Cardiovascular Health Disparities among Older Adults in South Korea

by

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy in Nursing
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ABSTRACT

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Abstract

The number of older adults in South Korea has increased faster than in other countries. Along with this trend, the increasing burden of cardiovascular disease among this population is of growing national concern. Central to this concern is a highly disproportionate burden of the disease observed among individuals with a low socioeconomic position.

Older adults with a low socioeconomic position in South Korea are indeed a marginalized population who have been exposed to decades of socioeconomic disadvantages due to Korea's unique history. They have also been unfavorably affected by the socioeconomic support and healthcare system and experienced widening disparities in access to healthcare services, all of which may lead to greater disparities in cardiovascular health.

In Western countries, where cardiovascular disease is the leading cause of death and health disparities among older adults, researchers have consistently provided in-depth and evidence of changing disparities. They have suggested strategic solutions for policy and healthcare professionals to decrease the detrimental influences of socioeconomic position on health for this group. However, few studies have been conducted on disparities in cardiovascular health among older adults based on socioeconomic position in South Korea. Therefore, the purpose of this dissertation is to

explore disparities in cardiovascular health among older adults according to socioeconomic position in South Korea.

This dissertation is organized into five chapters. Chapter 1 introduces the overall research agenda. Chapter 2 provides a systematic review of the literature on socioeconomic disparities in cardiovascular health among Korean adults. Based on Chapter 1 and the findings of the systematic review, the data-driven chapters are constructed to address the following aims. First, Chapter 3 will examine time trends in socioeconomic disparities in cardiovascular health over the past decade among older adults in South Korea. Second, Chapter 4 will investigate the role of material, behavioral, psychological, and social-relational factors in the explanation of disparities in cardiovascular health among older adults in South Korea. Particularly in this dissertation, health disparities are defined as differences in health between two or more socioeconomic groups within a population.

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1. Introduction

1.1 Target population

Disparity in cardiovascular health is of international importance as cardiovascular disease (CVD) has been the dominant cause of death worldwide for at least 50 years (Stoney et al., 2018). Notably, socioeconomic disadvantages have featured consistently as a key pathway by which this disparity has emerged (Ruiz & Brondolo, 2016; WHO, 2010). Although there have been improvements in economic prosperity, public health, and health care, robust international data has proved that substantial disparities remain in cardiovascular health in relation to socioeconomic disadvantages (Pahigiannis et al., 2019).

Several groups have been defined as disparity groups in this field based upon existing evidence or pre-existing theories of which groups may be subjected to adverse social, health, or economic consequences. In particular, racial/ethnic minorities, immigrants, women, and older adults, who have been traditionally or historically exposed to more socioeconomic disadvantages, have been the focus of research (Glymour et al., 2014; Ski et al., 2014). Many researchers have demonstrated that the poverty, poor educational or occupational opportunities, and absent/inadequate healthcare coverage found in these groups have been translated to disproportionate cardiovascular morbidity and mortality (de Mestral & Stringhini, 2017; Okwuosa et al., 2016; Pool et al., 2017). Importantly, research has been critical for identifying disparities

in cardiovascular health among *older adults* across all groups (Li et al., 2016; Vásquez et al., 2018; Yan et al., 2016).

Indeed, older adults have been consistently noted to be a group with significant health disparities in the literature (Clark, 2017). There are three main explanations supporting this argument. The first is the "social class effect" in the process of aging: those with lower educational attainment or lower income are more likely to age faster than average, which accelerates age-related health deterioration in their later life (Park et al., 2012). The second explanation is based on the life-course theory (Kuh et al., 2003); serious deprivation of socioeconomic rights accumulates to increase the vulnerability of people, especially underserved individuals, to inferior healthcare and insufficient resources, negatively affecting later health. The third explanation is that increasing unfavorable circumstances in old age worsens the health of this already socioeconomically disadvantaged group, which widens the health gap further (Jang, 2013). For instance, the probability of being unemployed/underemployed, working at jobs that lack financial security, or having fewer social networks, all of which are often experienced by low- to lower-middle-class older individuals, are also more likely (Northwood et al., 2018). Additionally, rising healthcare costs and out-of-pocket financial burdens prevent the poor elderly from obtaining adequate health insurance coverage and benefits (Baird, 2016).

Importantly, these explanations support findings of increased or persistent disparities in the cardiovascular health in old age observed in several studies, signifying the importance of conducting disparities research in the cardiovascular field with this population. For instance, studies showed that when socioeconomic adversity operating at different life stages accumulates, large differences in CVD risk are intensified as age increases (Chichlowska et al., 2009; Landös et al., 2018). The Cardiovascular Health Study demonstrated significant relationships between indicators of low socioeconomic position (SEP; e.g., limited income, fewer assets, and unemployment) and the prevalence of subclinical CVD among an elderly cohort (Nordstrom et al., 2004; Parashar et al., 2009). In particular, these indicators were associated with the increased deprivation of access to or utilization of consistent and necessary health care, promoting higher incidence of cardiovascular events.

Accordingly, in Western society, several research, clinical, and policy efforts have been devoted to reducing disparities in cardiovascular health for older adults. For instance, clinical interventions to improve the cardiovascular health of individuals with a low SEP have been suggested based on research evidence; behavioral counseling (e.g., smoking cessation or physical activity-promoting programs) targeting traditional cardiovascular risk factors for low-income people has been recommended by the US Preventive Services Task Force (LeFevre, 2014; Lin et al., 2014). Additionally, the surveillance of health disparities has directed social insurance policies to narrow the

cardiovascular health gap through improved access to health care and expanded medical services for disadvantaged elderly groups (Kanjilal et al., 2006; Romero et al., 2012).

In South Korea (hereafter "Korea"), older adults are currently the most vulnerable group to both poverty and ill health. They also constitute a large low-SEP portion of the population in terms of occupational prestige, income, and educational level (Park et al., 2012). At the same time, with an aging population and increasing life expectancy, older adults in Korea occupy a high percentage of the morbidity and mortality associated with CVD and their major risk factors (Chun, 2016; Statistics Korea, 2018a). Importantly, it has been reported that such cardiovascular health conditions may be closely related to their low SEP (and its corresponding disadvantages), as their SEP in Korean society directly corresponds to the ability to cope with unmet medical needs and the financial strain arising from expensive health care (Shin et al., 2018a). This existing evidence makes Korean older adults worth exploring in cardiovascular disparities research. However, as yet, these disparities remain poorly documented.

1.1.1 The significance of conducting disparities research in cardiovascular health among Korean older adults

Two opposing hypotheses can be debated regarding disparities research in cardiovascular health among older adults in Korea. Some support research with the life-course perspectives (i.e. divergence hypothesis), claiming that the socioeconomic gap in health diverges throughout most of life as socioeconomic disadvantages accumulate

over a lifespan (Herd, 2006; Kim & Durden, 2007). Meanwhile, others exclude them, contending that this gap mainly converges in old age due to biological decline in later life that offsets health variation across socioeconomic groups and social benefits in most developed countries already favor the elderly (i.e. convergence hypothesis; Crimmins et al., 2009; Xu et al., 2015). Nevertheless, much evidence strongly supports the former perspective due to the disadvantages that current older Korean adults have experienced across their lifespan, all of which have resulted in increased illness. These include the socioeconomic risk accumulated along Korea's unique history, the gradual loss of social resources and safety nets with age, and the decline in social benefits (Chang & Kim, 2016; Jung-Choi & Kim, 2013; Ki et al., 2017; Lee, 2016; Park, 2001), all of which may support exacerbated socioeconomic disparities in cardiovascular health in old age, thus indicating a need for research in this field.

The rapid speed of Korea's aging further constitutes a reason for performing disparities research with this population. The number of older adults in Korea has increased faster than that in any other country worldwide. It is predicted that Korea will become an aged society by 2021, and a super high-aged society by 2026, wherein older adults will comprise 20% of the entire population (Statistics Korea, 2018b). Importantly, rapid aging of the population in Korea will potentially accelerate the social and economic burden of CVD in the future (Hwang et al., 2019; Song & Chen, 2015).

Considering the aforementioned issues, research on disparities in cardiovascular health in older adult populations calls for greater attention in Korea. Nevertheless, our systematic review showed that evidence in older adult populations has been limited in this field (Chapter 2). Only four studies stratified age to include individuals older than 65 years, enabling exploration of the gradients of disparities according to age up to old ages (Choi et al., 2019; Kim et al., 2005; Kim et al., 2016; Seo et al., 2014).

Almost all of these studies, however, documented the existence of health disparities with simple associations between causes and outcomes, but did not expand on trends, pathways, or mechanisms that underlie disparities. Such approaches are not sufficient to help researchers understand complex health disparity issues that operate in older ages, nor to aid healthcare professionals or policy makers to make progress toward reducing associated disparities (Khang & Lee, 2012). That said, beyond documenting the existence of disparities, more sophisticated research is needed to reduce them (Adler & Rehkopf, 2006).

Adler particularly argues that this requires research on: (a) assessing and monitoring both long- and short-term time trends in health disparities to generate specific strategies that can lead to policies to reduce disparities; and (b) understanding the pathways and mechanisms by which health disparities are created to find interventions that can alleviate adverse social influences on health (Adler, 2006). The

current dissertation therefore aims to explore two aforementioned issues among older adults in Korea throughout Chapters 3 and 4.

1.2 The Conceptual framework of Social Determinants of Health

We found that the Conceptual framework of Social Determinants of Health (CSDH) suggested by the World Health Organization (WHO) is an appropriate model for this dissertation. The CSDH provides greater specificity regarding the mechanisms or pathways through which multiple levels of influential and interdependent factors give rise to inequitable health outcomes (Solar & Irwin, 2010). Importantly, the CSDH highlights broader political influences that lead to health disparities and policymakers must consider (Solar & Irwin, 2010), which distinguishes it from other disparities frameworks (Baum et al., 1999; Brunner, 1999) that tend to explore health disparities in individual-level factors and outcomes. The suitability of the CSDH has been confirmed through multiple disparity research projects (WHO, 2008, 2010).

As yet, the CSDH is general and theoretical rather than practical, and its major constructs or concepts have not been tailored for particular populations and settings. For the purposes of this dissertation, the model was thus modified using the evidence from the literature (Chapter 2), which explored the nature of socioeconomic disparities in cardiovascular health in Korea. In particular, this process added relevant context to this limited model to underpin disparities in cardiovascular health. Built upon the CSDH

and a systematic review (Chapter 2), the modified framework will help address the aims of Chapters 3 and 4.

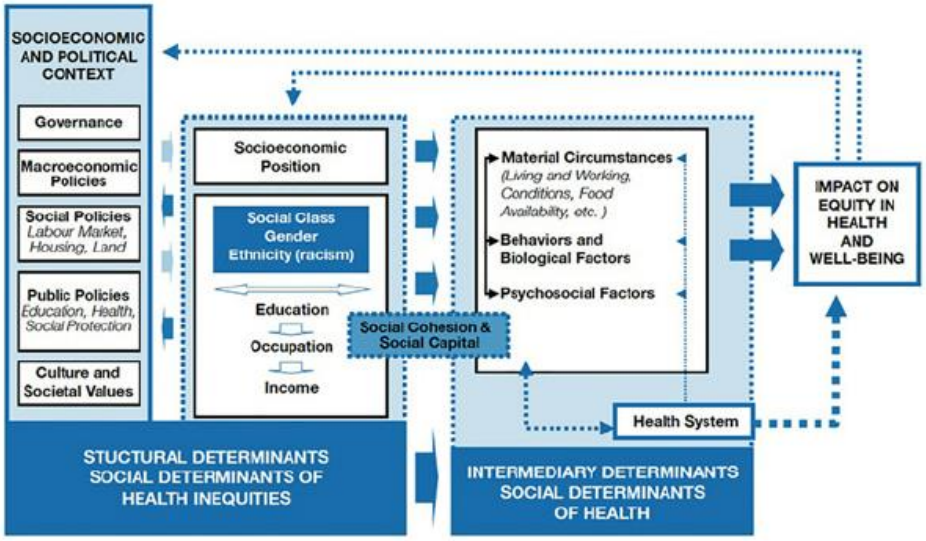

Figure 1. Conceptual framework of Social Determinants of Health

The WHO report (WHO, 2008, 2010) introduced several major approaches to provide a full and accurate estimate of the disparities in research based on the CSDH (see Figure 1). The major constructs of the framework are social determinants of health, intermediary determinants of health, and equity in health and well-being.

