



OPEN

## Examining the effects of social assistance on suicide-related behaviour among impoverished older adults in Korea using a nationwide cohort study from 2010–2019

Chungah Kim<sup>1</sup>, Gabriel John Dusing<sup>1</sup>, Hyunju Jin<sup>2,3</sup> & Antony Chum<sup>1,4,5</sup>✉

Suicide rates among older adults in Korea are one of the highest in the world. Although prior research found that poverty is associated with suicide mortality among older adults in Korea, it is unknown whether being a recipient of social assistance may reduce suicide risk among older adults living in poverty. We examined the impact of the public assistance program on suicide-related behaviour (SRB). Data from a nationwide cohort in the Korean National Health Insurance Database, including demographic and medical treatment information, linked to the vital statistics for 2010–19 was used. The entire Korean population born before 1951 was included ( $n = 7,889,086$ ). Flexible parametric survival model was performed to assess whether the risk of SRB hospitalisation and death differed across a) different levels of socioeconomic status, and b) social assistance status among the poor, using gender-stratified models. Older age, chronic disease, poverty, and being out of the labour market were associated with higher SRB hospitalisation and death for both genders. Among those living in poverty, social assistance recipients had lower rates for SRB death and hospitalisation, compared to the low-income non-recipients. Men who were non-recipients had 0.21 higher hazards ratio (95%CI 0.20 to 0.22) for SRB deaths compared to recipients, and the difference was 0.11 (95%CI 0.10 to 0.11) in women, with similar patterns for SRB hospitalizations. Poverty was associated with higher SRB death and hospitalisation among older adults in Korea. Social assistance targeting the older population may help reduce SRB.

Korea has the highest suicide mortality rate among high-income OECD (Organisation for Economic Co-operation and Development) countries and the fourth highest in the world at 28.6 per 100,000 in 2019<sup>1</sup>. As a comparison, the mean rate based in 2019 across OECD countries was 11.9 per 100,000<sup>1</sup>. The high suicide mortality in Korea, however, is not evenly distributed across age groups, but is more concentrated in the older adult (65+) population. As of 2022, while Koreans in their teens and 20 s have a suicide rate of 7.2 and 21.4 respectively, this rate grows to 27.0 for those in their 60 s, 37.8 for those in their 70 s, and up to 60.6 for those aged 80 +<sup>2</sup>. Alarmingly, suicide mortality rates in older adults have been observed to have tripled since 2000<sup>3</sup>. In the following, we discuss the nation's economic trajectory, the ensuing age-based inequalities, diminished familial supports, and an inadequate welfare system, setting the stage for our investigation into the relationship between poverty and suicide-related behavior in older Koreans.

South Korea, gaining its independence in 1948 after 36 years of Japanese colonialism, was predominantly an agricultural state and among one of the most impoverished nations in the world<sup>4</sup>. However, since 1961, the country underwent unprecedented rapid economic development, during which it was transformed into a middle-income country in the 1980s, and by the mid-1990 onwards, it was considered to be a high-income country, with

<sup>1</sup>School of Kinesiology and Health Science, York University, 4700 Keele St, Toronto, ON M3J 1P3, Canada. <sup>2</sup>Zhejiang Normal University, Zhejiang, China. <sup>3</sup>Seoul National University, Seoul, South Korea. <sup>4</sup>Dalla Lana School of Public Health, University of Toronto, 155 College St, Toronto, ON M5T 3M7, Canada. <sup>5</sup>Unity Health Toronto, St. Michael's Hospital, 30 Bond St, Toronto, ON M5B 1W8, Canada. ✉email: chuma@yorku.ca

current GDP per capita reaching \$47,242 USD (Purchasing Power Parity based) in 2021<sup>5</sup>. Despite the phenomenal development, not everyone benefited equally from the prosperity, and income inequality, as measured by the GINI coefficient (i.e. the proportion of total income that would have to be redistributed to equalise everyone's incomes<sup>6</sup>), grew from 0.26 in 1990 to 0.32 in 2020 in the general population.

Economic inequality is a particularly salient problem in the older population, where in 2021, older adults (over 65) had a GINI coefficient of 0.38<sup>7</sup>, and 43.4% of older adults live under the poverty line in 2018<sup>8</sup>. Due to the decline in traditional family support and weak welfare benefits targeting older adults, a large proportion of this population is mired in poverty even in the face of Korea's so-called "economic miracle" since the 1980s<sup>9</sup>. While Korean Confucian traditions protected older adults through strong social norms that adult children should take on financial and care responsibilities of their elderly parents, these norms have been waning in the past decades, which has eroded the traditional social safety net for Korean older adults. For instance, the share of Koreans believing that it is families who should support older adults shrank from 89.9% in 1998 to 31.7% in 2014<sup>10</sup>. The drop in family support of older adults is also evidenced by a shift away from multigenerational co-residence: after controlling for the changing age structure, fathers who live with their adult children fell from 60.8% to 28.6% over the period of 1980 to 2015 (and mothers from 68.1 to 36.3%)<sup>11</sup>. Meanwhile, the Korean welfare state has failed to keep up with the shift in culture and socioeconomic system to support the older adult population. As a result, many older adults in Korea continue to work past the typical retirement age, and as of 2020, 36.8% of adults over 65 were in the labour force (vs 19% in the US in the same year)<sup>12</sup>.

