

The Contribution of Material, Behavioral, Psychological, and Social-Relational Factors to Income-Related Disparities in Cardiovascular Risk Among Older Adults

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Background: Understanding the factors underlying health disparities is vital to developing strategies to improve health equity in old age. Such efforts should be encouraged in Korea. **Objective:** This study explored how material, behavioral, psychological, and social-relational factors contribute to income-related disparities in cardiovascular risk among Korean adults 65 years and older. **Methods:** This was a secondary analysis of Korean National Health and Nutrition Examination Survey data (2013–2017), targeting 7347 older adults (≥ 65 years). Socioeconomic position, defined as income, was the primary indicator. The outcome was binary for predicted cardiovascular risk (<90 vs ≥ 90 percentile). Disparities were measured using relative index of inequality (RII). The contributions of material, behavioral, psychological, and social-relational factors were estimated by calculating percentage reduction in RII when adjusted for these factors. **Results:** Among men aged 65 to 74 years and women 75 years or older, the largest reductions in RII were achieved after adjusting for social-relational factors. Among men 75 years or older and women aged 65 to 74 years, adjusting for material factors resulted in the largest reductions in RII. Adjustments for behavioral factors also reduced RII for both genders aged 65 to 74 years. **Conclusions:** Improving the social, material, and behavioral circumstances of lower-income older adults may help address income-related disparities in cardiovascular risk in old age.

KEY WORDS: aged, cardiovascular diseases, health status disparities, income, Korea

Health disparities disproportionately affecting people of lower socioeconomic position (SEP) has been an ongoing concern in cardiovascular health globally.¹ Promising approaches to reduce these disparities

are increasingly described in the literature. In particular, researchers argue that understanding various factors underlying disparities is crucial to developing effective strategies to improve health equity.^{2,3}

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The conceptual framework of the social determinants of health proposed by the World Health Organization⁴ is particularly useful to address a range of factors that underlie cardiovascular disparities. The framework explains how SEP affects populations' health through a set of *intermediary determinants of health*; notably, material, behavioral, psychological, and social-relational factors have been identified as important modifiable intermediary factors.⁴ Indeed, studies have successfully explained socioeconomic disparities in cardiovascular health using these factors.^{5–12}

Specifically, studies have shown that SEP primarily impacts cardiovascular health through material resources such as financial resources; working and housing conditions; or access to goods, services, and healthcare.^{5,6} Others argue that health-damaging lifestyle choices such as smoking, physical inactivity, and unhealthy diets (which are found more often in socioeconomically deprived people) are the main contributors to poor cardiovascular health among populations.^{5–8} Some research emphasizes that psychological or emotional distress such as stress, depression, or anxiety are also unevenly experienced by people of lower SEP, further contributing to social inequalities in cardiovascular health.^{6,8,9} Finally, social-relational factors such as marital status and living arrangement are important determinants of cardiovascular health¹⁰ and considered some of the main underlying mechanisms behind cardiovascular health disparities.^{11,12} Importantly, interventions addressing material, behavioral, psychological, and social-relational issues help reduce health disparities in low SEP individuals.^{2,3}

Many established models support the additional influence of material, behavioral, psychological, and social-relational factors on cardiovascular health outside the influence of old age.¹³ Yet, to our knowledge, no Western studies have comprehensively investigated the influence of these intermediary factors on the effects of SEP on cardiovascular outcomes in older adults; existing research investigated only 1 or 2 intermediary factors to explain the mechanisms behind these disparities.^{14,15} Nursing research in South Korea (hereafter “Korea”) follows a similar pattern. As revealed by a recent review by Lee and Im,¹⁶ studies in Korea exploring the mechanisms linking SEP and cardiovascular health largely focus on the working-age population. Many Korean researchers have examined the influence of lifestyle behaviors,¹⁷ access to health services,¹⁸ depression,¹⁹ or suicidal ideation²⁰ on cardiovascular health in older adults. However, they did not consider socioeconomic variation in these factors and its subsequent impact.

Because of the rapidly aging population of Korea, the rate of individuals with or at risk of cardiovascular diseases (CVDs) is increasing.²¹ A volume of studies has reported that such cardiovascular health conditions are closely related to low SEP among older Korean adults.^{22–25} In particular, Lee and colleagues revealed that socioeconomic

disparities in cardiovascular risk among older adults have persisted from 2008 and have widened recently.²⁵ Understanding the intermediary factors underlying these disparities may help develop effective strategies to improve cardiovascular health equity for older Korean communities.

With this in mind, this study aimed to explore how the material, behavioral, psychological, and social-relational factors to the association between SEP and cardiovascular outcomes among older adults in Korea. Considering that Korea is a rapidly aging society with widening socioeconomic gaps associated with various issues including cardiovascular health disparities, lessons learned from this analysis can provide useful insights into addressing health disparities in countries facing a similar challenge.