1.2.1 Social determinants of health: socioeconomic position, structural determinants

The CSDH strongly highlights the concept of 'SEP' which plays a central role in the determinants of health disparities. SEP is an aggregate concept that includes both resource-and prestige-based measures (Galobardes et al., 2006). SEP is found to be significant as it serves as a marker of various experiences with many social determinants of health (Galobardes et al., 2007; Marmot, 2002).

The model proposes that SEP and associated outcomes can be tackled by structural determinants including socioeconomic and political contextual forces and social stratifiers. In all cases, structural determinants present themselves in a specific political and historical context. In this model, *socioeconomic and political contextual forces* are broadly defined as upstream influences that generate, configure, and maintain social hierarchies on health and define individual SEP within hierarchies of power, prestige, and access to resources. The examples include governance, social and public policy approaches to health promotion, or other cultural and societal values. The authors of the WHO report particularly argued that disparity research must be concerned with issues relevant to the contextual forces as the research results in turn help evaluate policies' impact and inform future policy development and reform (WHO, 2010).

Social stratifiers are those that generate or reinforce divisions within our society. The most important social stratifiers are social class, gender, or race/ethnicity. In the WHO report, the authors emphasize a need to recognize how social stratifiers are linked to SEP and capture SEP-related disparities across the divisions in these factors (WHO, 2008). Together, with social stratifiers, SEP and socioeconomic and political contextual forces are referred to as 'social determinants of health'.

1.2.2 Intermediary determinants of health: material, behavioral/biological, and psychosocial factors

According to the CSDH, social determinants of health influence health through more specific, intermediary determinants. The main categories of intermediary

determinants of health are *material factors, behavioral* and/or *biological factors,* or *psychosocial factors* (WHO, 2010). Material factors characterize the tangible properties that satisfy health, physical, and security needs, and are linked to economic resources, living standard indicators, and the conditions of the physical environment. Behavioral factors mainly reflect an individual's health-protecting and health-damaging activities. Biological factors reflect the underlying genetic pathology that variably affects health. Psychosocial factors pertain to individuals' intrapersonal, interpersonal, and social experiences, and are often related to cognitive and emotional stressors, coping styles, or social support.

1.2.3 Equity in health and well-being

It is proposed that the interaction between social determinants and intermediary determinants of health determines the equity in health and well-being. This endpoint health outcome that emerges at the end of the social "production chain" of health disparities in the CSDH may comprehensively encompass the concepts of general health, disease severity, as well as morality in not only patient but also in public at large (WHO, 2010). Meanwhile, the authors of the WHO report stressed the need to choose appropriate endpoint health outcomes based on disease etiologies.

1.3 The conceptual model of the dissertation

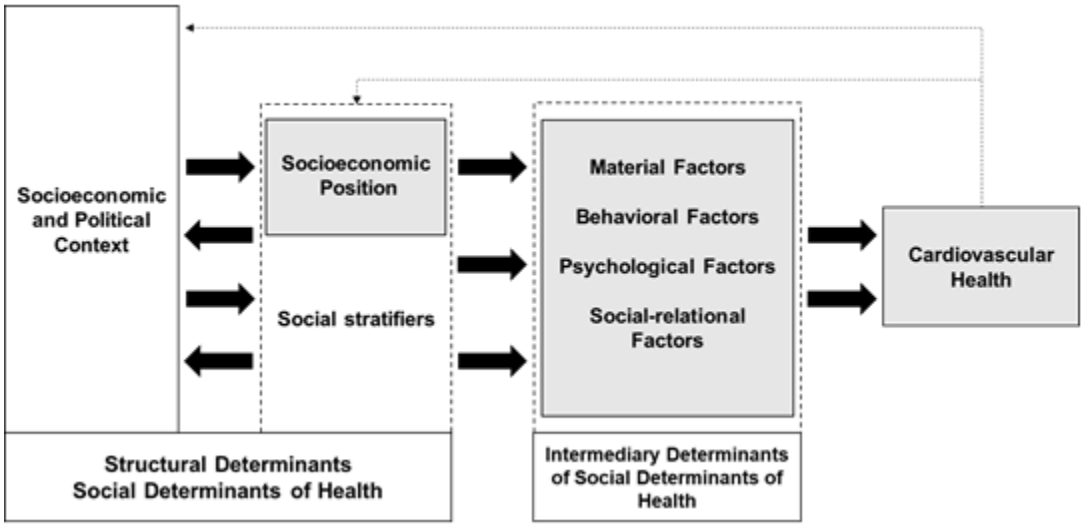

Figure 2. Conceptual model of the dissertation[1]

The modified framework describes the relationships among social determinants of health, intermediary determinants, and cardiovascular health in Korean older adults (see Figure 2). The model was simplified by extracting only the important concepts from the CSDH, which are considered useful to explore time trends in health disparities and mechanisms by which SEP influences cardiovascular health. The major concepts are SEP, political contextual forces, social stratifiers, material factors, behavioral factors, psychological factors, social-relational factors, and cardiovascular health. The model highlights SEP as the most significant sources of disparities in cardiovascular conditions. In this model, SEP and associated disparities in cardiovascular health are influenced by the political contextual forces and social stratifiers. Additionally, SEP influences

[1] A bold arrow indicates a direct influence of one variable on another while the dot arrow lines represent feedback loops (indirect influence).

cardiovascular health through material, behavioral, psychological, and social-relational factors.

1.3.1 Social determinants of health: SEP, political contextual forces

For older adults, SEP refers to the individual-level determinants that determine the degree of access to opportunities, including accurate health information, higher-quality health services, and physical and social privileges (Jang, 2013; Pérez-Hernández et al., 2017). According to Chapter 2, the most fundamental drivers of disparities in cardiovascular health have been associated with different SEP. In particular, the important path of influence is through income for the older adult population, which promote health by improving access to a regular source of healthcare at a later life stage (Ki et al., 2017).

In this model, SEP and associated disparities in cardiovascular health are influenced by political contextual forces. Herein, political contextual forces are defined as upstream factors that define older adults' SEP within hierarchies of power, prestige, and access to resources. Importantly, political contextual forces that position social and health opportunities across different SEP groups of older adults include the national health insurance policy (Jeon & Kwon, 2017). The insurance policy places older adults into two hierarchies according to their income level—National Health Insurance and Korean Medicaid beneficiaries—allowing for different in-kind health benefits.

Following from the findings of a systematic review (Chapter 2), health disparities were linked with the insurance hierarchy, with findings demonstrating more adverse cardiovascular outcomes among people who belong to Korean Medicaid. This implies that, disparity research should take the issues pertinent to political contextual forces into account to improve Korean Medicaid. Given that the ratio of Korean Medicaid to the total population per age group shows the highest divergence among older adults (Korean Statistical Information Service, 2017), it is necessary to aim research efforts at this population.

To fully characterize all major components of political context is beyond the scope of the dissertation. However, monitoring disparities may help formulate and evaluate the progress of social policies and therefore impart important future policy implications (Khang & Lee, 2012). Indeed, as shown in the modified framework (see Figure 2), the disparity results in feedback again to political contextual forces and these processes create a process of continual circulation. Chapter 3 thus aims to monitor the changing magnitude of disparities in cardiovascular health in relation to the insurance policy. The results will guide subsequent policies to improve the health of lower-income, older Medicaid beneficiaries in Korea.

1.3.2 Social determinants of health: social stratifiers

In this model, SEP and associated disparities in cardiovascular health are influenced by social stratifiers. Herein, social stratifiers are defined as those factors that

create social stratification among older adults. In particular, age and gender are the most important social stratifiers in this population (Dannefer, 2011): men and women of different ages and life stages are both allocated to and socialized to expect distinctive roles, resources, and relationships, thus developing different patterns in health disparities. Indeed, age and gender heterogeneity in the relationship between SEP and cardiovascular outcomes was reported in the systematic review (Chapter 2). This implies that, recognizing health disparities across the divisions of age and gender subgroups is necessary to accurately measure disparities, which requires age and gender stratification within all socioeconomic classes in research (WHO, 2010).

Age and gender stratification are important in disparity research in Korea when taking the historical socioeconomic background into account. For instance, the meaning of SEP varies, and socioeconomic conditions can form differently according to different birth cohorts in consideration of rapid socioeconomic transition (Khang, Lynch, & Kaplan, 2004). Likewise, gender-based socioeconomic disparity stemming from the Confucian-influenced social structure may support gender stratification. (Chun, 2006). Such perspectives on age and gender stratification may help refine the purpose of Chapters 3. For instance, systems to monitor health disparities must involve age and gender analysis (WHO, 2008).

1.3.3 Intermediary determinants of health: material, behavioral, psychological, and social-relational factors

In this model, SEP influences cardiovascular health through material, behavioral, psychological, and social-relational factors, creating "mechanisms" underlying disparities. These four groups of intermediary factors convey particular meaning for older adults: material factors represent resources that protect household budgets from expensive care, provide financial security during retirement, and ensure access to healthcare, and empirically are measured by health insurance, homeownership, and physical environment (Kershaw & Albrecht, 2015; Sadarangani et al., 2019; Thornton et al., 2016); behavioral factors refer to activities that promote or hinder cardiovascular health such as smoking status, alcohol consumption, physical exercise, maintaining a desirable weight, and attendance at health check-ups (Kim et al., 2011; Sung & Lee, 2010); psychological factors represent a set of psychological, cognitive, or affective components that may affect ill-health and may include stress, depression, and suicidal ideation (Han et al., 2012); social-relational factors reflect social support, network, or resources to maintain healthy living, and empirical indicators often involve marital or living status (Kim & Lee, 2013).

Western literature consistently supports that disparities partially account for differences in these four groups of factors, and the results have served as a basis for informing practical interventions to reduce disparities and improve outcomes (Beauchamp et al., 2010; Kershaw et al., 2013; Piccolo et al., 2016; Robertson et al., 2015).

Our best current evidence indicates that the unequal distribution of material, behavioral, and psychological factors contribute to disparities in cardiovascular health across diverse ages (Chapter 2). Additionally, investigating the role of social-relational factors in the explanation of disparities in cardiovascular health is also needed, especially in older adults due to their significance in explicating the health of this group (Kim & Lee, 2013).

The overall statement emphasized a need to investigate the role of four groups of intermediary factors that link SEP to cardiovascular health in older adults. This will be addressed in Chapter 4. Importantly, as discussed in section 1.3.1, the analysis will be stratified by age and gender as various age- and gender-specific factors are associated to produce different mechanisms between the genders at different ages (Dannefer, 2011). For instance, evidence from behavioral studies demonstrated that behaviors that increase the risk of CVDs differ among men and women (Ruiz et al., 2018).

1.3.4 Cardiovascular health

Cardiovascular health refers to cardiovascular outcomes that result from the impact of SEP. In this dissertation, we are operationalizing cardiovascular health as older adults' cardiovascular risk factors.

As mentioned earlier, choosing appropriate health outcomes in disparity research should be based on disease etiologies (WHO, 2010). Mortality has been regarded as a good general indicator of a population's overall health. Nevertheless,

mortality as the disparity outcome poses challenges to conducting research (Adler, 2006). Mortality is a function of multiple components including vulnerability and exposure to socioeconomic risk, injury, or disease and the quality of diagnosis and treatment, each of which may show different patterns of disparity (Adler, 2006); as such, identifying how disparities in mortality manifest cannot be accurately predicted. Even with a more extended cohort design, no single study can capture every process involved in mortality disparities (Peterson et al., 2018).

Many researchers use morbidity indicators that have yielded consistent findings on marked socioeconomic differences in specific categories of CVD and the variables that are commonly identified as important pathways from SEP to CVD (Adler, 2006). However, it is impossible to assess poor levels of health before initial CVD events when using morbidity data, which may impede a better evaluation of disease occurrence and designing primary prevention programs for CVD (Martinson et al., 2016). Thus, efforts to include the preclinical indicators of disease states (i.e. risk factors) are recommended (Adler, 2006).

Such guidance will help choose accurate health indicators in Chapters 3 and 4. Particularly, Chapter 3 will address trend analyses of disparities in cardiovascular risk condition. This strategy will offer strategies to responding to future disparities in CVD morbidity and mortality under specific projected risk factor scenarios (Danaei et al., 2009; Schultz et al., 2018). Chapter 4 will explore how material, behavioral,

psychological, and social-relational factors contribute to disparities in cardiovascular risk. This will provide information on common underlying mechanisms to multiple diseases and could suggest a clear role for the prevention of CVD morbidity and mortality (Martinson et al., 2016).