Korea's welfare system lags behind similar high-income countries<sup>13</sup>. In Korea, there are three programs that supplement the income of older adults: (1) the National Pension Scheme, (2) Basic Pension, and (3) National Basic Livelihood Security System (NBLSS). We will discuss each in turn. Many western countries have long established public pension systems, but in Korea, it was not until 1988 when the National Pension Scheme, the primary mandatory public pension program (similar to the Canada Pension Plan in Canada and the Social Security Old-Age Benefits in the US), was introduced for employees ages 18–59<sup>14</sup>. Given its recent introduction and the condition requiring a minimum 10 years of contribution before benefits are paid<sup>14</sup>, only 25 percent of older adults received a pension by 2013. The second program is the Basic Pension which provides approximately KRW 300,000 (\$220 USD) per month as of 2022. This benefit is available to 70% of older adults, but is inadequate given the national poverty line based on 60% of the median income, which means KRW 1,166,887 (\$873 USD) for a single adult is required to meet subsistence living costs in 2022<sup>15</sup>. Third, to address the East Asian economic crisis that began in late 1997 and led to deepening financial insecurity among vulnerable groups, including retiring-age adults<sup>16</sup>, the Korean government established the NBLSS, a public assistance program, through the 1999 National Basic Livelihood Security Act. The NBLSS is a strict means-tested program for households who are under the absolute poverty line of KRW 583,444 (\$436 USD) as of 2022; however, it provides assistance to only 3.2% of the general Korean population, and to 7.9% of the older (65+) population<sup>17</sup>. The NBLSS offers a comprehensive range of benefits: livelihood income assistance, medical aid, housing, education, childbirth, funeral, and self-support assistance<sup>13</sup>. Although the NBLSS was not specifically targeted at older adults, about 40% of the recipients are older adults<sup>17</sup>.

Given that over 40% of older adults in Korea are in poverty and the existing welfare system has not fundamentally addressed this issue, it is important to understand the health consequences associated with poverty in older adults, including suicide-related behaviour (SRB), i.e. fatal and non-fatal self-inflicted injuries or self-poisonings with suicide or undetermined intent<sup>18</sup>. For instance, a prior study found that the suicide rate among those in poverty was 1.34 times higher, compared to those in the highest income group after adjusting for confounders<sup>19</sup>, and another study found that among older adults 65+, those in the highest income quartile (versus the lowest) were associated with lower odds of suicidal ideation by a factor of 0.59<sup>20</sup>. In both studies, while lower income was consistently demonstrated as the highest risk group, they did not explicitly examine whether those enrolled in public assistance (i.e. NBLSS) may have different SRB risks. On the one hand, qualification for the program may reduce SRB risk through its direct income-boosting effect. The benefit disbursed by the NBLSS as of 2020 is as follows: KRW 527,158 (\$527 USD) per single-person household, KRW 897,594 (\$898 USD) per two-person household, KRW 1,161,173 (\$1161 USD) per 3-person household, and KRW 1,424,752 (\$1425 USD) per 4-person household. On the other hand, those at highest risk of SRB may self-select into NBLSS (e.g. those who are more likely to be facing additional vulnerabilities such as housing insecurity, given the 'no asset' eligibility criteria of NBLSS). Learning about the potential SRB risk disparity between NBLSS participants vs. other poor households may have public policy implications (e.g. provide preliminary evidence for the protective effects of public assistance in Korea), or may help to identify a uniquely vulnerable subpopulation among older adults living in poverty. Given the need to investigate the association between poverty in older adults and suicide mortality/suicidal attempts in the context of the welfare system, we ask the following research question:

- 1) What is the association between poverty and SRB among older adults in Korea?
- 2) Among those in the lowest socioeconomic status (SES) groups, was enrollment in the public assistance program associated with lower risks of SRB after adjusting for the effects of disability and comorbidity?

## Methods

### Study population

We created the study cohort for all individuals born in 1950 or before in South Korea at baseline in 2010 ( $n = 7,889,086$ ), using the Korean National Health Information Database (NHID) from January 2010 to December 2019. The NHID contains personal and demographic information and medical treatment data for all Korean citizens. Korea's universal healthcare system consists of National Health Insurance and Medical Aid enrollees (excluding temporary residents). National Health Insurance is administered in 2 ways: (1) workplace health

insurance (i.e., workers and employers registered at any workplace hiring at least 1 employee) and their dependents (e.g., spouses, parents and children, and siblings), and (2) community insurance (i.e., including those who are not registered as insured employees, including the unemployed, the self-employed, and retirees not supported by employed family members)<sup>21</sup> and their dependents. Both groups pay a mandatory monthly premium (based on their income and assets). Certain low-income individuals (with no ownership of assets such as real estate or children who can support them) are insured through Medical Aid and receive NBLSS benefits. However, a significant number of low-SES individuals do not receive Medical Aid/NBLSS, due to the stringent asset criteria and rules about family support obligations, e.g., elderly parents must demonstrate that they are not receiving support from their children.

The NHID encompasses the entirety of Korea's population and is administered by the National Health Insurance Service, the sole health insurance provider in Korea<sup>22</sup>. An independent report has assessed the reliability of this linkage, deeming it to be of high quality<sup>23</sup>. The data was subsequently de-identified before given to our team for analyses. This comprehensive system consists of multiple databases. Among them, the eligibility database, part of the NHID, contains essential socio-demographic details for the entire Korean population. These details encompass various parameters such as gender, age, place of residence, and insurance premium calculations based on income and assets. Mortality data from death certificates were collected by Statistics Korea, and subsequently linked to the national health insurance database by NHIS using a unique 13-digit resident registration number. We performed a complete case analysis, since the Korean national health insurance system comprehensively manages and legally protects all citizens' medical records, ensuring no data is missing. The Institutional Review Board of Seoul National University approved our study and waived the requirement for informed patients' consent due to the nature of secondary data analyses using de-identified information (IRB NO. E2110/001-006). All methods were performed in accordance with the relevant guidelines and regulations.