METHODS

Sample

This study was based on the Korean National Health and Nutrition Examination Survey (KNHANES) conducted by the Korea Centers for Disease Control and Prevention. The KNHANES provides reliable statistics on the health and nutritional status of the Korean population through nationwide cross-sectional surveys. The target population consists of nationally representative noninstitutionalized civilians in Korea. Each survey year includes a new sample of approximately 10 000 individuals 1 year and older. As of 2007, the KNHANES is an annual rolling survey that uses a stratified, multistage, clustered sampling method to allow for annual analysis of nationally representative sample data. Sampling units were based on geographical area, gender, and age using household registries. The KNHANES is composed of 3 distinct sections: a health interview survey, a health examination survey, and a nutrition survey for dietary assessment. The present study uses the health interview and health examination survey.

Our study population was limited to adults 65 years or older. To explore the underlying factors contributing to cardiovascular health disparities, data collected from January 2013 to December 2017 were pooled; this period reflects a time when income disparities in cardiovascular risk generally persisted and even widened among older adults in Korea.²⁵ We removed individuals with a history of CVD ($n = 104$) and or missing components of the cardiovascular risk assessment data ($n = 397$). This selection led to a final sample of 7311 (57.5%, women). This study received institutional review board approval from the institution with which the authors are affiliated.

Measures

Cardiovascular Risk

We operationalize the term “cardiovascular health” as the risk of developing CVD over a 10-year period. We

determined the individual risk for CVD using a health risk appraisal model for coronary heart disease developed using data from the Korean Heart Study.²⁶ This model was developed using a multivariate Cox proportional hazard model based on retrospective cohort data, in the same way as the Framingham risk assessment instrument.²⁷ The proposed model was later validated through a test of a random representative sample of the Korean population enrolled in the national insurance system.²⁸

The first step in estimating the future risk of CVD was to calculate the summation of categorical values for the following major CVD risk factors: (a) gender, (b) age, (c) total cholesterol, (d) high-density lipoprotein cholesterol, (e) systolic blood pressure, (f) smoking, and (g) diabetes (Supplemental Digital Content 1, <http://links.lww.com/JCN/A131>). This generates a continuous risk score, with lower scores indicating better cardiovascular health. We used the score to identify binary levels of CVD risk, defined as low-level and high-level risk groups. As suggested in the literature,^{29,30} we defined the high-risk group when the risk score was 90 percentile or higher in each gender, as the proposed model was validated by comparing actual events and prediction of events according to the decile of predicted risk for each gender.

Socioeconomic Position Measures

Income was used as a measure of SEP as it describes important aspects of the health disparities in Korea after the economic crisis in the 1990s. In particular, we used equivalized income, which takes into account the differences in a household's size and composition.³¹ Equivalized income was divided into quartiles following the criteria for categorizing the income level provided by the annual KNHANES report.

Intermediary Determinants

Material, behavioral, psychological, and social-relational intermediary factors were defined based on the items proposed in Moor et al³² and the availability of the relevant variables in the KNHANES dataset.

Material Factors

Material factors were defined with the variables that assessed home ownership, barriers to accessing health care, and having private health insurance. Home ownership was assessed with 3 categories of "1 home," "more than 1 home," or "renters." The presence of barriers to accessing healthcare or private health insurance was each recorded using the binary answers of yes or no. Barriers to accessing healthcare were assessed with a binary question, "Have you encountered any barriers when accessing the healthcare system in the past year for any reason?" Having private health insurance was assessed with a binary question, "Do you have a private health insurance?"

Behavioral Factors

Three types of health behavior were considered: alcohol consumption, regular exercise, and attendance at health check-ups. The item "alcohol consumption" was categorized into 2 levels as moderate (≤ 1 time/week and ≤ 2 drinks/1 occasion for women; ≤ 2 time/week and ≤ 3 drinks/1 occasion for men) and heavy (≥ 2 times/week or > 2 drinks/1 occasion for women; ≥ 2 time/week and > 3 drinks/1 occasion for men) based on the National Institute on Alcohol Abuse and Alcoholism criteria.³³ Regular exercise and attendance at health check-ups took a binary answer of "yes" or "no." Health check-ups were measured by a single question: "Have you had a general health check-up over the past few years?" Lastly, regular physical activity was defined by the fulfillment of "sufficient activity" by the Korean version of the International Physical Activity Questionnaire.³⁴

Psychological Factors

Psychological factors included perceived stress level, anxiety/depression, and suicidal ideation. Perceived level of stress was defined with the variable asking how much stress the participant usually experience. The participants answered using the following 4-point Likert scale response categories: never or rarely, sometimes, a lot of the time, and most or all of the time. Anxiety/depression was assessed using the anxiety-depression subscale from the EuroQol 5-dimensional questionnaire.³⁵ This subscale takes 1 of 3 ordinal scale answers: "I do not feel anxious or depressed," "I feel somewhat anxious or depressed," and "I feel very anxious or depressed." Suicidal ideation was defined with a variable asking "Have you had suicidal thoughts?" which took a binary answer of "yes" or "no."

Social-Relational Factors

Two social-relational factors were defined using the marital status and living arrangement variables. Marital status was dichotomized as married/partnered or unmarried/unpartnered. For living arrangements, we used the categories as defined in the dataset: living alone or lived with others (1 vs 2 or more people in the household).