1.4 Dissertation aims, research questions, hypotheses

In Korea, the magnitude of health disparity can be greatly maximized in old age due to the cumulative effect of disadvantages in social opportunities, the loss of social resources, and economic deprivation, compounded with biological deterioration (Chang & Kim, 2016; Jung-Choi & Kim, 2013; Ki et al., 2017; Lee, 2016; Park, 2001). It has been reported that such disadvantages are highly correlated with adverse cardiovascular health outcomes (Clark et al., 2009; de Mestral C & Stringhini S, 2017; Glymour et al., 2014). Yet, a systematic review (Chapter 2) indicates that socioeconomic disparity in cardiovascular health in older adults remains uninvestigated.

This dissertation is organized into five chapters. Chapter 1 provides a rationale for the target population for the current study and the essential framework which the study rests upon. Chapter 2 systematically reviews the breadth of previous work on socioeconomic disparities in cardiovascular health in Korea. Based on Chapters 1 and 2, the conceptual model (see Figure 2) is created, which suggests great directions for future research among Korean older adults. Importantly, an understanding of the time trends in health disparities and how intermediary factors may contribute to them is needed to

establish practical interventions. Therefore, I aim to investigate two issues above specifically amongst older adults in Korea. This will be achieved through data-driven approaches and presented in Chapters 3 and 4.

Specifically, Chapter 3 will examine time trends in socioeconomic disparities in cardiovascular risk over the past decade by age and gender among older adults in Korea. This work situates the focus of responsibility for achieving health equity at the political rather than individual level by exploring income-related health disparities in relation to the national insurance policy. To address this aim, the research questions will be asked "What are the magnitudes of income-related health disparities in cardiovascular risk factors from 2008 to 2017 in Korea by gender and age under the current insurance policy?" and "Is there any significant change in the trend with regard to income-related health disparities in cardiovascular risk factors from 2007 to 2017 in Korea by gender and age?"

Chapter 4 will explore the role of material, behavioral, psychological, and social-relational factors accounting for the association between SEP and cardiovascular risk by age and gender among older adults in Korea. We hypothesize that the four groups of factors contribute to socioeconomic disparities in cardiovascular risk. This will be a secondary analysis of cross-sectional data from the Korean National Health and Nutrition Examination Survey (KNHANES) conducted by the Korean Ministry of Health and Welfare. Our aims will be achieved using the summary measures of the

Relative Index of Inequality (RII) and the Slope Index of Inequality (SII). The percentage attenuation in the RII and SII accounted for by intermediary factors will be calculated to examine their mediating roles.

Finally, Chapter 5 is an overall summary of the dissertation. Study limitations, implications, and recommendations for future research will be discussed. The value of this dissertation lies in informing policymakers of what should be improved and strengthened to contribute to the eventual elimination of inequity in social conditions among older adults throughout all segments of society. It will also help healthcare professionals to prioritize their services and interventions and allow equitable reductions in cardiovascular morbidity and mortality in this population.

2. A Systematic Review

To improve the cardiovascular health of those with socioeconomic disadvantages, the nature of their disparities must be explored to inform targeted interventions for this group. However, these efforts have been scarce in all areas of nursing research and practice in Korea. This systematic review aims to examine the nature of socioeconomic disparities in cardiovascular health in Korea. Multiple electronic databases including PubMed, CINAHL, EMBASE, and Cochrane (2009–2019.06) were searched. A total of 42 articles published in English or Korean that examined socioeconomic disparities in cardiovascular health in Korea were selected, reviewed, and analyzed using a narrative synthesis. Socioeconomic disparities existed in cardiovascular health among Korean populations across the disease continuum from risk factors to mortality. The magnitudes, directions, and significance of the observed associations between SEP and cardiovascular health varied by SEP indicators, gender, and age groups. Five studies (12%) explained the mediation and moderation of multiple factors to the associations. This body of knowledge will serve as a basis to inform strategies, interventions, or policies to reduce disparities in cardiovascular health.

2.1 Introduction

Socioeconomic disparities affecting people of lower SEP more than those of higher SEP have been an ongoing global concern in cardiovascular health. A number of international studies have shown that low SEP is an established predictor of high

prevalence, morbidity, and mortality of CVDs and their major risk factors (Glymour et al., 2014). In Korea, CVD is a leading public health problem, and early and emerging evidence indicates that Korea follows the aforementioned global trend (Okwuosa et al., 2016).

Socioeconomic disparities in cardiovascular health have been described in Korean literature since the early part of the 21st century, notably due to Westernization influencing individual lifestyle and dietary patterns which markedly increased CVDs among the population (Okwuosa et al., 2016). Khang et al. in 2004 and Song et al. in 2006 were among the first studies documenting that such increases were disproportionately higher among lower SEP individuals. Since then, much research has been done in this field. Importantly, this research has been critical from a public health perspective not only to enhance public awareness of socioeconomic disparities but also to develop practical health improvement strategies for lower SEP group individuals. For instance, studies have suggested that targeted behavioral interventions (Eom et al., 2017) or public policies (Khang et al., 2009a) improve CVD risk factors among lower-income groups.

However, the results from individual studies may not be applicable, as each study has produced a varied association between SEP and cardiovascular outcomes. Indeed, the direction and significance of the association is not uniform and differs by the choice and categorization of SEP indicator (e.g., education, income) and the examined outcome (e.g., hypertension, cholesterol; Glymour et al., 2014). Furthermore, the

characteristics and backgrounds of study participants and population size are defined heterogeneously across diverse studies, generating inconsistent results (Backholer et al., 2017). Variations can also be due to statistical diversity, methodological differences such as adjustment variables, utilized design, or evaluated time points (Backholer et al., 2017).

Unless disparities are clearly understood along with a comprehensive understanding of the association between SEP and cardiovascular outcomes, we are limited in our ability to decrease the disproportionate burden of CVD. In addition, the political implications of health disparities should be based on a review and synthesis of currently available data (Khang et al., 2012). However, no previous systematic review of the literature on this topic has been conducted. Therefore, we aimed to conduct a systematic review investigating the nature of socioeconomic disparities in cardiovascular health in Korea. This systematic review should motivate future research, interventions, and health policy initiatives for cardiovascular health in Korea.

2.2 Methods

2.2.1 Study selection

We conducted a systematic review according to the PRISMA checklist (http://prisma-statement.org/prismastatement/Checklist.aspx) using the online databases, including PubMed, CINAHL, EMBASE, and Cochrane. Given the rapid transformation of social structures in Korea, we limited the publication date to the past decade (2009-2019.06) to reflect current information. The search strategy included the

key concepts of health disparities, health inequity, socioeconomic factors, socioeconomic environment, and cardiovascular health. Sample search terms used for the PubMed searches were summarized in Table 1 and Supplement 2 (of the article, http://doi.org/10.1097/JCN.0000000000000624). The four searched databases yielded a total of 1,292 potential studies without duplicate publications.

Table 1. Search terms in PubMed

Concepts	Search terms
Korea	"Korea"[Mesh] or "Republic of Korea[Mesh]"
Cardiovascular health	"Cardiovascular Diseases"[Mesh] OR death OR mortality OR coronary OR cardiac OR heart OR cardiovascular OR "Myocardial Ischemia"[Mesh] OR "Myocardial Infarction"[Mesh] OR Stroke[Mesh] OR "Cerebrovascular Disorders"[Mesh] OR "Heart Failure"[Mesh] OR "Metabolic Syndrome"[Mesh] "cardiovascular risk factor" OR "cardiovascular risk factors" OR Hypertension[Mesh] OR "Blood Pressure"[Mesh] OR Hyperlipidemias[Mesh] OR "Diabetes Mellitus"[Mesh] OR "Obesity"[Mesh]
Health disparities	"Socioeconomic Factors"[Mesh] OR socioeconomic OR social OR "Social Class"[Mesh] OR "Health Status Disparities"[Mesh] OR inequalit* OR disparit* OR inequit* OR "Social Environment"[Mesh] OR "Education"[Mesh] OR "Educational Status"[Mesh] OR Income[Mesh] OR Poverty[Mesh] OR "Occupations"[Mesh] OR "Work"[Mesh] OR "Employment"[Mesh] OR "Geography"[Mesh] OR geographic

Note. The details of non-PubMed searches are presented in Appendix

2.2.2 Inclusion/exclusion criteria

Only full-text articles published in English or Korean in peer-reviewed journals that examined socioeconomic disparities in cardiovascular health in Korea were included. Only studies of adult populations (over 19 years of age) were selected, given that disparities in children or adolescents might follow different patterns than those of adults. SEP was used to measure disparity, and SEP was determined using the indices defined by authors included in the systematic review. Importantly, we allowed for the inclusion of a broad spectrum of SEP from individual-level indices (e.g., education, income) to the aggregate-level such as

organizational-level indices (e.g., working environment) or community-level indices (e.g., area deprivation).

In addition, a broad range of cardiovascular conditions was used as outcome criteria, namely were sub-risk factors of CVD (e.g., diabetes, hypertension, dyslipidemia, metabolic syndrome), specific categories of CVD, and associated mortality. In this paper, CVD is defined as the presence of coronary heart disease, myocardial infarction (MI), cerebrovascular accident (strokes and transient ischemic attack), peripheral artery disease, and congestive heart failure.

The articles that did not report empirical research studies were excluded (e.g., review articles, editorials, commentaries, conference proceedings, columns, literature reviews, systematic reviews, meta-analyses, clinical case studies, or book chapters). Studies were further excluded if: (1) they did not report explicit markers of SEP; (2) they were based on a homogenous sample of low- or high-SEP groups, which did not allow for a comparison between different SEP groups; (3) SEP was used as a confounder or a moderator; or (4) the article was not available.

2.2.3 Study appraisal

Two researchers (graduate-level students) independently examined the titles and abstracts identified in the initial search. Discrepancies were resolved through discussion until the authors concurred on data interpretation. Forty-six potential studies that were clear from the title/abstract review were retrieved for full-text reviews. Of these, 38

studies met the inclusion criteria. In addition, the reference lists of the retrieved articles were reviewed to identify and retrieve other articles on the topic that were missed during the initial search. In sum, a total of 42 studies were eligible for review. The PRISMA diagram provides a visual description of the process utilized for retrieving and selecting the articles (see Figure 3).

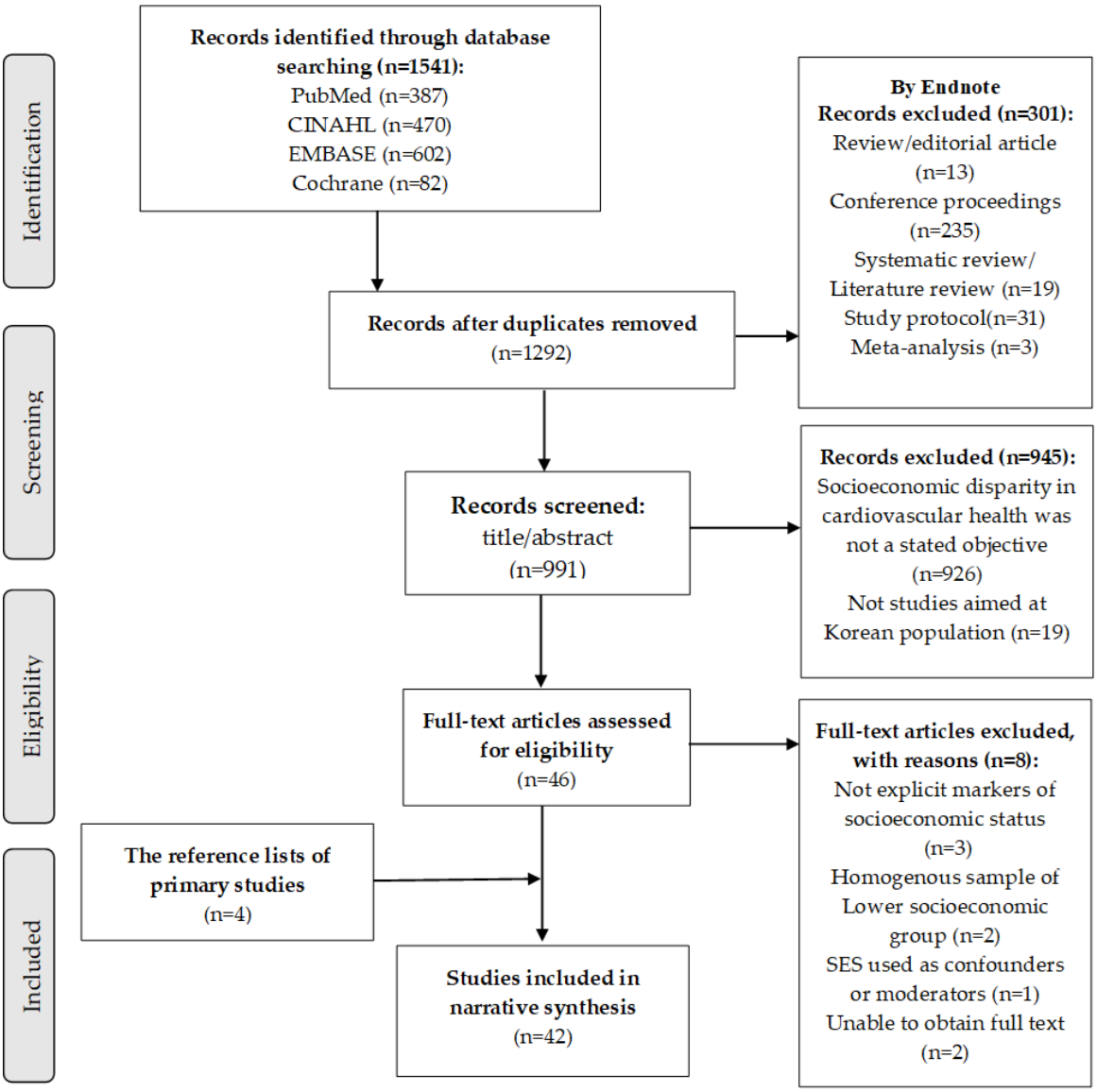

Figure 3. PRISMA diagram for search strategy (2009-2019.06)

Due to the high heterogeneity of included studies, a meta-analysis was not possible. Thus, they were presented as a narrative (as opposed to statistical) synthesis, which collates textual information from across the studies (Popay et al., 2006). A narrative synthesis was conducted in four stages: quality assessment, data extraction, data synthesis, and reporting findings.