### Outcome: suicide-related behaviour

This study has two outcomes, which includes (1) death from self-harm with suicidal or undetermined intent and (2) SRB-related hospitalization. For our first outcome, we used the International Classification of Diseases version 10 (ICD-10) codes to identify deaths from self-harm (X60–X84) and deaths that are of undetermined intent (Y10–Y34). It is now common practice to include death by undetermined intent (i.e. no evidence for intent to die) into studies of SRB (Walkup et al., 2012), this is particularly important given the context of this classification in Korea. Where legal authorities find no recorded evidence of intent to die (e.g. suicide note), at the time of the person initiated self-killing (especially by self-poisoning), the death is coded as being due to an “event of undetermined intent”. The classification is applied if the intention to die “cannot be established beyond a reasonable doubt”, which is a legal construct (rather than evaluating the balance of probability for suicide) that leads to an underestimation of true suicides<sup>24</sup>. In a prior study, using psychological autopsy methods (which involve interviews with friends, family, and a chart review of clinical notes), a Finnish study has uncovered suicide intent in 87% of 139 deaths that were classified to be undetermined intent<sup>25</sup>. A Korean study, investigating the trends in suicides by pesticide, and undertermined deaths by pesticide poisoning, estimated the misclassification of suicides as undetermined deaths has led to suicides (by pesticides) to be underestimated by 15–31% between 1991 and 2012<sup>26</sup>. Therefore, we include deaths of undetermined intent as part of the primary outcome.

For our second outcome, SRB hospitalization, we used the ICD-10-codes X60–X84, Y87.0, U03, and Y10–Y34 to identify hospitalization for suicide attempts. In a prior study of Korean adolescent suicide-related emergency department visits from 2016 to 2019<sup>27</sup>, it was found that 3006 out of 11,462 (26.23%) suicide-related emergency department visits was followed by hospitalization and the rest were discharged. Of note, those who were hospitalised had significantly higher levels of acuity based on the Korean Triage and Acuity Scale (79.9% of hospitalised patients were considered urgent or greater at triage vs. 47.1% of discharged patients,  $p < 0.001$ ). We also included probable suicide attempts (see Supplementary Table 1 for the all ICD-10-codes), which included wrist lacerations (S61.9) and poisoning from psychotropic drugs (T43). Previous studies have included these codes for probable suicide attempts in Korea<sup>28</sup>. Since intentional self-harm was not covered by Korean National Health Insurance until 2014, using only international self-harm codes has been found to underestimate attempted suicides by 62–81%<sup>29</sup>.

### Measure of SES

Levels of SES were inferred from National Health Insurance premiums, which are calculated at the household level. Premiums are calculated based on monthly wages for waged workers and their dependents, and a combination of assets and all income are considered for those who are unemployed, retired, and self-employed. Insurance premiums were provided as categorical data, and divided into quartiles based on the general population distribution. To note, each 10,000 KRW is approximately \$10 USD. Based on 2010 numbers, insurance premiums for the employee insurance enrollees range from 0–31,980 KRW in Q1, 31,981–50,740 KRW in Q2, 50,741–105,120 KRW in Q3, and 105,121–1,753,300 KRW in Q4. Given these premiums, the maximum income for Q1 is 600,000 KRW, 1,551,989 KRW for Q2, and 2,924,221 for Q3. For the majority of workers in Q1, their incomes are below the national poverty threshold of 550,000 as of 2010, and for the purpose of this study, we will consider the Q1 group to be living in poverty. To add, while the majority of our sample of older adults are not working adults, the national formulas were created to evaluate retired individuals based on their other incomes (e.g. investment incomes) and assets (e.g. home and car ownership) to equalize them to the same thresholds—for instance, Q1 retirees have similar standards of living compare to Q1 employed workers. To add, while the majority of our sample of older adults are not working adults, the national formulas were created to evaluate retired individuals based on their other incomes (e.g. investment incomes) and assets (e.g. home and

car ownership) to equalize them to the same thresholds—for instance, Q1 retirees have similar standards of living compare to Q1 employed workers.

The NBLSS group, as mentioned earlier, are low-income individuals who meet additional criteria (e.g. no assets and no direct children supporting them), and are also considered to be in the lowest income. The ‘others’ groups include individuals who do not pay national health insurance premiums, which includes institutionalised populations, soldiers, and those who are on long-term leave (e.g. sick leave). Since the last group do not pay premiums, we are unable to infer their socio-economic status; however, they are included as a separate group in the models.