Statistical Analysis

Given the importance of the age- and gender-specific analysis in disparity research,³⁶ all analyses were conducted separately by age (65–74 and ≥ 75 years) and gender groups (men, women). We first described the distribution of the 4 intermediary factors separately by the income levels and examined statistical associations between intermediary factors and income level using the χ^2 test. In preliminary analyses, the prevalence and the relative risks (RRs) of high CVD risk were reported by the income levels and the intermediary factors. Generalized linear models for binomial data were used

to estimate the RR, and the calculation of RR was adjusted for survey year (2013–2017).

In the main analyses, we used the following steps to assess the contribution of 4 groups of intermediary factors to the explanation of income disparities in cardiovascular risk: (1) The relative index of inequality (RII)³⁷ was calculated to assess the magnitude of the association between income and the outcome variable (ie, binary levels of CVD risk); (2) we estimated the extent of the reduction in the RII adjusted for intermediary factors; and (3) several combinations of intermediary factor subsets were further adjusted to explore their direct and indirect contributions.

To calculate the RII, the population in each income stratum was assigned a Redit score, calculated based on the midpoint of the range in the cumulative distribution of sample in each stratum.³⁸ This score was then used in generalized linear models, with a logarithmic link function to model RIIs. Values of RII larger than 1 imply that the likelihood of being in a high-CVD risk group is higher in the lower income group. We calculated the RII adjusted for survey year (initial base model), adjusted separately for each intermediary factor group, and finally adjusted for all factors. The percentage reduction in the RII was used to calculate the mediation proportion (attenuation) for each adjustment using Equation 1³⁹:

$$\frac{(\text{RII}_{\text{base}} - \text{RII}_{\text{model with the intermediary factor}}) / (\text{RII}_{\text{base}}) \times 100\%}{(1)}$$

The direct contribution was assessed by subtracting the percentage reduction in the RII of a model including all factors except for the given factor, from a model including all factors; this indicates the percentage of contribution that is attributable to the given factor alone. This method has been previously described and recommended,^{40,41} as the separate analysis (Equation 1) does not reveal the actual contribution of the intermediary factor. The indirect contribution was subsequently calculated by subtracting the direct contribution (of the given factor) from the total contribution of the given factor. More details on this calculation are given in Supplemental Digital Content 2, <http://links.lww.com/JCN/A132>.

All statistical analysis was performed using SAS, version 9.4 (SAS Institute, Cary, North Carolina). Sampling weights, strata, and cluster identifiers were incorporated to produce valid population estimates that accounted for the complex survey design of KNHANES. For the merged data, we calculated an integrated weight in proportion to the total number of primary sample units of each year.

There were approximately less than 13% of cases with missing data points for all variables, and the Little test⁴² revealed that the data were not missing completely

at random ($P < .001$). Participants with missing data did not differ from participants without missing data on cardiovascular risk or other baseline characteristics (bivariate analyses, $P > .060$). As data were not missing completely at random but showed no evidence of biased attrition, those data were considered missing at random. Although the multiple imputation technique is a recommended approach to deal with such data, it may not be well suited for the present analysis, which mainly comprises of categorical variables.⁴³ Therefore, the single imputation technique was used to preserve sample size. In particular, missing values on continuous variables were replaced by means of the expectation-maximization method. Missing values on categorical variables were replaced with the most common response category for each variable.

RESULTS

Distribution of Intermediary Factors for Different Income Quartiles by Age and Gender (Table 1)

Groups Aged 65 to 74 Years

The distributions of the material, psychological, and social-relational factors differ significantly across the income levels for both genders ($P < .001$); those with advantages in these factors were concentrated among the higher income groups. Regarding the behavioral factors, the higher income group had more regular exercisers in both genders ($P < .05$). The higher income groups tended to have more regular health check-ups than lower income groups in both genders, but this tendency was statistically significant only in men ($P < .001$). No significant difference was observed in alcohol consumption across income levels.

Groups 75 Years or Older

All material and social-relational factors differed significantly across income levels in both genders; the percentage of the disadvantaged conditions in material and social-relational factors was significantly higher in the lower income groups ($P < .05$). Among the behavioral factors, only moderate drinking showed a significant association with income level in men ($P < .001$), whereas only engaging in health check-ups was associated with income level in women ($P = .026$). There was no significant difference in the psychological factors across income levels in both genders.