2.2.4 Quality assessment

Retrieved articles were appraised for methodological quality using the Joanna Briggs Institute critical appraisal tools. Two researchers independently assessed the studies, answering "Yes", "No", "Unclear", or "Not applicable" responses to 8 questions (for cross-sectional studies) about methodological concerns. The number of "Yes" responses were summed for each study and displayed as total points. The quality scores of individual articles are presented in Supplement 3 (of the article, http://doi.org/10.1097/JCN.0000000000000624).

2.2.5 Data extraction and synthesis

Each of the articles was evaluated and organized in chronological order based on the primary author's last name. Each study was abstracted into 10 different categories including the article number, study design and database, cohort size, age characteristics of participants, sampling method, measurement of SEP, outcome variables, a brief illustration of results with a statistical test of association between SEP and cardiovascular health (effect size), and the quality score. Where possible, the effect size

was expressed in the form of Relative Risk (RR), Hazard Ratio (HR), Odds Ratio (OR), Relative/Slope Index of Inequality, *p*-value, Concentration Index, or β statistics. These are presented in Supplement 3 (of the article, http://doi.org/10.1097/JCN.0000000000000624).

The extracted data from quantitative studies were summarized and analyzed individually in a narrative fashion and transformed into a common textual format (Popay et al., 2006). This approach includes an examination of the differences and similarities between the findings of different studies as well as the identification of patterns in the data (Popay et al., 2006).

2.2.6 Reporting findings

In this paper, the basic features of the analyzed studies were summarized. Next, a narrative synthesis of quantitative findings was presented. As study approaches (e.g., study designs) were diverse, these were synthesized into five approaches depending upon the key findings: associations between SEP and health by SEP indicator, mechanisms linking SEP and health, trend in disparity, disparity magnitude according to gender, and disparity magnitude according to age. The findings are summarized in Table 2 to Table 4.

Table 2. Summary of associations between SEP and cardiovascular health

No	Study Design/ Model 1. Unadjusted 2. Fully adjusted	Study scope W: Women M: Men	Outcome P: Prevalence I: Incidence	SEP relationship (Individual level) +: Positive, -: Negative, No: No association				SEP relationship (Working or geographic environment) +: Positive, -: Negative	Mechanisms 1. Mediator 2. Moderator	Disparity magnitude Inc: Increase Dec: Decrease	
				Edu	Income	Health insurance	Occupation			Time trends	By age or gender
Park et al., 2016a	R-cohort/ 1	National	HTN(P,I)	-							M>W
Cha et al., 2012	C-S/2	National	HTN(P)	-			W (Higher prevalence in manual labors, non-standard employees)				
Baek et al., 2015	P-cohort/ 2	National	HTN(I)	-	-						
Kim & Nam, 2017	C-S/1	National	DM(P)	-						Dec	M>W
Kim et al., 2017a	C-S/2	National	MetS(P)	-					1:Healthy food consumption		W>M
Byeon et al., 2019	C-S/2	National	10-year risk of CVD	Edu-income composite(-)							
Kim et al., 2017b	C-S/1	National	Mortality from obese disease	-						Inc	Dec with age
Jung-Choi et al., 2011a	Longitudinal/1	National	Mortality from cerebrovascular disease, DM, IHD	-						Inc	Dec with age
Khang &Kim,	C-S/1	National	Mortality from CVD	-	-		Higher mortality in manual workers,				

2016							laborers, agricultural/fishery/self-employed, or low social class groups				
Kim et al. 2012	C-S/2	Province	Obesity(P)	M(-) W(no)	M(+) W(no)		M(no) W(Higher prevalence in the employed)				
Park et al., 2012	C-S/1	National	MetS(P)	M(+) W(-)	M(no) W(-)						
Lee et al., 2013	C-S/2	National	DM(P)	M(-) W(-)	M(-) W(no)						W>M
Choi et al., 2019	C-S/2	National, W	Obesity(P)	W(-)	W(-)						Inc with age
Kim, et al., 2013a	C-S/1	National	Well-controlled HTN(P)		-					Dec	
Shin & Kang, 2018	C-S/1	National	Obesity, DM (P)		-					W:Inc M:stable	W>M
Kim et al., 2017c	R-cohort/2	National	Mortality from CVD		-						
Shin et al., 2018b	C-S/1	Province	Cardio-cerebrovascular disease(I)		-						
Park et al., 2011	C-S/2	National	Obesity(P)		M(+) W(-)					Inc	
Hwang et al., 2019	C-S/1	Province, W	10-year risk of MI and coronary death		W(-)						

Table 3. Summary of associations between SEP and cardiovascular health (Cont'd)

No	Study Design/ Model 1. Unadjusted 2. Fully adjusted	Study scope W: Women M: Men	Outcome P: Prevalence I: Incidence	SEP relationship (Individual level) +: Positive, -: Negative, No: No association				SEP relationship (Working or geographic environment) +: Positive, -: Negative	Mechanisms 1. Mediator 2. Moderator	Disparity magnitude Inc: Increase Dec: Decrease	
				Edu	Income	Health insurance	Occupation			Time trends	By age or gender
Park et al., 2010	C-S/1	Province	DM, HTN(P)	Edu-income composite(-)							
Min et al., 2010	C-S/1	Province	MetS (P), 10-year risk of CVD	Edu-income composite(-)							
Lim et al., 2012	C-S/1	National	MetS (P)	W:Edu-income composite(-) M: no							W>M
Chung et al., 2018	C-S/2	National	Obesity(P)	W:Edu-income composite(-) M:no				M: Higher prevalence in rural residents with lower educational level			
Kim et al., 2014	C-S/2	Patients in 66 hospitals	Mortality from AMI, congestive heart failure, cerebrovascular disease			Higher mortality in Medicaid beneficiaries			1:Quality of care, equal access to healthcare		
Kim et al., 2016	R-cohort/2	National	Mortality from CVD			Insurance premium levels (-)					
Jung-Choi et al., 2011b	Longitudinal/1	Government employees, teachers, and their dependents	Mortality from diseases of the circulatory system (hypertensive disease, IHD, heart failure,			Insurance premium levels (-)					M>W

			stroke)								
Seo et al., 2014	R-cohort/2	National	Stoke(I)		Higher incidence in Medicaid beneficiaries with low income						Dec with age
Cho et al., 2019	R-cohort/2	National	AMI, stroke (I)			Insurance premium levels (-)			2:Depression		
Kim et al., 2013b	Matched case-control/2	National	Hemorrhagic stroke(I)				Higher incidence in blue-collar workers	Longer working hours, exposure to strenuous activity, and shift work increased the incidence			
Han et al., 2018	R-cohort/1	Public officers nationwide	Angina pectoris, AMI, cerebrovascular disease(I)				Higher incidence in police officers, and fire fighters				
Kang & Kim, 2014	Longitudinal/2	National	Stroke, CVD(I)				Voluntary retirement and involuntary job loss increased the incidence				

Table 4. Summary of associations between SEP and cardiovascular health (Cont'd)

No	Study Design/ Model 1. Unadjusted 2. Fully adjusted	Study scope W: Women M: Men	Outcome P: Prevalence I: Incidence	SEP relationship (Individual level) +: Positive, -: Negative, No: No association				SEP relationship (Working or geographic environment) +: Positive, -: Negative	Mechanisms 1. Mediator 2. Moderator	Disparity magnitude Inc: Increase Dec: Decrease	
				Edu	Income	Health insurance	Occupation			Time trends	By age or gender
Seon et al., 2017	C-S/2	Wage worker nationwide	HTN, DM, high HDL, low HDL, high triglyceride, high total cholesterol, obesity(P)				M: Lower prevalence in non-standard workers W: Higher prevalence in non-standard workers				
Hwang & Park, 2015	C-S/1	Blue-collar workers in small companies	10-year CVD risk					Having a cafeteria in workplace decreased the risk			
Jang et al., 2013	C-S/2	Wage worker nationwide	Obesity(P)					Working 60 hours increased the prevalence in both manual and non-manual workers			
Yoon et al., 2016	C-S/2	Wage worker nationwide, W	Obesity(P)					Working 60 hours increased the prevalence in both manual and non-manual workers			
Ahn et al., 2011	C-S/2	250 local districts	Out of hospital cardiac arrest					Area deprivation level[Carstairs](+)			
Lee et al., 2018	C-S/1	245 local districts	Morbidity and mortality from CVD					Area deprivation level[Carstairs](+), undersupply of healthcare resources(+), unhealthy behavior of resident(+)			M>W
Hong &	R-cohort/2	Patients	Case fatality					Higher fatality rate in	1:Higher		

Kang, 2014		admitted with AMI in 5 geographic regions	rate from AMI					smaller cities & towns	quality medical management and invasive procedures		
Park et al., 2016b	C-S/1	229 local districts	Mortality from HTN					The number of basic livelihood grant recipients per residence (+), proportion of highly educate people in the region(-)			
Cho et al., 2016	R-cohort/2	Patients newly diagnosed with HTN	Mortality from HTN					Higher HTN mortality in low-income people from more deprived areas			
Shin et al., 2016	R-cohort/1	National	Dyslipidemia mortality					Higher dyslipidemia mortality in low-income people from more deprived areas [Carstairs index]			
Lim et al., 2017	C-S/1	National	HTN, DM, hyperlipidemia(P)				Higher prevalence in a more sedentary working group (manager, expert, specialist, and clerk)		1:Sedentary leisure time		

Abbreviations: (A)MI, (acute) myocardial infraction; BMI, body mass index (kg/m2); CVD, cardiovascular disease; C-S, cross-sectional; DM, diabetes mellitus; HDL, high density lipoprotein; HTN, hypertension; IHD, ischemic heart disease; MetS, metabolic syndrome; P-cohort, prospective cohort; R-cohort, retrospective cohor

2.3 Results

2.3.1 Characteristics of the studies

Most of the studies were published in English after the year 2010. All the studies adopted a quantitative approach, and nearly half (N= 28, 54 %) used a cross-sectional research design. The sample sizes of the included studies ranged from 91 to over one billion participants. The participants' ages were grouped heterogeneously by study, but the majority of the studies (N= 38, 90 %) examined a broad range of age except for four studies with a specific middle-range age bracket. Among the studies using broad-age range, only five studies (12 %) stratified age to include individuals older than 65 years, enabling the exploration of the gradients of disparity by age. Most of the studies targeted a nationwide population and used a stratified, multistage probability sampling method to draw a representative sample of the population. In contrast, five studies (12 %) used a non-probability sampling method to acquire data from populations residing in particular provinces or sub-groups (e.g., certain occupations or in-hospital patients).