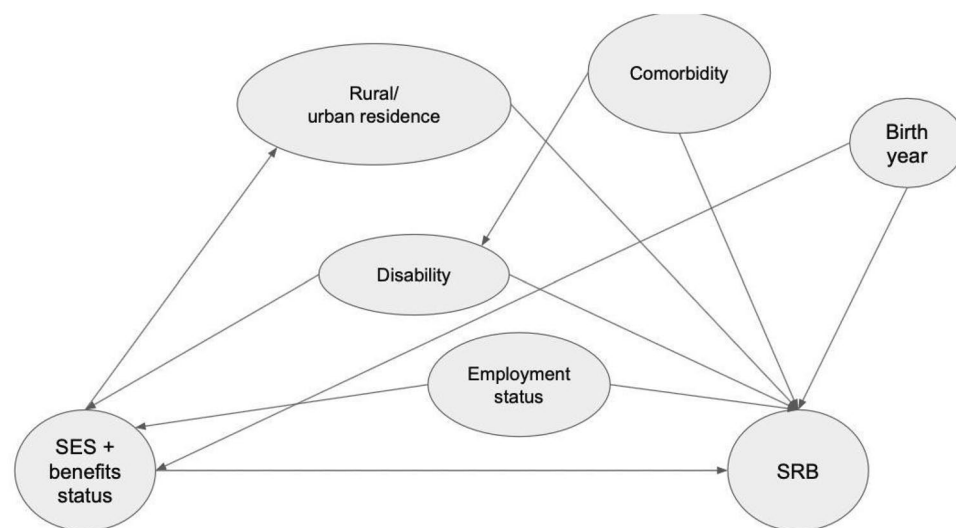
### Covariates

The covariates included in this study are (1) birth year, (2) urban/rural status, (3) employment status, (4) disability status, and (5) comorbidity index. Time-varying covariates were used including income, employment status, comorbidity, region, and disability status. Since they are sourced from administrative datasets, these variables are all updated annually<sup>30</sup>. Birth year was included as a continuous variable to adjust for age and cohort effects. Urban/rural status was determined by place of residence. An individual’s place of residence was classified as rural if their place of residence was in a local jurisdiction with population less than 100,000 (“gun”), and urban if in a jurisdiction with more population than 100,000 (“si”). Employment status was recorded as a binary variable (waged workers vs self-employed, out of the labour force, or unemployed). Information on all individuals with disability are registered in the eligibility database, and thus disability status was recorded as a binary variable (any disability vs no disability). Comorbidity was measured using the Charlson comorbidity index (CCI), which was calculated through the ICD-10 codes from January 1, 2010 to December 31, 2019 and recorded as 0,1,2,3, and 4+ comorbidities<sup>31</sup>. A directed acyclic graph (DAG) framework is employed to examine the relationships among covariates and to suggest a statistical analysis (Fig. 1).

### Statistical analysis

Descriptive statistics were calculated for incidence rates of (1) death from self-harm and undetermined intent, (2) deaths from self-harm only, and (3) SRB-related hospitalisation across levels of the main exposure and each covariate at baseline. Cox hazards model was used despite the Schoenfeld residuals test results suggesting a violation of the proportional hazards assumption<sup>32</sup>. This decision was informed by the understanding that, in practice, hazard ratios in many medical studies do not remain constant over time, and thus, the hazard ratios derived from our Cox model should be seen as weighted averages of time-varying effects throughout the follow-up period<sup>33</sup>. Royston-Parmar flexible parametric survival analysis was conducted, since the results of Schoenfeld residuals test indicated that the proportional hazards assumption was not met<sup>32</sup>. This survival model is an alternative to Cox regression by allowing greater flexibility in model fitting, and providing both baseline hazard and the effect of time-varying covariates on the baseline hazard<sup>32</sup>. Adjusted Hazards ratios (HRs) and 95% CIs were estimated by gender for each outcome using multivariate flexible parametric survival analysis. Lastly, to robustly examine the difference in SRB risk between the two low-income groups (i.e., Q1 vs NBLSS), we implemented a bootstrap approach, using 10,000 non-parametric bootstrap samples drawn without replacement. This method yielded empirical 95% confidence intervals for the difference in risk between the Q1 and NBLSS groups, offering a valid alternative that does not hinge on the restrictive normality assumption often associated with traditional interval estimation methods.

We conducted several sensitivity analyses. First, the Schoenfeld residuals indicated that the proportional hazard assumption was not met, potentially driven by the large number of participants, which includes the entire



**Figure 1.** Directed acyclic graph showing confounding variables of the relationship between exposures and outcome.

65 + population<sup>34</sup>. Therefore, we conducted a reanalysis using the Royston-Parmar flexible parametric survival analysis. This method serves as an alternative to Cox regression, offering increased flexibility in model fitting<sup>32</sup>. This step was taken to confirm the robustness of the results obtained from the alternative survival model. Second, we produced model results using deaths from self-harm only (excluding deaths from undetermined intents) and hospitalizations from suicide attempts only (excluding hospitalizations from probable suicide attempts) to verify the model with hospitalizations from suicide attempts only shows similar patterns to the model containing suicide attempts and probable suicide attempts. Third, we conducted a sensitivity analysis by including models that used inverse probability weighted Cox regression proposed to adjust for systematic censoring. Statistical significance was defined as a 2-sided P-value of < 0.05. Statistical analyses were performed by using STATA 13.0 (StataCorp LP, College Station, TX, USA).

## Results

Table 1 presents the number of events for deaths and hospitalizations from SRB, and their incidence rates. During the study period (2010–2019), among those who are 65 + in Korea, there were a total of 53,234 deaths from self-harm and undetermined intent, 40,180 deaths from self-harm only, and 38,430 hospitalizations from suicide attempts and probable suicide attempts. The average follow-up-year for the participants is 8.82 years. The incidence rates from suicide deaths were consistently higher than hospitalization rates, suggesting that many older adults die by suicide without ever being hospitalized. The incidence rates (per 100,000 person-years) for (1) deaths from self-harm and deaths of undetermined intent combined, (2) deaths from self-harm alone, and (3) hospitalizations from suicide attempts and probable suicide attempts were 76.53, 57.76 and 55.24, respectively. Individuals who were men, older, rural residents, not employed, had lower income, had any chronic diseases, and disability showed higher rates for all SRB outcomes.