Prevalence/RRs of High CVD Risk According to Different Income Quartiles and Intermediary Factors by Age and Gender (Table 2)

Groups Aged 65 to 74 Years

For both genders, lower income was associated with greater RR for a high CVD risk ($P < .01$). The RR was 2.96 times higher for men in the lowest income

TABLE 1 Distribution of Intermediary Factors for Different Income Quartiles by Age and Gender

Intermediary Factors	Groups Aged 65–74 Years								Groups 75 Years or Older							
	Men				Women				Men				Women			
	Income Quartiles ^a (%)				Income Quartiles ^a (%)				Income Quartiles ^a (%)				Income Quartiles ^a (%)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Material factors																
Home ownership																
1 house	52.3	53.0	54.4	54.3	47.9	55.6	52.1	53.7	46.1	49.9	59.1	59.7	47.5	56.9	55.6	50.1
>1 house	35.1	34.6	27.6	22.0	43.7	31.4	28.5	18.1	45.9	43.0	26.7	19.4	36.1	28.2	24.0	12.8
Renters	12.5	12.4	18.0	23.7	8.4	13.0	19.4	28.2	8.0	7.1	14.2	20.8	16.4	14.9	20.4	37.1
<i>P</i>			<.001				<.001				<.001				<.001	
Barriers to accessing healthcare																
No	93.8	93.5	91.4	85.5	91.0	89.3	84.1	79.7	97.2	95.8	93.2	85.5	87.2	85.6	85.7	77.5
Yes	6.2	6.5	8.6	14.5	9	10.7	15.9	20.3	2.7	4.2	6.8	14.5	12.8	14.4	14.3	22.5
<i>P</i>			<.001				<.001				<.001				.002	
Having private health insurance																
Yes	72.3	62.2	54.8	34.5	69.6	67.8	57.5	39.8	43.6	20.5	18.4	10.3	29.6	13.9	13.2	10.8
No	27.7	37.8	45.2	65.5	30.4	32.2	42.5	60.2	56.4	79.5	81.6	89.7	70.4	86.1	87.8	89.2
<i>P</i>			<.001				<.001				<.001				<.001	
Behavioral factors																
Alcohol consumption																
Moderate	41.8	50.4	49.6	47.4	86.5	88.2	87.2	86.2	37.1	54.4	57.2	61.8	92.1	91.2	90.0	87.3
Heavy	58.2	49.6	50.4	52.6	13.5	11.8	12.8	13.8	62.9	45.6	42.7	38.2	7.9	8.8	10	12.7
<i>P</i>				.309				.856			<.001					.288
Regular exercise																
Yes	52.9	44.5	43.2	41.6	38.5	41.5	36.4	28.2	44.6	34.9	33.1	33.3	29.5	24.2	23.1	19.6
No	47.1	55.5	56.8	58.4	61.5	58.5	63.6	71.8	55.4	65.1	66.9	66.7	70.5	75.8	76.9	80.4
<i>P</i>			.026				<.001					.362				.124
Attendance at health check-ups																
Yes	84.7	81.0	73.9	68.8	78.7	72.6	71.4	70.1	68.2	62.2	59.6	63.0	37.5	55.4	55.6	50.0
No	15.3	19	26.1	31.2	21.3	27.4	28.6	29.9	31.8	37.8	40.4	37.0	62.5	44.6	44.4	50.0
<i>P</i>			<.001				.147					.858			.026	
Psychological factors																
Perceived stress level																
Never or rarely	30.1	27.8	32.0	30.0	25.1	20.8	20.5	24.4	38.3	46.0	41.1	37.6	42.1	36.9	37.0	37.2
Sometimes	57.7	58.3	58.3	52.1	53.5	56.2	56.8	46.8	50.1	41.0	48.1	45.7	46.8	41.7	43.1	37.0
A lot of the time	11.1	12.3	7.5	14.2	15.9	18.8	16.9	23.9	8.1	10.2	7.3	12.9	9.0	18.5	17.4	20.3
Most or all the time	1.1	1.6	2.3	3.7	5.5	4.3	5.7	6.0	3.5	2.8	3.5	3.8	2.1	2.8	2.5	5.5
<i>P</i>			.030				.020					.643				.068
Anxiety/depression																
Not likely	89.6	90.8	87.9	82.1	86.5	85.3	78.5	74.2	90.5	86.1	86.6	81.6	84.7	87.1	77.4	77.8
Somewhat likely	9.5	5.8	10.7	16.0	12.6	12.8	18.8	20.8	6.8	12.8	10.8	14.9	12.4	9.9	18.6	16.0
Very likely	0.9	3.3	1.4	2.0	0.9	2.0	2.7	5.0	2.7	1.1	2.6	3.5	3.0	3.0	4.0	6.2
<i>P</i>			<.001				<.001					.247				.076
Suicidal ideation																
No	98.5	98.5	94.9	88.0	95.0	93.0	89.6	85.8	91.5	95.8	90.6	86.9	94.0	84.8	90.0	85.7
Yes	1.5	1.5	5.1	12.0	5	7	10.4	14.2	8.5	4.2	9.4	13.1	6.0	15.2	10.0	14.3
<i>P</i>			<.001				<.001					.142				.080
Social-relational factors																
Marital status																
Married/partnered	97.0	93.5	94.5	82.0	72.1	68.1	65.0	52.8	81.6	82.2	90.8	80.6	22.8	24.2	33.4	25.6
Unmarried/unpartnered	3.0	6.5	5.5	18.0	27.9	31.9	35	47.2	18.4	17.8	9.2	19.4	77.2	75.8	66.6	74.4
<i>P</i>			<.001				<.001					.021			.035	
Living arrangement																
≥2 people in the household	96.3	96.4	94.0	82.7	96.0	92.6	83.3	69.7	94.1	96.4	94.3	81.6	93.6	93.5	82.5	51.8
Living alone	3.7	3.6	6.0	17.3	4	7.4	16.7	30.3	5.9	3.6	5.7	18.4	6.4	6.5	17.5	48.2
<i>P</i>			<.001				<.001					<.001			<.001	

^aQuartile 1: ≥\$1801; quartile 2, \$1051–\$1800; quartile 3, \$601–\$1050; and quartile 4, ≤\$600.