Across the studies, socioeconomic disparities were identified using multiple SEP indicators. In the majority of the studies (N= 33, 79 %), the independent impacts or combined contributions of various SEP indicators (education, occupation, household income, type of health insurance, or health-insurance premium levels) on cardiovascular health were analyzed. Workplace indices such as physical or psychological disturbances of working conditions were utilized in four studies (10 %), and geographical factors such as the socioeconomic characteristics of a neighborhood or geographical region were

utilized in seven studies (17 %). All studies demonstrated significant associations between SEP factors and outcome measures from sub-risk factors to mortality in various medical conditions.

2.3.2 Associations between SEP and cardiovascular health by SEP indicator

Education. Thirteen studies (31 %) employed education as an SEP measure, out of which twelve (92 %) reported a negative association between the level of education and the outcome, while one study reported the opposite. Among studies that did not classify gender in the study population, inverse relationships with education were associated with the prevalence and incidence of hypertension (Baek et al., 2015; Cha et al., 2012; Park et al., 2016a), the prevalence of diabetes (Kim & Nam, 2017) and metabolic syndrome (Kim et al., 2017b), and 10-year CVD risk (Byeon et al., 2019). Inverse relationships were also associated with mortality from obesity (Kim et al., 2017c), diabetes (Jung-Choi et al., 2011a), ischemic heart disease (IHD; Jung-Choi et al., 2011a), cerebrovascular disease (Jung-Choi et al., 2011a), and CVD (Khang & Kim, 2016). On the other hand, studies adopting separate gender analysis produced heterogeneous results. Especially for men, a negative cross-sectional relation between educational level and obesity was observed (Kim et al., 2012). Among women, inverse associations with education were found for the prevalence of metabolic syndrome (Park et al., 2012), diabetes (Lee et al., 2013), and obesity (Choi et al, 2019). Only one study, which targeted

provincial residents (Kim et al., 2013a), showed a positive relationship between education level and the prevalence of metabolic syndrome, especially among men.

Income. Income was used as a disparity measure in twelve studies (29 %), out of which ten (83.3 %) reported that people with a higher income were more likely to have an adverse outcome compared to those with lower incomes, while two studies reported the opposite. For example, income level was negatively correlated with the prevalence and incidence of hypertension (Baek, et al., 2015; Shin & Kang, 2018), the prevalence of diabetes and obesity (Kim et al., 2017c), 10-year CVD risk (Byeon et al., 2019), and mortality from CVD (Khang & Kim, 2016; Shin et al., 2018b); among residents in a single province, income was also inversely associated with the prevalence of cardio-cerebrovascular disease (Park et al., 2011). Particularly among men, income level was positively associated with the prevalence of metabolic syndrome (Park et al., 2012) and obesity (Hwang et al., 2019; Kim et al., 2012). Among women, lower income was a significant prognostic factor in the prevalence of obesity (Choi et al., 2019; Hwang et al., 2019), and especially among provincial participants, it predicted a higher 10-year risk estimate of MI and coronary death (Park et al., 2010).

Adverse outcomes were also significantly more prevalent among those with a lower level for combined income and education. For instance, two prevalence studies revealed that a higher level of combined income and education significantly lowered the likelihood of having diabetes (Min et al., 2010), hypertension (Min et al., 2010), and

metabolic syndrome (Kim et al., 2013a), and lowered the 10-year CVD risk among provincial residents (Kim et al., 2013a). Furthermore, women belonging to both the low income and low education group in one cross-sectional study were more likely to have metabolic syndrome (Lim et al., 2012). One study reported that interactions between lower-income and lower educational level among women were significantly associated with obesity (Chung et al., 2018).

Health insurance. Disparities were also linked with the type or level of health insurance in five studies (13 %), with findings demonstrating more adverse outcomes among people with a low level of health insurance or who participate in Korean Medicaid (a taxpayer-funded insurance program). For example, one hospital registry-based study found higher cardiovascular mortality rates in relation to acute myocardial infarction (AMI), congestive heart failure, and cerebrovascular diseases in patients participating in Korean Medicaid than those in NHI (Kim et al., 2014). In addition, in one cohort study, lower health insurance premiums combined with diabetes synergistically escalated the risk of mortality from all causes, especially CVD (Kim et al., 2016). Differences in health insurance rates were also associated with high mortality due to diseases of the circulatory system (hypertensive disease, IHD, heart failure, and stroke; Jung-Choi et al., 2011b), incidence of stroke (Cho et al., 2019; Seo et al., 2014) and AMI (Cho et al., 2019).

Occupation/employment status. Disparities were also observed in different occupational groups in a total of seven articles (18 %), with worse outcomes mostly found for those in lower occupational or unemployment status. For example, one matched case-control study showed that blue-collar workers had a higher risk of stroke than white-collar workers (Kim et al., 2013b). A 13-year cohort study showed that police officers and firefighters had greater incidences of angina pectoris, AMI, and cerebrovascular disease than national and regional government employees (Han et al., 2018). One study reported an association between lower occupational classes (Korean standard occupational classification) and greater cardiovascular mortality (Khang & Kim, 2016). In addition, Kang et al. demonstrated that both voluntary retirement and involuntary job loss increased the risk of stroke or CVD in a prospective study of middle-aged to older men workers (Kang & Kim, 2014). Occupation also contributes to these disparities in women; two cross-sectional studies demonstrated that women working as manual laborers or non-standard employees were at a higher risk of hypertension than their white-collar counterparts (Cha et al., 2012; Seon et al., 2017). On the other hand, one study conducted in one province showed that the prevalence of obesity was higher among employed women (Kim et al., 2012).

Working environment. Four studies (10 %) demonstrated that strenuous labor and harmful working conditions posed a high risk for CVD. Hwang et al. showed that having a workplace cafeteria influenced 10-year CVD risk among blue-collar workers in

small companies (Hwang & Park, 2015). A study by Kim et al. found that longer working time, exposure to over 8 hours of strenuous activity per week, and shift work were associated with an increased risk of stroke (Kim et al., 2018). In addition, Jang et al. and Yoon et al. demonstrated that working more than 60 hours per week was significantly related to the prevalence of obesity in the adult working population (Jang et al., 2013; Yoon et al., 2016).

Geographic environment. Seven studies (17 %) determined the ways in which geographic environment contributes to cardiovascular outcomes. Three studies found intra-national differences by county- or borough- unit for out-of-hospital cardiac arrest (Ahn et al., 2011), CVD morbidity and mortality (Lee et al., 2018), and case-fatality rates from AMI (Hong & Kang, 2014). In each of these studies, findings were worse in the most deprived areas. Notably, two studies demonstrated an association between the socioeconomic characteristics of the neighborhood (e.g., healthcare resources per residents, behavioral risk factors of residents) and cardiovascular outcomes. For instance, Lee at al. found that neighborhood-level indices for socioeconomic disadvantages (area deprivation index), undersupply of healthcare resources, and unhealthy behaviors of residents (e.g., smoking, drinking) were positively related to CVD morbidity and mortality (Lee et al., 2018). Park et al. found that the standardized hypertension mortality rate was positively associated with the number of basic livelihood grant recipients (i.e. those on a national public assistance program) per

residence and negatively associated with the proportion of highly educated people in the region (Park et al., 2016b).

Interestingly, three studies demonstrated that disadvantages in both neighborhood environment and individual factors could jointly lead to adverse cardiovascular outcomes. For example, one study reported that interactions between rural residential areas and lower educational level among men were significantly associated with obesity (Chung et al., 2018). Two additional cohort studies showed that neighborhood deprivation exacerbated the influence of individual SEP on all-cause mortality among patients with newly diagnosed hypertension (Cho et al., 2016) and dyslipidemia (Shin et al., 2016).

2.3.3 Mechanisms linking SEP and cardiovascular health

Throughout the reviewed studies, simple associations between SEP and cardiovascular outcomes were clearly dominant. However, in five studies, these relationships were mediated or moderated by differences in multiple factors.

First, the relationships were mediated by behavioral (Kim et al., 2017b; Lim et al., 2017) and health system factors (Hong & Kang, 2014; Kim et al., 2014). One cross-sectional study found that the relationship between lower educational level and higher prevalence of metabolic syndrome was partially mediated by selected food groups (lower intakes of fruit, red meat, and milk; higher intakes of vegetable and soft drinks; Kim et al., 2017b). Another study revealed that sedentary leisure time is differently

associated with the prevalence of hypertension, diabetes, and hyperlipidemia, depending on occupation (Lim et al., 2017). In addition, one cross-sectional study targeting in-hospital patients showed that improving quality of care and ensuring equal access to health care for a population receiving Korean Medicaid reduced the disparities for mortality from AMI by 8.4% and 1.6%, respectively (Kim et al., 2014). One large retrospective cohort study reported that regional differences in case-fatality rate from AMI were caused by differences in access to high-quality medical care among different regions of Korea (Hong & Kang, 2014). Second, the relationship was moderated by psychological factors (Cho et al., 2019). One study demonstrated that depression correlated with an increase in AMI incidence in low and medium SEP groups, as compared to the high SEP group (Cho et al., 2019).

2.3.4 Trends in disparity

Six studies used several subsequent periodic data sets to monitor trends in health disparities over time. Though patterns of change varied both among and within groups, almost all studies demonstrated worsening socioeconomic disparities among the Korean population. In designs that linked death statistics and census data, there was an increasing trend in the magnitude of educational disparity, both in relative and absolute terms; disparities were detected for mortality with respect to diabetes (Kim et al., 2017c; Jung-Choi et al., 2011a), obesity (Kim et al., 2017c), IHD (Jung-Choi et al., 2011a), and cerebrovascular disease (Jung-Choi et al., 2011a). For trend analyses of periodic national

cross-sectional surveys, the magnitude of educational disparity in diabetes, in relative terms, decreased from 2007 to 2015 (Kim & Nam, 2017). Particularly in men, trend analyses from 2005 to 2015 found that income disparities with controlled hypertension decreased (Shin & Kang, 2018), whereas this trend was stable for obesity and diabetes in another study (Kim et al., 2017c). A contrasting trend in women showed that widening income disparity in obesity and diabetes has been observed over the past 14 years in a national cross-sectional survey (Kim et al., 2017c).

2.3.5 Disparity magnitude according to gender

The literature is mixed regarding gender differences in the association of SEP and cardiovascular outcomes. Three studies showed more apparent socioeconomic disparities in women than in men. For instance, the educational level had a stronger influence on the prevalence of metabolic syndrome (Kim et al., 2017b; Lim et al., 2012) and diabetes (Lee et al., 2013) in women than in men. On the other hand, another three studies showed a greater magnitude of socioeconomic disparities in men. Association between educational disparities and diabetes was more pronounced in men, though these disparities narrowed between 2007 and 2015 (Kim & Nam, 2017). In one longitudinal study from 1995-2003, graded inverse patterns between health insurance level and mortality from diabetes and hypertensive disease were clearer in men than in women (Jung-Choi et al., 2011b). In addition, the area deprivation index was more strongly associated with CVD morbidity and mortality in men (Lee et al., 2018).

2.3.6 Disparity magnitude according to age

The few studies stratifying the analysis of the contribution of SEP to cardiovascular outcomes by age group disagreed over whether disparities in cardiovascular outcomes are reduced or increased in old age. One study illustrated a widening gap in educational and income differences for obesity across successive age groups (Hwang et al., 2019), showing that the accumulation of socioeconomic adversity in health tended to intensify as age increased. However, this finding was not consistently reported with another three studies. Seo et al. showed that although a progressively increasing trend of disparity was identified up to age 80, advanced age obscured the effects of socioeconomic condition on cardiovascular outcomes (Seo et al., 2014). Kim et al. and Jung-Choi et al. showed that the relative magnitude of educational disparity in mortality due to obesity, cerebrovascular disease, diabetes, or IHD was much higher in younger groups than in older groups (Kim et al., 2017c; Jung-Choi et al., 2011a)

2.4 Discussion

This systematic review included 42 studies on the topic of socioeconomic disparities in cardiovascular health. Most studies reviewed here reported that adults with lower educational attainment were more likely than those better educated to suffer cardiovascular events, which supports previous reports of educational disparities in this field (Goldman et al., 2002; Kubota et al., 2017). The results suggest a need to correct

those disparities. For instance, Goldman et al. found that offering more intensive care and tailored health education to individuals with diabetes who had lower educational attainment helped eliminate educational disparities (Goldman et al., 2002). Such targeted approaches are clinically critical in Korea, as individuals with lower educational attainment were found to recall and comprehend less medical information, resulting in decreased adherence to recommended behaviors and regimens to prevent and/or manage CVD (Lee & Park, 2018). In addition, those disparities challenge public health policy as healthcare programs and campaigns in Korea are not equally distributed across different education groups (Ko et al., 2011).