	N of persons	Person-years	SRB deaths: Deaths from self-harm and undetermined intent	Deaths from self-harm only	SRB Hospitalizations: suicide attempts and probable suicide attempts
			Rate per 100 k person-years (number of events in study period)		
Gender					
Men	(43.25%) 3,411,802	(42.36%) 29,470,119	118.78 (35,006)	92.24 (27,183)	70.43 (20,755)
Women	(56.75%) 4,477,284	(57.64%) 40,094,056	45.46 (18,228)	32.42 (12,997)	44.08 (17,675)
Age					
60–69	(53.25%) 4,200,860	(57.36%) 39,902,562	52.75 (21,050)	44.09 (17,593)	38.92 (15,529)
70–79	(33.78%) 2,665,172	(33.18%) 23,077,986	95.94 (22,140)	71.40 (16,478)	73.38 (16,934)
80 +	(12.97%) 1,023,054	(9.46%) 6,583,627	152.56 (10,044)	92.79 (6109)	90.63 (5967)
Employed					
No	(92.27%) 7,279,547	(91.65%) 63,752,821	80.25 (51,159)	60.20 (38,379)	58.48 (37,285)
Yes	(7.73%) 609,539	(8.35%) 5,811,354	35.71 (2075)	30.99 (1801)	19.70 (1145)
Rurality					
Urban	(84.85%) 6,693,690	(85.24%) 59,294,925	74.31 (44,064)	56.94 (33,761)	45.28 (26,847)
Rural	(15.15%) 1,195,396	(14.76%) 10,269,250	89.30 (9170)	62.51 (6419)	112.79 (11,583)
SES Level					
Q4 (highest)	(39.39%) 3,107,631	(39.96%) 27,798,356	70.73 (19,663)	53.72 (14,932)	53.27 (14,808)
Q3	(20.55%) 1,621,492	(20.72%) 14,412,276	75.35 (10,859)	57.57 (8297)	55.49 (7998)
Q2	(13.32%) 1,051,090	(13.38%) 9,307,710	79.05 (7358)	60.36 (5618)	56.90 (5296)
Q1	(16.58%) 1,307,847	(16.61%) 11,557,957	77.87 (9000)	59.69 (6899)	50.43 (5829)
NBLSS (lowest)	(7.76%) 612,270	(7.06%) 4,910,838	102.65 (5041)	69.76 (3426)	70.37 (3456)
Unknown	(2.39%) 188,756	(2.27%) 1,577,038	83.26 (1313)	63.92 (1008)	66.14 (1043)
Charlson comorbidity index					
0	(58.21%) 4,592,392	(61.05%) 42,468,968	43.19 (18,343)	37.50 (15,926)	14.33 (6084)
1	(10.34%) 815,705	(10.18%) 7,082,255	99.01 (7012)	73.72 (5221)	94.86 (6718)
2	(8.95%) 706,274	(8.52%) 5,926,532	114.91 (6812)	81.92 (4855)	105.12 (6231)
3	(11.93%) 941,093	(11.10%) 7,723,631	136.31 (10,528)	92.90 (7175)	123.65 (9550)
4 +	(10.57%) 833,622	(9.15%) 6,362,689	165.65 (10,539)	110.06 (7003)	154.76 (9847)
Disability					
Yes	(17.47%) 1,378,530	(16.46%) 11,448,419	114.44 (13,102)	82.04 (9392)	80.96 (9269)
No	(82.53%) 6,510,556	(83.54%) 58,115,756	69.06 (40,132)	52.98 (30,788)	50.18 (29,161)

**Table 1.** Characteristics of the entire population of older adults born before 1951 (from the year 2010), including crude incidence rates of 3 outcomes for the entire study period (2010–19) across levels of all covariates.



Table 2 presents the adjusted hazards ratios (HRs) for SRB hospitalisation and deaths, stratified by gender. In general, the direction of effects is consistent across both genders. Regarding the association between SRB and income levels (i.e. lowest (Q1) to highest (Q4), excluding NBLSS recipients), individuals with lower incomes report an elevated event rate for SRB hospitalizations and deaths. For instance, for men in the Q1 income group compared to the Q4 group, the rate is increased by a factor of 1.47 (95% CI 1.43 to 1.52) while for women the rate is 1.14 times higher (95% CI 1.09 to 1.18). Individuals with unreported income (e.g. prisoners or soldiers) also show a higher rate compared to the Q4 income bracket. SRB deaths, in particular, display a dose–response relationship across genders, where a transition from the Q4 bracket to lower ones reflects an increase in the relative event rate, unlike the pattern for hospitalisations. Furthermore, the effects of income on mortality were stronger in men than women (e.g. 1.47 times the hazard in Q1 vs Q4 for men, and 1.14 times the hazard in Q1 vs Q4 for women). While rural men and women had twice the hazard of SRB hospitalisation compared to their urban counterparts, rural status was not associated with SRB deaths. Similar to the descriptive analysis, individuals who are not employed and individuals with disabilities had higher rates of SRB hospitalizations and deaths.

With regards to the comparison between the groups that are living in poverty (i.e. Q1 and NBLSS), Table 3 presents the results of the non-parametric bootstrap difference test, highlighting the significance of the difference between NBLSS and Q1. The results show that, for both men and women, those in the NBLSS group had consistently lower hazards for SRB hospitalisation and deaths compared to the Q1 group, despite being in a lower income, suggesting that there is some evidence that the NBLSS program may offer protection against SRB risk. The difference between Q1 and NBLSS was larger in men than women, e.g. for SRB deaths, being in Q1 was associated with 0.22 higher hazards ratio (95% CI 0.21 to 0.23) than NBLSS among men, but the difference was 0.11 (95% CI 0.10 to 0.12) in women.