Bold indicates significance.

group than for men in the highest. The RR was 1.95 times higher for women in the lowest income group than for women in the highest.

Among men, the RR was strongly associated with social-relational factors; the RR was 1.97 times greater for those who are unmarried or unpartnered ($P < .001$)

TABLE 2 Prevalence/Relative Risks of High Cardiovascular Disease Risk According to Different Income Quartiles and Intermediary Factors by Age and Gender

	Groups Aged 65–74 Years				Groups 75 Years or Older			
	Men		Women		Men		Women	
	%	RR ^a (95% CI)	%	RR ^a (95% CI)	%	RR ^a (95% CI)	%	RR ^a (95% CI)
Income								
Quartile 1 (≥\$1801)	4.8	1.00	6.7	1.00	2.4	1.00	6.7	1.00
Quartile 2 (\$1051–\$1800)	8.1	1.71 (0.85–3.42)	5.4	0.80 (0.39–1.64)	6.3	2.60 (0.55–12.43)	10.0	1.52 (0.67–3.45)
Quartile 3 (\$601–\$1050)	10.6	2.19 (1.19–4.03)	8.2	1.23 (0.66–2.25)	8.1	3.23 (0.76–13.69)	6.6	0.97 (0.40–2.36)
Quartile 4 (≤\$600)	14.3	2.96 (1.64–5.33)	13.0	1.95 (1.11–3.44)	12.3	5.29 (1.24–22.61)	10.2	1.56 (0.59–4.12)
<i>P</i> for χ^2 trend		.002		<.001		.008		.286
Intermediary factors								
Material factors								
Home ownership								
1 house	10.0	1.00	10.0	1.00	10.5	1.00	8.3	1.00
>1 house	10.2	0.98 (0.64–1.50)	7.2	0.72 (0.50–1.05)	7.6	0.67 (0.39–1.17)	8.8	1.07 (0.66–1.76)
Renters	12.2	1.21 (0.83–1.76)	12.6	1.27 (0.90–1.79)	11.0	1.05 (0.62–1.77)	11.3	1.36 (0.93–1.98)
<i>P</i>		.639		.035		.399		.260
Barriers to accessing healthcare								
No	10.2	1.00	9.4	1.00	8.8	1.00	9.4	1.00
Yes	12.8	1.25 (0.69–2.26)	11.7	1.22 (0.83–1.78)	18.2	2.12 (1.32–3.40)	8.8	0.93 (0.60–1.45)
<i>P</i>		.457		.271		.003		.743
Having private health insurance								
Yes	9.7	1.00	6.7	1.00	10.5	1.00	6.4	1.00
No	11.3	1.19 (0.86–1.64)	13.2	1.96 (1.47–2.61)	9.7	0.95 (0.56–1.60)	9.7	1.53 (0.82–2.88)
<i>P</i>		.412		<.001		.340		.167
Behavioral factors								
Alcohol consumption								
Moderate	10.7	1.00	9.7	1.00	10.9	1.00	9.7	1.00
Heavy	10.3	0.96 (0.70–1.33)	10.8	1.13 (0.76–1.67)	8.4	0.77 (0.50–1.19)	6.6	0.68 (0.41–1.14)
<i>P</i>		.824		.577		.241		.141
Regular exercise								
Yes	9.4	1.00	7.5	1.00	8.1	1.00	9.2	1.00
No	11.3	1.21 (0.88–1.66)	11.0	1.47 (1.06–2.04)	10.7	1.30 (0.85–2.01)	9.3	1.02 (0.68–1.52)
<i>P</i>		.222		.020		.199		.940
Attendance at health check-ups								
Yes	9.1	1.00	7.8	1.00	9.1	1.00	7.2	1.00
No	14.7	1.62 (1.16–2.26)	14.9	1.91 (1.44–2.53)	11.1	1.21 (0.79–1.85)	11.5	1.60 (1.13–2.26)
<i>P</i>		.005		.000		.370		.008
Psychological factors								
Perceived stress level								
Never or rarely	11.9	1.00	10.8	1.00	9.6	1.00	10.6	1.00
Sometimes	9.9	0.83 (0.58–1.19)	8.9	0.83 (0.59–1.17)	8.3	0.87 (0.54–1.41)	7.7	0.73 (0.49–1.08)

(continues)

TABLE 2 Prevalence/Relative Risks of High Cardiovascular Disease Risk According to Different Income Quartiles and Intermediary Factors by Age and Gender, Continued