The findings revealed that the associations between cardiovascular health and poverty by income or its proxies were similar to those by education. Clinically, our results suggest that low income can be a marker of vulnerability, identifying individuals who either need more medical attention or closer follow-up (Cainzos-Achirica et al., 2019). This approach may also identify subgroups who may benefit from structural interventions such as alleviating economic barriers to hospital access or specialized cardiovascular care (Cainzos-Achirica et al., 2019). From a policy standpoint, this provides strong support to policies to reduce income disparities and improve the health of poor or unemployed individuals. For instance, European cities such as Barcelona, Utrecht, and Helsinki are evaluating the need for basic universal income (Barber, 2011).

Differences in cardiovascular outcomes were found between NHI and impoverished Korean Medicaid patients, which confirms persistent health disparities under the current welfare scheme in Korea (Kwon, 2008). Korea's Medicaid system is faced with many challenges that may adversely affect beneficiaries' long-term cardiovascular health. This includes high payment for uncovered services, a limited choice of doctors, and insufficient coverage for major illness (Kwon, 2008). The World Health Organization emphasizes strengthening and orienting health and welfare systems through Universal Health Coverage (UHC) to ensure equity in cardiovascular health and health care ("WHO," n.d.). UHC especially advocates for the poorest individuals by providing them access to health care with financial risk protection, granting their choice of doctor at private hospitals, and subsidizing affordable medicines and medical procedures ("WHO," n.d.). One study has reported that this approach reduced disparities in cardiovascular outcomes (Pilote et al., 2007).

The majority of the reviewed studies showed that manual, low-paid, or industrial-based workers suffered more from cardiovascular illness. Importantly, a few studies advanced to report the disparities induced by unsatisfactory workplace conditions among such groups (Cho et al., 2019; Kim et al., 2013b; Seo et al., 2014). In Korea, where the culture is patriarchal and labor unions are weak, workers' statuses are relatively low with a lack of control over their working condition (Min et al., 2014). In particular, people with unsecure employment in Korea are not only susceptible to social

hazards but to workplace hazards such as unsafe working environments and long working hours (Min et al., 2014). Work-related stress models point out that extreme demand coupled with low feelings of job control results in psychological strain, eventually adversely affecting on workers' health (Tennant, 2001). As yet, efforts to improve work-based health challenges which may worsen cardiovascular conditions have scarcely been reflected in policy priorities in Korea (Hwang & Park, 2015).

Geographic disparities were noted by seven of the included studies, shifting our attention from the individual level to higher-level differences. Interestingly, a few studies have specified the role of socioeconomic components of residents that may influence cardiovascular health alongside geographic factors (Kang & Kim, 2014; Hwang & Park, 2015). They argue that economic hardships of the residents or their behavioral risk factors account for much of the geographical disparities in CVD morbidity and mortality, which aligns with previous studies (Gebreab et al., 2015; Mensah et al., 2017). These results suggest that the burden of CVD in local districts of Korea could be partly addressed by a regional-level approach to achieve both adequate support of disadvantaged residents and control of their behavioral factors.

Six of the reviewed studies explained different levels of factors—nutritional behaviors, sedentary leisure time, quality of care, variations in access to health services, or depression—that mediate or moderate the association between SEP and cardiovascular outcomes. The findings are important as these factors can be used as

interventions to reduce or eliminate health disparities. For instance, previous Western studies have shown the widespread health benefits of dietary intervention (Estrada Del Campo et al., 2019) or physical activity-promoting programs (Schulz et al., 2015) in reducing CVD risk factors in low-SEP cohorts. In the literature, systematically improving quality of care and access to affordable health care was associated with the elimination of apparent disparities in cardiovascular health (Pilote et al., 2007). Further, Schneiderman et al. demonstrated the effect of psychosocial interventions to reduce cardiac death or nonfatal MI among ethnic minorities by addressing depression and low perceived social support (Schneiderman et al., 2004).

Studies on data trends from this review consistently reported that socioeconomic disparities in cardiovascular mortality increased over time, which is in contrast to former studies demonstrating that those disparities decrease markedly in high-income countries (Roth et al., 2015; Cheng et al., 2018). From a policy perspective, this emphasizes the need for a new prevention perspective concerning mortality reduction in Korean society. However, due to the small number of such studies, accurate assessments of the trends in specific situations and cases were limited. Therefore, rigorous analysis of data, beyond simple evaluations such as "the gap in disparity is widening", is needed to identify underlying etiologies in changing scales of disparity for both general and sub-populations such as specific age, gender, or occupational groups (Kahng et al., 2012).

Gender heterogeneity in the relationship between SEP and cardiovascular outcomes was reported in this review. This differs from another systematic review on this topic which has demonstrated an excess cardiovascular events rate in women with low SEP (Backholer et al., 2017). The findings also go against the argument which links an increased rate of cardiovascular events with the perception of "women's inferiority" in Korea. In Korean society, the overall inferior status of women originates from the Confucianism-influenced social structure (Kim & Ruger, 2010). This cultural force subordinates women socially and economically, acts as an obstacle in the pursuit of health knowledge and resources, and makes these individuals more likely to encounter undesirable health events (Kim & Ruger, 2010). However, the position of women has been elevated both socially and politically around the world, favorably changing the relative distribution of health resources, opportunities, constraints, and power. Such trends and our results suggest a need to continue generating data that accurately reflects the changing phenomena.

The few studies included in this review adequately powered for age-specific analysis disagreed over whether disparities in cardiovascular health are reduced or increased in old age. Two opposing hypotheses for this phenomenon have been found in the literature. Some argue that disparities continue as advantages and disadvantages accumulate over the lifespan (i.e. divergence hypothesis; Lowry & Xie, 2009). Others maintain that disparities become gradually diminished (i.e. convergence hypothesis)

mainly due to two reasons: biological decline in later life which may offset health variation across socioeconomic groups; and attenuation of the socioeconomic gap due to social security, which is somewhat favorable to the older generation in most developed countries (Lowry & Xie, 2009). Although several Korean studies consistently supported the divergence hypothesis (Jung-Choi & Kim, 2013; Ki et al., 2017), this hypothesis remains unclear in cardiovascular research and requires further exploration.

2.5 Limitations

Our review has several limitations. First, data were only gathered among the Korean population, thus its scope is limited. Studies in this field require a systematic review of comparable studies in other countries. Second, studies are constrained by cross-sectional studies. Although some studies monitored both long- and short-term trends in health disparities using periodic cross-sectional survey data, it is not feasible to examine a trajectory of the same person's health outcome repeatedly over time. Therefore, it is important to be aware of predictive limitations. Third, research is largely quantitative, evoking studies in mainstream epidemiology journals, in an effort to precisely document broad-based disparities. However, it is equally important to note that a qualitative study can uncover previously unknown factors, while a quantitative approach often yields merely descriptive findings of the influence of SEP on predefined factors. One promising avenue might be the use of mixed-methods, which might help bridge the publication divide and methodological break in health disparities research.

2.6 Conclusion

We synthesized the literature on socioeconomic disparities in cardiovascular health in the Korean population, proposing an association between several SEP factors and differences in cardiovascular health conditions and outcomes. Our study provides recommendations for advancing the field of disparities in cardiovascular health and informs the implementation of interventions and policies.

First, tackling education, income, and occupation-related disparities in cardiovascular health are required. Importantly, special care and tailored educational strategies to enhance cardiovascular outcomes of people with lower educational attainment might correct the disparities. Herein, the role of nurses is emphasized as nurses in Korea are responsible for a major portion of patient care and education through the continuum of care. In addition, Korea should actively advocate welfare policies to improve the health of the poor and Medicaid-dependent population, and develop strategies for improving employment settings and work-associated cardiovascular problems. Second, regional-level initiatives are required to reduce geographic disparities in cardiovascular health; these initiatives should address the socioeconomic conditions of the residents and their behavioral risk factors. Third, several behavioral, health system, and psychological factors have been identified as important mechanisms for socioeconomic disparities in cardiovascular health. In the future, healthcare professionals could consider them as interventions to reduce health

disparities. Fourth, disparities in cardiovascular mortality are increasing in the current rates and trends, and this provides a direction to establish national priorities to improve mortality prevention among the population. At the same time, trends marking disparities in specific contexts or population should be further explored to adapt for the needs of these populations. Lastly, a better understanding of possible age and gender differences in the relationship between SEP and cardiovascular outcomes is necessary to prioritize interventions amongst groups with greater health disparities.

3. A 10-year Trend in Income Disparity of Cardiovascular Health among Older Adults in South Korea

Although CVD risk has lessened in Korea, it is unclear whether older adults in all socioeconomic strata have benefited equally. This study explored trends in income disparities in CVD risk among older adults in Korea. This was a secondary analysis of KNHANES (2008-2017), targeting 14,836 older adults (≥ 65 years). SEP, defined as income and use of welfare benefits, was the primary indicator. The outcome was binary for predicted CVD risk (< 90th vs. ≥ 90th). The SII and RII were used to assess trends in disparities. The percentage of older adults with a predicted CVD risk of 90% or more declined over time, but this was due to a decrease among the more affluent. Disparities have persisted since 2012, with a worsening trend seen for Korean Medicaid recipients. We found significant absolute and relative disparities among men over 75 years of age in recent years (SII > 0.19, RII > 7). These results may inform and improve policies regarding income disparity reduction and cardiovascular health.

3.1 Introduction

CVDs are among the most serious public health problems in many countries. Despite overall improvements in cardiovascular health, studies consistently report widening disparities in CVD outcomes (Coke, 2018; Mills et al., 2016). As such, tracking disparities in cardiovascular health has become an important component of the global health policy agenda (Healthy People, 2020). Importantly, this monitoring has impacted

the government's plans and has led to a lessening of burden of health problems among socioeconomically disadvantaged populations (Pahigiannis et al., 2019).

Korea is no exception. Although change patterns vary both among and within different socioeconomic groups, most studies demonstrate that disparities in cardiovascular health are evident and that a widening gap exists over time in Korea (Kim & Nam, 2017; Kim et al., 2017c). Based upon these data, government policies have been consistently targeted toward reducing disparities. For instance, the Korean government has expanded health promotion social policies, welfare programs, and care services related to CVD risk factors, targeting populations with low incomes (Ministry of Health and Welfare, 2011). However, older adults have not been a major focus of these efforts.

It is critical to examine trend data in disparities in CVD among older adults so that future social policies for the health of the older population with lower income take into account the unique circumstances experienced by this population (Khang & Lee, 2012). The current Korean older adult generation has lived through major politico-economic changes in the society over the past decades such as rapid economic growth, economic crisis, neoliberal structural reforms and increased income disparity (Lee et al., 2017). Such income disparities have remained relatively constant since the early 2000s, which has led to widening health disparities and deepening health problems (Park et al., 2012). In addition, in recent years, a growing number of eligible older adults, notably

those having low incomes, have abstained from applying for social and health benefits due to the limitations of the socioeconomic support system currently in place (Jeon & Kwon, 2017; Jeon et al., 2017; Ki et al., 2017).

Lower-income older individuals may suffer more from cardiovascular events, a condition known to be significantly affected by deprivation of financial resources and limited access to health services (Clark, 2017). Further, with increasing life expectancy, Korean older adults are affected by more diverse CVD risk factors including one's SEP (Chun et al., 2016). Therefore, studies of the persistence or worsening of income-driven disparities in cardiovascular health should be prioritized accordingly.

The present study thus aimed to explore trends in income disparities in cardiovascular health among older adults in Korea. In particular, we aimed to explain cardiovascular disparities with the trends in the prevalence and disparities of CVD risk conditions. This approach will inform health policies for reducing future burden of CVD and responses to future disparities in CVD morbidity and mortality (Martinson et al., 2016).

3.2 Methods

3.2.1 Design

We used the data from the Korean National Health and Nutrition Examination Survey (KNHANES) conducted by the Korean Ministry of Health and Welfare. The KNHANES is a nationwide, representative, cross-sectional survey of the Korean

population to represent non-institutionalized civilian Koreans. The KNHANES utilizes a complex, multi-stage probability sample design; specifically, a three-stage sample design is used. The primary sample units (PSUs) are chosen from a sampling frame of all resident registration addresses or census blocks. Each PSU consists of approximately 50 - 60 households. Following the selection of PSUs, all dwelling units in the PSU are listed and 20 households are selected through the field survey for household screening. The final stage of selection occurs in the household, where all members aged 1 year and over are selected to participate. Approximately 10,000 persons are sampled in all 192 PSUs per year. KNHANES was chosen because it provides comprehensive and detailed information on socioeconomic status, health behaviors, healthcare utilization, anthropometric measures, and clinical profiles for CVD, all of which were relevant to this research. More detailed information on KNHANES is provided elsewhere (http://knhanes.cdc.go.kr).