Results from a series of sensitivity analyses are available in Supplementary Tables 2 and 4. The results are substantially similar to the main findings. First, the estimated hazard ratios are similar to those estimated in the flexible parametric survival model, which shows that our results are robust to the changes in the hazard function

	Men		Women	
	SRB Death	SRB hospitalisation	SRB Death	SRB hospitalisation
Rural/urban				
Urban	Reference	Reference	Reference	Reference
Rural	1.02 (0.99 to 1.05)	2.15 (2.08 to 2.21)	1.00 (0.96 to 1.04)	2.02 (1.95 to 2.08)
SES				
Q4 (highest)	Reference	Reference	Reference	Reference
Q3	1.17 (1.13 to 1.20)	1.14 (1.09 to 1.18)	1.10 (1.06 to 1.15)	1.09 (1.04 to 1.14)
Q2	1.33 (1.29 to 1.38)	1.20 (1.15 to 1.26)	1.12 (1.07 to 1.18)	1.15 (1.09 to 1.21)
Q1	1.47 (1.43 to 1.52)	1.14 (1.09 to 1.19)	1.17 (1.12 to 1.22)	1.10 (1.05 to 1.15)
NBLSS (lowest)	1.26 (1.21 to 1.32)	0.91 (0.86 to 0.97)	1.06 (1.01 to 1.11)	0.98 (0.94 to 1.04)
Others (unknown)	1.11 (1.03 to 1.1)	1.16 (1.06 to 1.27)	1.15 (1.04 to 1.26)	1.22 (1.11 to 1.35)
Comorbidity				
0	Reference	Reference	Reference	Reference
1	2.32 (2.24 to 2.41)	7.27 (6.94 to 7.62)	2.34 (2.23 to 2.45)	5.83 (5.52 to 6.16)
2	2.57 (2.48 to 2.66)	7.40 (7.04 to 7.77)	2.77 (2.64 to 2.90)	6.98 (6.61 to 7.38)
3	3.08 (2.99 to 3.18)	8.20 (7.84 to 8.58)	3.13 (3.00 to 3.27)	8.72 (8.28 to 9.19)
4+	3.48 (3.37 to 3.59)	9.63 (9.20 to 10.09)	3.99 (3.82 to 4.16)	11.38 (10.79 to 12.00)
Employment status				
Employed	Reference	Reference	Reference	Reference
Not in the labour market	2.21 (2.10 to 2.32)	1.97 (1.84 to 2.11)	2.23 (1.90 to 2.61)	1.74 (1.50 to 2.02)
Disability				
Yes	Reference	Reference	Reference	Reference
No	1.22 (1.19 to 1.25)	1.091 (1.05 to 1.13)	1.19 (1.15 to 1.24)	1.09 (1.05 to 1.13)
Age	0.96 (0.96 to 0.96)	0.97 (0.97 to 0.97)	0.94 (0.94 to 0.95)	0.97 (0.97 to 0.97)

Table 2. Adjusted hazard ratios for the risk of SRB death and hospitalisation by gender from Cox regression.

	Men		Women	
	SRB death	SRB hospitalisation	SRB Death	SRB hospitalisation
Q1—NBLSS	0.22 (0.21 to 0.23)	0.23 (0.22 to 0.24)	0.11 (0.10 to 0.12)	0.12 (0.11 to 0.12)

Table 3. Posthoc test for difference in hazards between NBLSS (lowest SES) and Q1 (second lowest SES), 95% CI obtained from 10,000 bootstrap samples.

used. Second, the models for a) deaths from self-harm only and b) hospitalizations for suicide attempts (excluding probable suicide attempts) have similar results (i.e. direction and strength of associations) compared to their respective counterpart models in the main analyses, particularly for levels of income, which suggests that the addition of deaths from undetermined intent and hospitalizations from probable suicide attempts may not have biased our results. The models that used inverse probability weighted Cox regression (Supplemental Table S4) shows that the estimated hazard ratios are similar to those in the main model, which implies that there was no evidence of systematic censoring that may bias our results.

## Discussion

The present study found that the income gradient in suicide mortality (with stronger linear trends in men than women); however, the risk of SRB hospitalization across levels of income appears in two clusters (i.e. where Q1-3 had similar high risk vs Q4 with lower risk). In addition, the strength of association between each risk factor and both outcomes were similar between men and women, the effect of poverty appear to vary by gender, i.e. income disparity in SRB hospitalization and suicide deaths were consistently stronger in men than women. Among the two lowest income groups (i.e. Q4 and NBLSS), post-hoc test provides evidence that enrollment in NBLSS may help reduce the risk of SRB. Specifically, while those in Q1 have slightly higher incomes than the NBLSS group, the risk of SRB death and hospitalisation are consistently higher in the Q1 group relative to the NBLSS group for both men and women (all difference significant at  $p < 0.01$ ) after accounting for the effects of covariates.

The association between poverty and SRB can be explained by well-established literature supporting the importance of income and material conditions for health and health inequalities. Financial security not only allows for access to necessary goods and services, such as adequate housing and diet, but may also help reduce exposure to psychosocial risk factors (e.g., stressful life events)<sup>35</sup>. Therefore, social epidemiological investigations have focused on the protective role of the social welfare state functions that provides a minimum level of financial security<sup>36,37</sup>. The consistent income gradient in health and protection offered by NBLSS may explain the patterns observed in our study.

Our finding that low-income was associated with high SRB risk in older adults is similar to a previous Korean study: Choi et al. using the NHID found that the poor population among older adults aged 60+ had higher relative rates by a factor of 1.34 for suicide deaths from 2002 to 2013<sup>19</sup>. In addition, among older adults (50+) in Korea admitted to the hospital for any injuries, a prior study found that comorbid conditions and poverty status were major risk factors for self-harm injuries<sup>38</sup>. However, this study has limited generalizability since it only included patients who were hospitalised rather than the general population. Furthermore, the study only used a simple logistic regression model that failed to account for time trends (e.g. economic downturns that can change patterns of suicide attempts). We also found that enrollment in the NBLSS (i.e. social assistance) was associated with reduced SRB risk. This is consistent with previous studies based in the US. In the US, the Old-Age Assistance is a means-tested income assistance program that was implemented in 1935 as part of the Social Securities Act. A prior American study found the introduction of program was associated with a 30% reduction in suicide mortality relative the counterfactual<sup>39</sup>. Similarly, another study found that the Old-Age Assistance program was associated with a 22.4% reduction in suicide deaths<sup>40</sup>.