	Groups Aged 65–74 Years				Groups 75 Years or Older			
	Men		Women		Men		Women	
	%	RR ^a (95% CI)	%	RR ^a (95% CI)	%	RR ^a (95% CI)	%	RR ^a (95% CI)
A lot of the time	7.8	0.66 (0.38–1.13)	10.5	0.97 (0.64–1.47)	17.7	1.81 (1.08–3.01)	8.7	0.82 (0.51–1.31)
Most or all the time	18.0	1.51 (0.63–3.64)	12.0	1.12 (0.63–1.99)	7.7	0.85 (0.33–2.22)	15.7	1.49 (0.80–2.76)
<i>P</i>		.271		.563		.027		.130
Anxiety/depression								
Not likely	9.9	1.00	10.0	1.00	9.7	1.00	9.3	1.00
Somewhat likely	14.3	1.45 (0.88–2.40)	8.7	0.86 (0.60–1.24)	10.7	1.13 (0.66–1.89)	7.5	0.82 (0.47–1.40)
Very likely	12.1	1.22 (0.53–2.78)	11.8	1.17 (0.59–2.29)	7.8	0.85 (0.31–2.35)	15.3	1.66 (0.93–2.95)
<i>P</i>		.235		.655		.850		.164
Suicidal ideation								
No	10.1	1.00	9.3	1.00	9.9	1.00	8.6	1.00
Yes	16.2	1.60 (0.85–3.08)	13.9	1.48 (1.01–2.19)	9.3	0.94 (0.50–1.74)	13.9	1.62 (1.05–2.47)
<i>P</i>		.166		.050		.857		.027
Social-relational factors								
Marital status								
Married/partnered	1.0	1.00	8.3	1.00	9.2	1.00	7.36	1.00
Unmarried/unpartnered	18.9	1.97 (1.37–2.83)	12.2	1.47 (1.09–1.97)	13.0	1.41 (0.91–2.17)	10.0	1.36 (0.88–2.09)
<i>P</i>		<.001		.009		.126		.163
Living arrangement								
No, ≥2 people in the household	10.0	1.00	8.9	1.00	9.3	1.00	8.2	1.00
Living alone	14.9	1.47 (1.02–2.14)	13.3	1.49 (1.13–1.97)	13.3	1.40 (0.86–2.27)	11.2	1.36 (0.99–1.89)
<i>P</i>		.044		.005		.151		.056

Bold indicates significance. Abbreviations: RR, risk ratio; CI, confidence interval. ^aAdjusted for survey year (2013–2017).

and 1.47 times greater for those who lived alone ($P = .044$). Those who had not engaged in health check-ups tended to have an increased RR ($P = .005$). The material factors and the psychological factors did not show any significant associations with RR in men.

For women, disadvantages in the 2 material factors were associated with increased risk; the RR was 1.27 times higher for those with no home ownership ($P = .035$) than those with 1 house and was 1.96 times higher ($P < .001$) for those without a private health insurance than those with a private health insurance. Those who had not engaged in regular exercise ($P = .02$) or health check-ups ($P < .001$) showed greater RRs. Furthermore, higher RRs were observed for those with disadvantages in all social-relational factors ($P < .01$). Similar to men, no significant associations were found regarding psychological factors in women.

Groups 75 Years or Older

Similar to the groups aged 65 to 74 years, the RRs tended to increase as the income level decreases, but this trend was statistically significant only for men ($P = .008$). For men, the lowest income group had 5.29 times greater RRs than the highest income group. In addition, the RRs increased significantly for men with barriers to healthcare access and higher levels of stress ($P = .003$). The RRs were significantly higher for women who had not engaged in health check-ups ($P = .008$) or had a suicidal ideation ($P = .027$). Although not significant, the RRs were higher for those who did not have partners or lived alone.

Percentage Reduction in RII When Adjusted for Intermediary Factors by Age and Gender (Table 3)

Groups Aged 65 to 74 Years

Among men, social-relational factors showed the highest impact on RII. When these factors were adjusted for in the model, RII was reduced from 3.09 to 2.80; that is, RII was reduced by 13.7%. Adjusting for the behavioral factors resulted in a 13.5% reduction in RII. The direct contributions of social-relational and behavioral factors to RII were 6.9% and 5.4%, respectively. When all intermediary factors were included, RII declined by 24.4%. Among women, there was a 31.8% reduction in RII when the material factors were adjusted for. The material factors also showed the largest direct contribution to RII (19.3%). Behavioral factors and social-relational factors attenuated RII by 15.2% and 14.0%, respectively. Adjustments for psychological factors reduced RII by only less than 2.0%. When all factors were adjusted for, RII declined by 47.5%.

Groups 75 Years or Older

Among men, adjusting for the material factors led to the largest reductions in RII (8.3%), and their direct contribution was 6.8%. The RII dropped by 7.4%

when adjusted for behavioral factors. However, adjustments for psychological and social-relational factors led to smaller reductions in RII. The RII was reduced by 16.8% when all factors were adjusted for. Among women, the largest reductions in RII were achieved after adjusting for the social-relational factors (32.0%), with the direct contributions of 23.3% reduction. The material factors reduced RII by 22.9%. Considering all intermediary factors, RII declined by 46.4%.