KNHANES is composed of three 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. The study was exempted by the Institutuional Review Board (IRB) of the university where authors are affiliated.

3.2.2 Analysis sample

Trend analyses were conducted with the data from 2008 to 2017 using five two-year time periods: 2008–2009, 2010–2011, 2012–2013, 2014–2015, and 2016–2017. From the initial total of 15730 participants, 708 were excluded for incomplete anthropometric data. In addition, 186 people with a preexisting diagnosis of CVD were excluded to prevent reverse causality; respondents were considered to have a pre-existing diagnosis if they had ever been told by the doctor that they had angina pectoris, stroke, or myocardial infarction. A final total of 14836 older adults (57.94 % female) were included in the analyses. Power analysis was not undertaken given that the study was designed to generate, rather than to test, hypotheses.

3.2.3 Measures

Cardiovascular health. The primary outcome was the risk of developing CVD over a 10-year period, using a risk function developed specifically for the Korean population by Jee et al. (2014) considering the following factors: (a) sex, (b) age, (c) total cholesterol, (d) high-density lipoprotein cholesterol, (e) systolic blood pressure, (f) smoking, and (g) diabetes (Table 5). This is a continuous CVD risk score, with lower scores representing better cardiovascular health. The score was used to identify binary levels of CVD risk (defined as low-level risk and high-level risk). We defined cases as belonging to a high-risk group when the risk score was equal to or greater than the 90th percentile in each gender, given that the model was validated by comparing an actual

event with the prediction of self-reported event based on the decile of the predicted risk in each risk factor (Lee et al., 2016a). This risk-function model displays accurate predictions of cardiovascular health risks among Koreans and has been employed in numerous studies (Lee et al., 2016a).

Table 5. The Korean risk score (Jee et al., 2014)

Men
x = 0.13759*(AGE-45.7991)-0.0006964*(AGESQ-2186.58)+0.24130*(HTN2 0.40678)+0.54176*(HTN3-0.18005)+0.79091*(HTN4-0.06823)+0.30303*(TC2-0.43540)+0.72508*(TC3-0.31439)+1.02770*(TC4-0.08486)+1.51018*(TC5-0.01387)-0.41580*(HDL2-0.31063) -0.59809*(HDL3-0.22692)-0.80256*(HDL4-0.27050)-1.13973*(HDL5-0.11410)-0.00207*(EXSMOK-0.23029)+0.60138*(CUSMOK-0.53016)+0.49443*(DM-0.08389). **Y** = exp(x). The absolute 10-year risk of CHD is KRS-M =(1-0.99313**y), where 0.99313 is the baseline survival rate for men.
Women
x = 0.12962*(AGE-47.5808)-0.0003965*(AGESQ-2363.65)+0.41491*(HTN2-0.32308) +0.66187*(HTN3-0.14102)+1.10282*(HTN4-0.06657)+0.20005*(TC2-0.41642) +0.44176*(TC3-0.29841)+0.52267*(TC4-0.09640)+1.03573*(TC5-0.02196)-0.28121*(HDL2-0.18651) -0.18543*(HDL3-0.16015)-0.47018*(HDL4-0.30597)-0.72046*(HDL5-0.31451)+0.23099*(EXSMOK-0.03970)+0.67653*(CUSMOK-0.05079)+0.58729*(DM-0.06026). **Y** = exp(x). The absolute 10-year risk of CHD, KRS-W =(1-0.99815**y), where 0.99815 is the baseline survival rate for women.

Note.
AGESQ = the square of age
HTN = hypertension (HTN2: prehypertension, HTN3: stage 1 hypertension, HTN4: stage 2 hypertension)
TC = total cholesterol (TC2: 160-199 mg/dl, TC3: 200-239 mg/dl, TC4: 240-279 mg/dl, TC5: ≥280 mg/dl), HDL is HDL-cholesterol (HDL2: 35-44 mg/dl, HDL3: 45-49 mg/dl, HDL4: 50-59 mg/dl, HDL5: ≥60 mg/dl)
EXSMOK = ex-smoker
CUSMOK = current smoker
DM = diabetes

SEP measures. Income was used as the indicator of SEP. Equivalized income (the household monthly income[1] divided by the square root of the household size, "Organization for Economic Co-operation and Development [OECD]," n.d.) and welfare benefits were used to define five income groups. The target population was first divided into non-Korean Medicaid beneficiaries and Medicaid beneficiaries. The former was subdivided into quartiles based on equivalized income, and this determination was

[1]the household monthly income includes wages, pensions, unemployment benefits, social security benefits, and bank interest.

based on the Korean national household income quartile criteria. Next, older adults belonging to Korean Medicaid beneficiary group were classified separately and ranked in a bottom group.

Covariates. We included the following covariates, which showed a significant association with the main outcome of this study (i.e., binarized CVD risk) in the univariate analysis: (a) initial health status including activity limitation (yes/no); (b) behavioral factors including weight control (yes/no), regular physical activity (yes/no), and regular health check-up (yes/no); and (c) geographical location (urban/rural).

3.2.4 Statistical analysis

Given the importance of the age-specific analysis in disparities research (Khang, Lynch, & Kaplan, 2004), all analyses were conducted by 10-year birth cohorts (i.e. younger-old group: 65–74 years, older-old group: ≥ 75 years). Stratification was also done by gender as the ways in which income contributes to poorer cardiovascular health status in women compared with men vary (Backholer et al., 2017).

Sample characteristics were reported for each of the two-year five time period using descriptive statistics. The prevalence of older adults with predicted CVD risk of 90% or greater (i.e. high CVD risk) was estimated for different gender and age groups in each time period. To test the statistical significance of a trend in prevalence over time, we computed *p*-values for the linear effect of the survey year variable representing five

time periods on the outcome variable (i.e. binary levels of CVD risk), as estimated by logistic regression.

Disparities in high CVD risk were assessed using both absolute (the prevalence difference [PD] and the SII) and relative inequality measures (the relative risk [RR] and the RII). The RD and RR involve pair-wise comparisons of different socioeconomic groups. The RII and SII are regression-based summary measures of inequalities calculated across the entire socioeconomic distribution (Moreno-Betancur et al., 2015).

To estimate the SII and RII, the grouped income data are transformed into cumulative rank probabilities (ridit scores; Donaldson, 1998) ranging from 0 (highest income) to 1 (lowest income), with values reflecting the midpoint of the cumulative proportion of the population in each income group (Eq.1). This score was then used in generalized linear models (GLMs) with an identity link function to calculate SIIs, and with a logarithmic link function to model RIIs. Each analysis using a GLM regression included the following covariates–initial health status, behavioral factors, and rural/urban residence–for ridit score. A positive SII and an RII that is larger than 1 represent inequality in favor of the highest income group.

$$\boldsymbol{w_k = \frac{1}{2} p_k + \sum_{j=1}^{k-1} p_j\,,\ where\ p_j = Prob(x_j)} \qquad (1)$$

The linear trend of RR and PD for high CVD risk was conducted by obtaining the *p*-value for an interaction term (income by survey year) in GLMs. To assess trends in RII and SII, we used the methods outlined by Ernstsen et al. (2012) using pooled survey

data (with survey-specific ridit scores) and included covariates for ridit score described earlier and a interaction term (ridit score by survey year). A p value of < 0.05 for the interaction is indicative of significant change in the inequality measure over time. Both relative and absolute measures have been proven to be meaningful for monitoring socioeconomic disparities, given that differences or changes in the overall levels of health outcomes are carefully considered (Houweling et al., 2007). To accommodate a possible nonlinear quadratic trend, a second order polynomial trend was also included in the main effect model by adding the time^2 variable along with the interaction of the independent variable and the polynomial trends.

All analyses were performed with SAS software (SAS Institute, Inc., Cary North Carolina) after accounting for the complex sample designs including primary sampling units, stratification, and sample weights. The number of samples with missing outcome measures was minimal (< 6% for all variables) thus the maximum number of available samples was retained by single imputation. Missingness of continuous variables were Missing At Random (MAR) thus imputed with the expectation-maximization method. Missing values on categorical variables, which are also MAR, were replaced with the most common category for each variable.

3.3 Results

3.3.1 Characteristics of the study population by survey year (Table 6)

Table 6 shows the characteristics of the study population by time periods. The percentage of women was consistently higher than men. The mean age remained approximately 72 years old across the survey years. The proportion of the older-old group within the entire population fluctuated slightly without a clear direction of change and it ranged from 33–39%. The quartile income distribution of older adults also remained stable, and the proportion of Medicaid remained between 6–9% across the years.

Table 6. Characteristics of the study population by survey year

	2008 –2009	2010 - 2011	2012 - 2013	2014 - 2015	2016 - 2017
Gender, n (%)					
Men	1236 (39.9)	1230 (42.7)	1181 (42.1)	1276 (43.1)	1317 (42.7)
Women	1866 (60.1)	1651(57.3)	1625 (57.9)	1683 (56.9)	1771 (57.3)
Age, years					
Mean ± SD	72.20 ± 4.83	72.37 ± 4.74	72.53 ± 4.89	72.69 ± 5.01	72.86 ± 5.12
Age, group, n (%)					
65-74 years	2067 (66.6)	1922 (66.7)	1769 (63.0)	1800 (60.8)	1832 (63.1)
75+ years	1035 (33.4)	959 (33.3)	1037 (37.0)	1159 (39.2)	1256 (36.9)
Gender, n (%)					
Men	1236 (39.9)	1230 (42.7)	1181 (42.1)	1276 (43.1)	1317 (42.7)
Women	1866 (60.1)	1651(57.3)	1625 (57.9)	1683 (56.9)	1771 (57.3)
Income[a], n (%)					
Quartile 1(–$600)	775 (25.0)	675 (23.4)	685 (24.4)	731 (24.7)	745 (24.3)
Quartile 2($601–1050)	683 (22.0)	715 (24.8)	705 (25.1)	696 (23.5)	757 (24.0)
Quartile 3($1051–1800)	721 (23.2)	648 (22.5)	621 (22.1)	649 (21.9)	686 (22.4)
Quartile 4($1801–)	650 (21.0)	695 (24.1)	631 (22.5)	686 (23.2)	699 (22.7)
Medicaid	273 (8.8)	148 (5.2)	164 (5.9)	197 (6.7)	201 (6.6)

n, unweighted number of cases in the sample

SD, standard deviation

[a]based on the Korean national household income quartile criteria. Korean won is converted to US dollar.

3.3.2 Prevalence of high CVD risk for different income levels by different age and gender groups (Table 7, Figure 4-5)

For men aged 65–74 years, the proportion of the high CVD risk individuals decreased linearly among the quartile 1 group ($p = 0.015$), but remained unchanged for other quartile groups and this age group as a whole. Only the Medicaid group showed an increasing trend from 2012/2013, but the increase was not statistically significant. For women in the same age group, an inverse U-shaped polynomial trend ($p = 0.031$) was seen in the quartile 1 group and the highest proportion was found in 2010/2011. A significant decreasing linear trend was observed for the quartile 2 ($p = 0.029$) and for the entire group ($p = 0.007$).

For men aged 75 years and up, the risk trend for quartile 1 showed an inverse U-shaped pattern ($p = 0.039$); it spiked in 2012/2013, then sharply decreased in the following time periods. On the other hand, the Medicaid group showed a U-shaped pattern ($p = 0.030$), with the year 2010/2011 being the lowest. The quartile 3 showed a significant decreasing linear trend ($p = 0.011$). For women of this age groups, the proportion of the high CVD risk individuals showed a significant linear decreasing trend for the quartile 2 and for the entire group ($p < 0.05$).

The male group as a whole, the proportion of the high CVD risk adults among the Medicaid group were noticeably higher compared to other SEP groups in more recent years. In the female group as a whole, a strong socioeconomic gradient existed in

each time period due to the fact that lower SEPs were associated with a higher proportion of the high CVD risk individuals, especially in the Medicaid groups.