There are some limitations associated with this study. First, our measure of SRB hospitalization (which included probable suicide attempts) was not validated, although we supplemented the results with the sensitivity analysis using the outcome of hospitalization for suicide attempts only, which likely underestimate the true number of attempts. Second, we did not adjust for marital status due to the data availability in the NHID, but spousal deaths may be a major risk factor for self-harm in older adults<sup>41</sup>. Third, biases may also arise given that there may have been old people in poverty who had already died (by suicide or other causes), before the study period started. Lastly, while this paper is focused on poverty and a public assistance program as the main exposure, our models also show many other important characteristics associated with SRB death and hospitalization (e.g. unemployment and comorbidity) that is beyond the scope of our discussions. Despite the limitations, this study utilized a large health administrative data where the information on the entire non-institutionalized older population was included to provide strong evidence on the effects of poverty and a social security program on suicide deaths and attempts. All predictors in our models including levels of income and healthcare utilisation were not self-reported, which improves the reliability and validity of the results.

In our study, we provide preliminary evidence that social assistance targeting older adults in Korea may help reduce suicide mortality and attempts. The expansion of NBLSS, so that more older adults living in poverty may qualify for its benefits, will likely help to reduce suicide-risk in this vulnerable subpopulation. Further research involving international and counterfactual comparisons are needed to further develop strong evidence to support policies on old-age social assistance to reduce SRB.

## Data availability

Although data are accessible from the National Health Insurance (NHI) database, the access to data used in this study is provided only for the researchers who have applied for and have obtained permission. Further information is available on the online homepage of NHI Sharing Service (<https://nhiss.nhis.or.kr>). The data that support the findings of this study are available from the corresponding author, Antony Chum, upon reasonable request.