DISCUSSION

This study shows the presence of income-related disparities in cardiovascular risk among both men and women and demonstrates how a variety of potentially modifiable intermediary factors can influence those disparities across older Koreans. The importance of these factors differs by both gender and age group.

The Importance of Social-Relational Factors in Reducing Disparities

Among men aged 65 to 74 years, social-relational factors (ie, marital status and living arrangement) had an important influence on income disparities in cardiovascular risk. This was expected as all included variables were significantly associated with differentials in CVD risk while showing clear patterns based on income level. Our findings partly agree with other published studies on health disparities. For instance, Stringhini et al¹⁴ reported that low social integration (eg, family relations, positive/negative support, and loneliness) accounted for a partial degree of cumulative socioeconomic disparities in CVD mortality among British men older than 50 years. Khalatbari-Soltani et al¹⁵ revealed that being unmarried and living alone were both associated with a higher risk of CVD mortality among lower-income men older than 70 years in Australia.

Social-relational factors also had a significant role in income disparities of cardiovascular risk among women 75 years or older. These findings can be attributed to a strong association between social-relational factors and income seen in our analysis. Especially, most individuals who were unpartnered or lived alone were in the lower-income groups. This finding is somewhat intuitive considering the traditional paternal Korean culture where women tend to be subservient to and financially dependent on their husbands.⁴⁴ Combined with less conjugal social support, such economic instability may negatively impact cardiovascular health management; similar findings have been reported in a previous Korean study.⁴⁵

Although this study cannot be generalized, the present results help improve the understanding of social relationship's influence on cardiovascular health among disadvantaged older adults. In addition, the findings of this study also offer directions for future research and nursing practice. As suggested by the present results,

TABLE 3 Percentage Reduction in Relative Index of Inequality When Adjusting for Intermediary Factors by Age and Gender

	Groups Aged 65–74 Years				Groups 75 Years or Older			
	RII ^a (95% CI)	% Reduction	Direct Contributions ^b	Indirect Contributions ^c	RII ^a (95% CI)	% Reduction	Direct Contributions ^b	Indirect Contributions ^c
Men								
Base model	3.09 (1.76–5.43)				4.16 (1.79–9.66)			
+Material factors	3.00 (1.75–5.17)	4.1	-0.1	4.2	3.90 (1.61–9.42)	8.3	6.8	1.5
+Behavioral factors	2.81 (1.61–4.89)	13.5	5.4	8.1	3.93 (1.68–9.18)	7.4	6.2	1.2
+Psychological factors	2.90 (1.67–5.03)	9.1	1.7	7.4	4.20 (1.82–9.67)	-1.0	-1.3	0.2
+Social-relational factors	2.80 (2.34–2.39)	13.7	6.9	6.8	4.08 (1.75–9.50)	2.6	2.8	-0.2
All factors	2.58 (1.48–4.51)	24.4			3.63 (1.52–8.67)	16.8		
Women								
Base model	3.30 (1.87–5.80)				1.69 (0.82–3.45)			
+Material factors	2.56 (1.41–4.66)	31.8	19.3	12.6	1.53 (0.76–3.32)	22.9	13.5	9.3
+Behavioral factors	2.95 (1.67–5.18)	15.2	6.9	8.3	1.71 (0.83–3.35)	-3.5	7.6	-11.1
+Psychological factors	3.26 (1.84–5.76)	1.7	0.1	1.6	1.62 (0.79–3.30)	9.2	6.4	2.8
+Social-relational factors	2.97 (1.66–5.33)	14.0	8.8	5.2	1.47 (0.68–3.18)	32.0	23.3	8.7
All factors	2.21 (1.19–4.08)	47.5			1.37 (0.63–2.99)	46.4		

Abbreviations: RII, relative index of inequality; CI, confidence interval.

^aAdjusted for survey year (2013–2017).

^bThe direct contribution is calculated by [the percentage reduction in the RII from a model including all factors – the percentage reduction in the RII of a model including all factors except for the given factor]. The sum of direct contributions does not equal the percentage reductions shown by the full model as part of the total percentage reduction in the full model may be shared by multiple factors.

^cThe indirect contribution was subsequently calculated by subtracting the direct contribution (of the given factor) from the total contribution of the given factor.

interventional studies improving social relationships for older men are recommended to reduce health disparities. From clinical perspective, health practitioners should acknowledge the importance of social relations in improving cardiovascular health in the oldest-old women group.

