46-0.53)	0.52 (0.48-0.56)	0.47 (0.38-0.57)	0.47 (0.41-0.54)	0.47 (0.41-0.55)	0.44 (0.23-0.87)
4 th quartile (highest)	0.38 (0.35-0.42)	0.41 (0.37-0.45)	0.33 (0.26-0.42)	0.39 (0.33-0.46)	0.39 (0.33-0.46)	0.53 (0.29-0.96)
Job status						
Employed	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Self-employed	2.02 (1.87-2.18)	1.70 (1.53-1.89)	1.39 (1.06-1.83)	3.65 (2.93-4.56)	3.01 (2.26-4.02)	2.89 (1.27-6.60)
Not employed	3.26 (3.02-3.51)	2.75 (2.48-3.05)	2.61 (1.80-3.80)	2.71 (2.25-3.27)	2.21 (1.70-2.87)	1.68 (0.61-4.62)
Residence						
Capital	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Metropolitan area	0.71 (0.65-0.77)	0.68 (0.62-0.75)	0.98 (0.78-1.23)	0.68 (0.59-0.80)	0.69 (0.59-0.81)	0.61 (0.31-1.20)
City/town	1.06 (0.99-1.13)	1.04 (0.97-1.12)	1.25 (1.03-1.52)	0.90 (0.80-1.02)	0.90 (0.79-1.03)	0.95 (0.56-1.63)
Charlson comorbidity index						
0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
1	0.95 (0.87-1.04)	0.95 (0.86-1.05)	0.98 (0.81-1.20)	1.00 (0.87-1.16)	1.00 (0.86-1.16)	1.07 (0.60-1.93)
≥2	1.84 (1.66-2.03)	1.96 (1.76-2.18)	1.31 (0.99-1.74)	2.22 (1.89-2.61)	2.22 (1.88-2.62)	2.26 (1.11-4.59)

Adjusted hazard ratio calculated by Cox proportional hazards regression after adjustments for age, household income, job status, residence, and Charlson comorbidity index.

25 26 27 Supplementary Table 4. Hazard ratios for the effect of health behaviors and cardiovascular risk factors on death from unknown causes among those who underwent

health examinations.

	Adjusted hazard ratio (95% confidence interval)						
		Men			Women		
	Unadjusted	Age-adjusted	Fully-adjusted	Unadjusted	Age-adjusted	Fully-adjusted	
Smoking							
Never smoker	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
Past smoker	1.04 (0.80-1.36)	1.00 (0.76-1.30)	1.03 (0.78-1.35)	0.54 (0.08-3.87)	0.57 (0.08-4.13)	0.49 (0.07-3.53)	
Current smoker	1.71 (1.45-2.01)	1.74 (1.48-2.05)	1.58 (1.32-1.89)	1.54 (0.56-4.21)	1.62 (0.59-4.47)	1.16 (0.41-3.33)	
Physical activity, times per week							
None	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
1-2	0.98 (0.84-1.14)	0.98 (0.84-1.14)	0.98 (0.83-1.15)	1.07 (0.62-1.85)	1.07 (0.62-1.84)	1.09 (0.63-3.53)	
3 or more	0.93 (0.76-1.15)	0.92 (0.75-1.13)	0.97 (0.79-1.20)	1.05 (0.50-2.20)	1.01 (0.48-2.14)	1.01 (0.48-2.13)	
Alcohol consumption, times per week							
None	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
1	0.81 (0.65-0.99)	0.82 (0.66-1.01)	0.79 (0.64-0.98)	0.71 (0.41-1.25)	0.75 (0.43-1.31)	0.76 (0.43-1.33)	
2 or more	1.36 (1.15-1.62)	1.36 (1.15-1.61)	1.14 (0.94-1.37)	1.18 (0.66-2.11)	1.25 (0.69-2.25)	1.14 (0.62-2.10)	
Body mass index, kg/m ²							
<23.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
23.0-24.9	0.75 (0.62-0.91)	0.71 (0.59-0.86)	0.68 (0.56-0.83)	1.28 (0.67-2.45)	1.20 (0.63-2.30)	1.08 (0.56-2.08)	
≥25.0	0.97 (0.82-1.13)	0.90 (0.77-1.06)	0.73 (0.62-0.87)	1.15 (0.55-2.42)	1.08 (0.51-2.27)	0.78 (0.36-1.70)	
Blood pressure, mmHg							
<120/80	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
120/80-139/89	1.20 (1.00-1.44)	1.19 (1.00-1.43)	1.19 (0.99-1.43)	1.34 (0.83-2.15)	1.31 (0.82-2.12)	1.28 (0.79-2.08)	
≥140/90	2.58 (2.11-3.14)	2.47 (2.03-3.02)	2.32 (1.89-2.86)	2.97 (1.33-6.63)	2.76 (1.23-6.19)	2.47 (1.08-5.69)	
Fasting serum glucose, mg/dL							
<100.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
100.0-125.9	1.39 (1.18-1.65)	1.33 (1.12-1.58)	1.21 (1.02-1.44)	1.54 (0.81-2.92)	1.49 (0.79-2.83)	1.41 (0.74-2.69)	
≥126.0	3.19 (2.42-4.21)	2.88 (2.18-3.81)	2.20 (1.65-2.92)	5.51 (1.73-17.54)	5.13 (1.61-16.38)	4.01 (1.22-13.20)	
Total cholesterol, mg/dL							
<200.0	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
200.0-239.9	1.16 (0.98-1.36)	1.09 (0.93-1.28)	1.07 (0.91-1.26)	0.99 (0.53-1.84)	0.97 (0.52-1.79)	0.90 (0.48-1.68)	
≥240.0	1.52 (1.20-1.91)	1.39 (1.10-1.76)	1.25 (0.98-1.59)	1.69 (0.62-4.66)	1.64 (0.60-4.53)	1.40 (0.50-3.92)	