Received: 13 March 2023; Accepted: 10 May 2024

Published online: 18 July 2024

## References

- World Health Organization. *Suicide Mortality Rate (per 100,000 population) - OECD Members* | Data. <https://data.worldbank.org/indicator/SH.STA.SUIC.P5?locations=OE> (2019).
- Statistics Korea. *National Indicator*. <https://www.index.go.kr/unity/potal/main.do?sessionId=fY9GlCT6S6qcgjmQKCKIq7dXRyYp-KEfjzvb4-Y.node11> (2023).
- Lee, J. & Oh, Y. E. Effect of social exclusion on depression and suicidal ideation among the elderly in Korea: Focus on gender differences. *Korean J. Community Living Sci.* **27**, 831–850 (2016).
- Heo, U., Jeon, H., Kim, H. & Kim, O. The political economy of South Korea: Economic growth, democratization, and financial crisis. *Md. Ser. Contemp. Asian Stud.* **2008**, 1 (2008).
- OECD. *Korea—OECD Data*. <http://data.oecd.org/korea.htm>.
- The World Bank. *Glossary* | DataBank. <https://databank.worldbank.org/metadataglossary/world-development-indicators/series/SI.POV.GINI>.
- OECD. *Old-Age Income Inequality is High in Korea*. (2022).
- OECD. *Poverty Rate*. <https://www.oecd-ilibrary.org/content/data/0fe1315d-en> (2018).
- OECD. *Sustaining the Miracle on the Han River* (OECD, 2021). <https://www.oecd.org/country/korea/thematic-focus/sustaining-the-miracle-on-the-han-river-103653fa/>.
- Kim, Y. K., Lee, Y., Choi, S., Kim, G. & Lim, S. The diversification of family structure and the role of families and governments in family support. *Sejong KIHASA* (2015).
- Kye, B. & Choi, Y. Are parents and children coresiding less than before? An analysis of intergenerational coresidence in South Korea, 1980–2015. *Demogr. Res.* **45**, 1–16 (2021).
- OECD. *Elderly Population* (OECD, 2014).
- Jeon, B., Noguchi, H., Kwon, S., Ito, T. & Tamiya, N. Disability, poverty, and role of the basic livelihood security system on health services utilization among the elderly in South Korea. *Soc. Sci. Med.* **178**, 175–183 (2017).
- Social Development Division. *Income Security for Older Persons in the Republic of Korea*. <https://www.unescap.org/sites/default/d8files/knowledge-products/SDD%20Working%20Paper%20Ageing%20Income%20ROK%20v1-4.pdf> (2015).
- Ministry of Health and Welfare. *Median Income as of 2022, Criteria for Selection of Livelihood and Medical Benefits, and Minimum Level of Guarantee*. <https://www.law.go.kr/%ED%96%89%EC%A0%95%EA%B7%9C%EC%B9%99/2022%EB%85%84%EA%B8%B0%EC%A4%80%EC%A4%91%EC%9C%84%EC%86%8C%EB%93%9D%EB%B0%8F%EC%83%9D%EA%B3%84%C2%B7%EC%9D%98%EB%A3%8C%EA%B8%89%EC%97%AC%EC%84%A0%EC%A0%95%EA%B8%B0%EC%A4%80%EA%B3%BC%EC%B5%9C%EC%A0%80%EB%B3%B4%EC%9E%A5%EC%88%98%EC%A4%80> (2021).
- Choi, J. W. *et al.* Medical security and catastrophic health expenditures among households containing persons with disabilities in Korea: A longitudinal population-based study. *Int. J. Equity Health* **15**, 1–8 (2016).
- Statistics Korea. *Recipients of National Basic Livelihood Security System*. [https://kosis.kr/statHtml/statHtml.do?orgId=622&tblId=DT\\_62201\\_K000027](https://kosis.kr/statHtml/statHtml.do?orgId=622&tblId=DT_62201_K000027) (2023).
- Silverman, M. M., Berman, A. L., Sanddal, N. D., O'Carroll, P. W. & Joiner, T. E. Rebuilding the tower of babel: A revised nomenclature for the study of suicide and suicidal behaviors part 2: Suicide-related ideations, communications, and behaviors. *Suicide Life. Threat. Behav.* **37**, 264–277 (2007).
- Choi, J. W., Kim, T. H., Shin, J. & Han, E. Poverty and suicide risk in older adults: A retrospective longitudinal cohort study. *Int. J. Geriatr. Psychiatry* **34**, 1565–1571 (2019).
- Lee, H.-Y., Hahm, M.-I. & Park, E.-C. Differential association of socio-economic status with gender- and age-defined suicidal ideation among adult and elderly individuals in South Korea. *Psychiatry Res.* **210**, 323–328 (2013).
- Jeong, S., Cho, S. & Kong, S. Y. Effect of income level on stroke incidence and the mediated effect of simultaneous diagnosis of metabolic syndrome diseases; a nationwide cohort study in South Korea. *Diabetol. Metab. Syndr.* **14**, 110 (2022).
- Lee, J., Lee, J. S., Park, S.-H., Shin, S. A. & Kim, K. Cohort profile: The national health insurance service–national sample cohort (NHIS-NSC), South Korea. *Int. J. Epidemiol.* **46**, e15–e15 (2017).
- Oderkirk, J. *Survey Results: National Health Data Infrastructure and Governance* (2021).
- Snowdon, J. Comparing rates and patterns of male suicide and “hidden suicide” between nations and over time. *JOMH* **17**, 7–16 (2021).
- Ohberg, A. & Lonnqvist, J. Suicides hidden among undetermined deaths. *Acta Psychiatr. Scand.* **98**, 214–218 (1998).
- Cha, E. S., Chang, S.-S. & Lee, W. J. Potential underestimation of pesticide suicide and its impact on secular trends in South Korea, 1991–2012. *Inj. Prev.* **22**, 189–194 (2016).
- Lee, K.-S. *et al.* Suicide attempt-related emergency department visits among adolescents: A nationwide population-based study in Korea, 2016–2019. *BMC Psychiatry* **22**, 418 (2022).
- Kim, H. *et al.* Risk of suicide attempt after thyroidectomy: A nationwide population study in South Korea. *Psychiatry Investig.* **18**, 39 (2021).
- Kim, H. *et al.* Risks of suicide attempts after prescription of zolpidem in people with depression: A nationwide population study in South Korea. *Sleep* **43**, zsz235 (2020).
- Shin, D. W., Cho, B. & Guallar, E. Korean national health insurance database. *JAMA Intern. Med.* **176**, 138–138 (2016).
- University of Manitoba. *Concept: Charlson Comorbidity Index*. <http://mchp-appserv.cpe.umanitoba.ca/viewConcept.php?conceptID=1098> (2021).
- Miladinovic, B. *et al.* A flexible alternative to the Cox proportional hazards model for assessing the prognostic accuracy of hospice patient survival. *PLoS ONE* **7**, e47804 (2012).
- Stensrud, M. J. & Hernán, M. A. Why test for proportional hazards? *Jama* **323**, 1401–1402 (2020).
- Hess, K. R. Graphical methods for assessing violations of the proportional hazards assumption in Cox regression. *Stat. Med.* **14**, 1707–1723 (1995).
- Skalická, V., van Lenthe, F., Bambra, C., Krokstad, S. & Mackenbach, J. Material, psychosocial, behavioural and biomedical factors in the explanation of relative socio-economic inequalities in mortality: Evidence from the HUNT study. *Int. J. Epidemiol.* **38**, 1272–1284 (2009).
- Bambra, C. Health inequalities and welfare state regimes: Theoretical insights on a public health ‘puzzle’. *J. Epidemiol. Community Health* **65**, 740 (2011).
- Kim, C. *et al.* Do social protection programmes have a causal effect on suicide mortality? A protocol for a systematic review and meta-analysis. *BMJ Open* **12**, e054677 (2022).
- Kim, S., Jeon, H. & Park, J. The association of physical and mental illness and self-harm resulting in hospitalization: A population-based study of older adults in South Korea. *Int. J. Environ. Res. Public Health* **19**, 8303 (2022).
- Stoian, A. & Fishback, P. Welfare spending and mortality rates for the elderly before the Social Security era. *Explor. Econ. Hist.* **47**, 1–27 (2010).
- Emery, J. H. & Matheson, J. A. Should income transfers be targeted or universal? Insights from public pension influences on elderly mortality in Canada, 1921–1966. *Can. J. Econ. Can. Décon.* **45**, 247–269 (2012).
- Pitman, A., Osborn, D., King, M. & Erlangsen, A. Effects of suicide bereavement on mental health and suicide risk. *Lancet Psychiatry* **1**, 86–94 (2014).



### Author contributions

CK and AC conceived the idea of the paper. HJ and CK curated the data and conducted the analysis. CK, GJD, and AC wrote the main manuscript text. All authors reviewed the manuscript.

### Funding

Funding for this project was provided by the project principal investigator (Antony Chum) through the Canada Research Chair Program (CRC-2021-00269).

### Competing interests

The authors declare no competing interests.

### Additional information

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1038/s41598-024-61845-2>.

**Correspondence** and requests for materials should be addressed to A.C.

**Reprints and permissions information** is available at [www.nature.com/reprints](http://www.nature.com/reprints).

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2024