The Importance of Material Factors in Reducing Disparities

Material factors explained the largest proportion of income disparities in cardiovascular risk among men 75 years or older, and this effect comes mainly from the contribution of access to healthcare. This finding extends upon previous Korean studies that showed that inadequate access to care has been associated with apparent disparities in cardiovascular health.^{46,47} Especially in Korea, many low-income oldest-old adults report inadequate access to their needed healthcare because of skyrocketing healthcare costs, limited noninsured services, and substantial out-of-pocket payments.⁴⁸ Furthermore, they have not benefitted from the equitable utilization of primary care and medical services as Korean society increasingly suffers residential segregation based on SEP.⁴⁹ According to previous evidence and the current findings, it is essential to implement targeted interventions or policies to improve access to healthcare in this age group. This is also an important global consideration in countries where social inequality in access to healthcare has been a great concern among the oldest-old population.⁵⁰

Material factors also contributed to the largest portion of the income disparities in cardiovascular risk among women aged 65 to 74 years, which corroborates the findings of previous studies.^{6,41,51} Among the material factors analyzed, private health insurance seemed to most significantly affect these disparities. Because of the insufficient coverage provided by public health insurance, many Koreans pay for supplementary insurance to receive diverse benefit packages and customized plan choice in the event of critical illness (eg, stroke or cancer).⁵² However, inequalities to access or maintain private health insurance have persisted among older adults in Korea owing to high premiums; this is especially prevalent among older women, whose premiums are generally 15% to 40% higher than the men's.⁵² This disparity may partially explain the present results. Although there are many debates on the role of private health insurance within the Korean healthcare system, the present results reinforce the importance providing affordable coverage to low-income women. Germany successfully addressed this issue with an aging reserve policy.⁵³

The Importance of Behavioral Factors in Reducing Disparities

Behavioral factors (ie, regular exercise and health check-ups) contributed to much of the income disparities in cardiovascular risk for both men and women aged 65

to 74 years. This finding indicates that behavioral interventions can be an effective means to improving cardiovascular outcomes and reduce health disparities. For instance, a social welfare program that included long-term exercise training successfully reduced the prevalence of metabolic syndrome among older Korean adults with low household incomes (average age, 67.5 ± 3.7 years).⁵⁴ A community-based CVD prevention program aimed at increasing physical activity has demonstrated promising results among low-income older adults with hypertension in Korea (average age, 72.64 ± 8.17 years).⁵⁵

Simultaneously, it is important to acknowledge that income levels also affect the behavioral factors investigated in this study. Interestingly, it seems that income impacts health check-up attendance, although all Korean adults older than 40 years are equally provided periodic health check-ups and screening programs without copayment. This suggests that greater efforts from multiple sectors should be carefully coordinated to ensure that individuals of all income levels, especially lower-income older adults, access their rightful health-promotion services.⁵⁴

Limitations and Strengths

This study had some limitations. First, given the limitations of a cross-sectional design, no causal conclusions could be drawn between income and cardiovascular risk. Second, although this study covers a balanced selection of material, behavioral, psychological, and social-relational factors from the main social contexts of the elderly, including a different set of variables in each factor may result in different estimations of contribution. Third, the original variables included in the secondary dataset potentially lacked depth because they were operationally defined by a single survey item or subset of test items. This may have influenced their estimated strengths as intermediary factors for this analysis. For example, psychological factors did not exert the greatest influence, although previous studies have reported the widening socioeconomic disparities in mental illness, especially among older adults in Korea.^{56,57} Fourth, although missing data were a relatively minor problem as about 87% of the data were present, the single imputation method may have introduced a bias as it does not consider uncertainty among imputed values. Lastly, although the analysis shows that intermediary factors can contribute to RII reduction, our estimates of the effect size may be imprecise; the RIIs estimated in this study show wide confidence intervals, which overlap substantially between the base model and the factor adjusted models. Such observed wide confidence intervals are common in this type of analysis, which reported health disparities using RII.^{58,59} Therefore, the present interpretations should be used with caution.

What's New and Important

- This is the first study to quantify the contribution of material, behavioral, psychological, and social-relational factors to cardiovascular risk among older Korean adults of differing SEPs.
- The present study shows that interventions that improve social and material living conditions in lower-income old individuals can be an effective means of reducing cardiovascular disparities in old age.
- This study's innovative use of an RII needs to be replicated with careful methodological considerations to confirm the influence of intermediary factors on cardiovascular health.

Despite these limitations, the present study used a large sample from a nationwide, population-based dataset to help minimize selection bias. In addition, all analyses were stratified by age and gender; therefore, the results should be useful for developing age- and gender-specific approaches that can effectively control cardiovascular risk among the elderly population across different socioeconomic statuses. Lastly, a better understanding of disparities in cardiovascular risk status could lead to early prevention strategies for preventing future disparities in CVD morbidity and mortality.

CONCLUSION

This study explored how material, behavioral, psychological, and social-relational factors contribute to disparities in cardiovascular risk among older Korean adults of differing incomes. The present results suggest that multiple factors are important for tackling these disparities and improving population health. In particular, the findings indicate that providing social-relational resources may be a valuable addition to strategies for reducing income disparities in cardiovascular risk among men aged 65 to 74 years and women 75 years or older. In addition, addressing material aspects such as access to healthcare services seems to be crucial when attempting to reduce cardiovascular risk among lower-income men 75 years or older and women aged 65 to 74 years. Lastly, behavioral interventions specifically targeted at lower income groups may also help reduce income disparities in cardiovascular risk for men and women aged 65 to 74 years.

Notably, our findings should be used to inform the current cardiovascular health-related interventions and policies in Korea, which historically emphasize behavioral aspects of health. Furthermore, the evidence presented should be used by healthcare professionals to identify and prioritize better CVD prevention and health promotion methods for older adults.

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