- Hazard ratio calculated by Cox proportional hazards regression.
- Fully-adjusted model includes adjustments for age, household income, job status, residence, Charlson comorbidity index, smoking, physical activity, alcohol consumption, body mass index, blood pressure, fasting serum glucose, and total cholesterol.

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65	Supplementary	Table 5. Descriptive characteristics of the study population according to health screening examinations

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	Did not undergo health		
	screening	Underwent health screening	<i>p</i> value
Number of people	12,140,300	3,394,138	
Age, years, N (%)			
20-24	3,163,358 (26.1)	321,428 (9.5)	< 0.001
25-29	2,712,612 (22.3)	935,971 (27.6)	
30-34	3,038,338 (25.0)	1,094,621 (32.3)	
35-39	3,225,992 (26.6)	1,042,118 (30.7)	
Sex, N (%)			
Men	5,752,285 (47.4)	2,202,347 (64.9)	< 0.001
Women	6,388,015 (52.6)	1,191,791 (35.1)	
Household income, N (%)			
1 st quartile (lowest)	3,370,955 (27.8)	565,109 (16.7)	< 0.001
2 nd quartile	2,890,080 (23.8)	875,960 (25.8)	
3 rd quartile	2,974,306 (24.5)	1,008,231 (29.7)	
4 th quartile (highest)	2,904,959 (23.9)	944,838 (27.8)	
Job status, N (%)			
Employed	1,609,020 (13.3)	3,200,069 (94.3)	< 0.001
Self-employed	2,048,820 (16.9)	120,242 (3.5)	
Not employed	8,482,460 (69.9)	73,827 (2.2)	
Residence, N (%)	, , , , , , , , , , , , , , , , , , ,		
Capitol	2,843,873 (23.4)	727,463 (21.4)	< 0.001
Metropolitan area	3,213,913 (26.5)	880,687 (26.0)	
City/town	6,082,514 (50.1)	1,785,988 (52.6)	
Charlson comorbidity index, N (%)			
0	9,842,843 (81.1)	2,667,945 (78.6)	< 0.001
1	1,728,118 (14.2)	557,078 (16.4)	
>2	569,339 (4.7)	169,115 (5.0)	

p value calculated by Chi squared test. Acronyms: N, number of people.

73 74 Supplementary Table 6. Hazard ratios for suicide according to health screening examinations.

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	Did not undergo health	
	screening	Underwent health screening
Total		
Events	32,768	5,044
Person-years	120,815,686	33,836,991
aHR (95% CI)	1.00 (reference)	0.75 (0.72-0.79)
Men		
Events	19,657	3,967
Person-years	57,160,876	21,942,367
aHR (95% CI)	1.00 (reference)	0.76 (0.73-0.80)
Women		
Events	13,111	1,077
Person-years	63,654,811	11,894,624
aHR (95% CI)	1.00 (reference)	0.70 (0.65-0.76)

75 76 77 Adjusted hazard ratio calculated by Cox proportional hazards regression after adjustments for age, household income, job status, residence, and Charlson comorbidity index.