Table 7. Prevalence of high CVD risk for different income levels by age and gender groups

	2008 - 2009 % (95% CI)	2010 - 2011 % (95% CI)	2012 - 2013 % (95% CI)	2014 - 2015 % (95% CI)	2016 - 2017 % (95% CI)	*p*-value for x^2 trend linear	*p*-value for x^2 trend polynomial
65-74 years							
Men							
Quartile 1	11.1 (6.5 - 15.6)	9.0 (3.3 - 14.8)	10.5 (4.8 - 16.3)	5.9 (2.4 - 9.4)	5.1 (2.1 - 8.1)	**0.015***	0.553
Quartile 2	7.3 (3.2 - 11.5)	12.1 (6.7 - 17.5)	10.0 (5.6 - 14.4)	6.6 (2.9 - 10.2)	9.4 (4.5 - 14.3)	0.913	0.687
Quartile 3	12.0 (7.4 - 16.6)	12.4 (7.5 - 17.3)	15.5 (9.0 - 22.0)	8.8 (4.8 - 12.8)	9.1 (4.3 - 13.8)	0.214	0.332
Quartile 4	9.2 (4.7 - 13.6)	10.4 (5.5 - 15.3)	11.3 (5.7 - 16.9)	10.0 (4.0 - 15.9)	10.6 (5.0 - 16.2)	0.781	0.762
Medicaid	9.8 (3.1 - 16.6)	8.6 (6.3 - 11.0)	6.8 (0.0 - 16.6)	13.6 (4.2 - 23.0)	18.6 (0.0 - 40.1)	0.325	0.441
Total	10.0 (8.0 - 12.0)	11.0 (8.3 - 13.6)	11.6 (8.9 - 13.6)	7.9 (5.8 - 10.0)	9.0 (6.2 - 11.8)	0.245	0.471
Women							
Quartile 1	6.4 (3.2 - 9.6)	11.4 (6.3 - 16.5)	10.3 (5.2 – 15.3)	6.3 (3.2 – 9.4)	4.3 (1.3 - 7.4)	0.088	**0.031***
Quartile 2	12.3 (7.4 - 17.2)	12.2 (7.4 – 16.9)	9.4 (4.9 – 14.0)	6.7 (3.1 - 10.3)	7.3 (3.9 – 10.6)	**0.029***	0.970
Quartile 3	13.3 (8.3 - 18.3)	13.9 (8.6 – 19.2)	8.7 (4.7 – 12.7)	6.0 (2.6 - 12.7)	11.4 (6.9 - 16.0)	0.259	0.129
Quartile 4	11.3 (6.7 - 15.8)	11.2 (6.3 – 16.1)	9.1 (4.8 – 13.4)	10.4 (6.0 - 14.9)	8.5 (4.1 – 12.8)	0.369	0.910
Medicaid	16.0 (8.3 – 23.7)	15.2 (4.0 - 26.4)	23.8 (8.8 – 38.8)	10.8 (2.1 -19.4)	19.8 (7.7 - 31.8)	0.729	0.937
Total	11.0 (8.8 – 13.3)	12.3 (10.0 – 14.6)	10.2 (7.8 – 12.6)	7.5 (5.7 – 9.2)	8.3 (6.3 – 10.4)	**0.007****	0.740
75+ years							
Men							
Quartile 1	6.4 (1.0-11.8)	6.3 (0.5 - 12.1)	9.1 (2.7-15.4)	6.8 (1.5-12.1)	1.2 (0 – 3.4)	**0.032***	**0.039***
Quartile 2	11.7 (3.7 – 19.6)	7.6 (1.2 - 14.0)	9.1 (2.1 - 16.1)	8.9 (3.2 - 14.7)	11.4 (5.8 - 17.1)	0.808	0.394
Quartile 3	19.1 (8.1 – 30.0)	12.7 (5.0 – 20.3)	4.7 (0 – 10.8)	8.0 (1.8 - 14.2)	5.9 (1.9 - 9.8)	**0.011***	0.313
Quartile 4	11.5 (3.0 – 19.9)	11.7 (5.4 – 18.0)	8.2 (3.3 – 13.0)	14.4 (6.8 – 22.0)	18.1 (9.4 – 26.7)	0.160	0.282
Medicaid	16.9 (0.0 – 34.1)	0.4 (0.3 - 6)	3.4 (0.0 – 10.2)	3.8 (0 – 11.5)	17.7 (5.0 – 30.4)	0.709	**0.030***
Total	12.4 (8.0 – 16.8)	9.3 (6.0 - 12.5)	7.6 (4.6 – 10.5)	9.4 (6.4 – 12.4)	9.6 (6.5 – 12.7)	0.473	0.142
Women							
Quartile 1	8.2 (3.5 - 12.9)	15.4 (6.7 – 24.0)	7.5 (3.0 – 12.1)	8.9 (4.2 - 13.5)	9.1 (4.2 - 14.2)	0.735	0.750
Quartile 2	17.6 (10.4 – 24.7)	13.7 (6.3 - 21.0)	4.8 (1.6 – 8.0)	10.3 (3.5 – 17.2)	5.7 (2.0 – 9.3)	**0.005****	0.400
Quartile 3	11.2 (5.0 – 17.4)	11.1 (4.8 – 17.3)	10.3 (5.2 – 15.4)	5.9 (0.7 – 11.1)	9.3 (4.1 – 14.5)	0.448	0.687
Quartile 4	10.9 (4.8 – 17.0)	10.5 (3.7 – 17.2)	8.4 (3.5 – 13.2)	7.1 (3.0 – 11.1)	7.1 (3.2 - 11.1)	0.206	0.861
Medicaid	17.6 (9.5 – 25.8)	19.4 (7.9 – 30.5)	14.7 (8.0 - 21.5)	11.0 (4.7 – 17.3)	17.8 (9.5 – 26.1)	0.614	0.397
Total	12.5 (9.4 - 15.7)	13.2 (9.7 – 16.6)	8.4 (5.8 – 10.9)	8.4 (6.1 – 10.8)	8.6 (6.3 – 10.9)	**0.009****	0.471

*$p < 0.05$, **$p < 0.01$

CI, confidence interval; CVD, cardiovascular disease

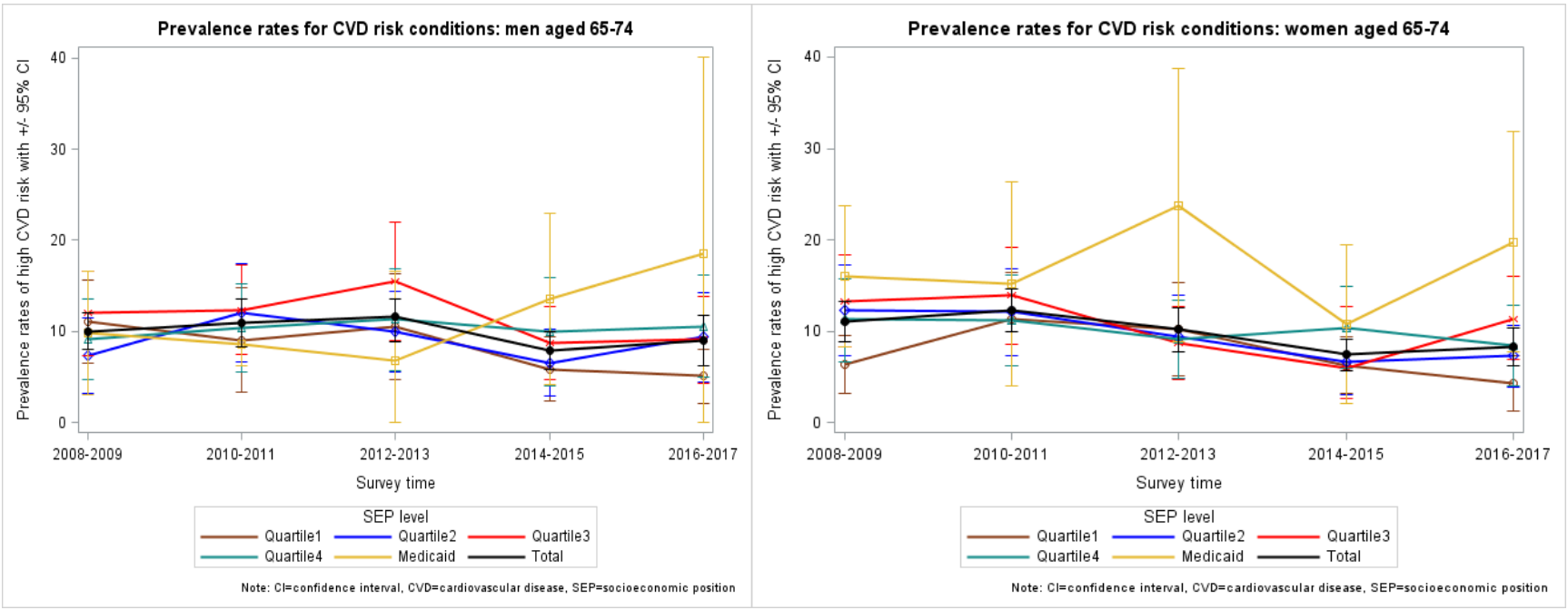

Figure 4. Prevalence of high CVD risk for different income levels by different age and gender groups: 65-74 years

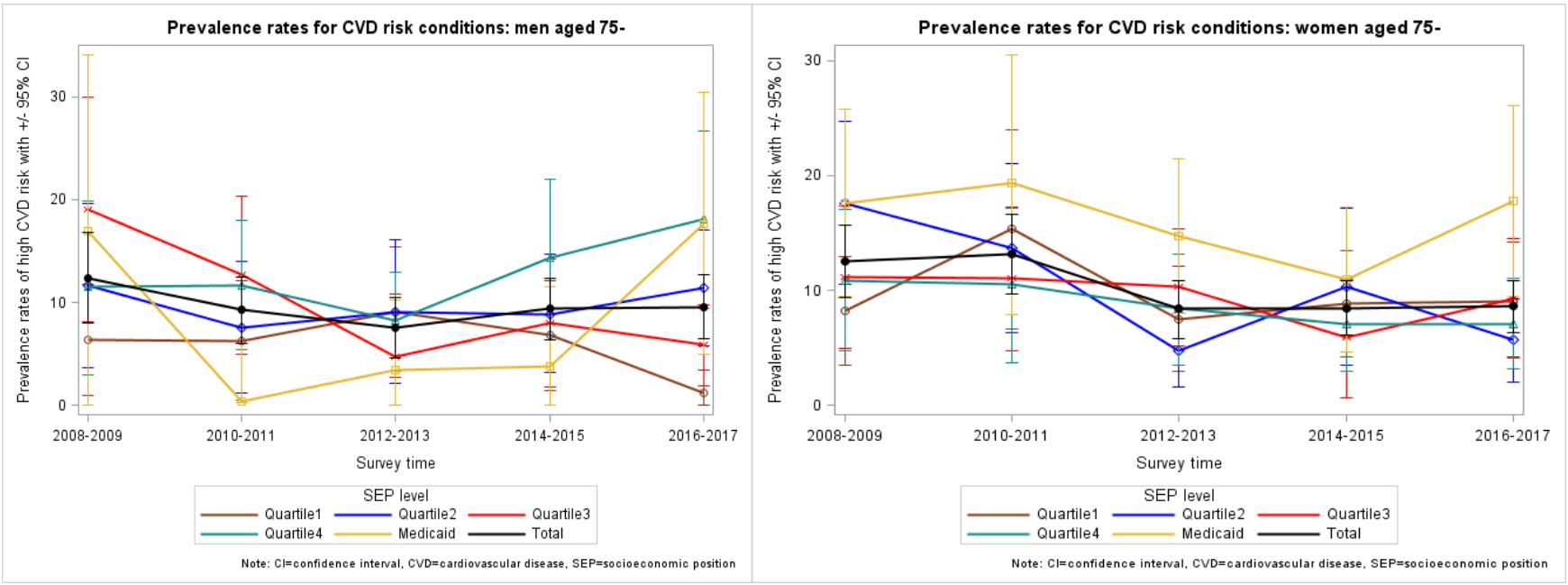

Figure 5. Prevalence of high CVD risk for different income levels by different age and gender groups: ≥ 75 years

3.3.3 Trend in absolute disparities in high CVD risk among older adults from 2008 to 2017 (Table 8, Figure 6-8)

For men aged 65–74 years, no statistically significant trends were found for the PDs. However, although not statistically significant, the absolute magnitude of income disparities for high CVD risk measured by SII increased over time peaking in 2016/2017. For women of this age group, the PDs between quartiles 1 vs 2, quartiles 1 vs 3, quartiles 1 vs 4, and SII showed U-shaped trends; however, only the risk trend between quartiles 1 vs 3 was significant ($p = 0.007$).

For men aged 75 years and up, the PDs between quartiles 1 vs 3, quartiles 1 vs 4 and quartile 1 vs Medicaid followed significant U-shaped trends over time ($p < 0.05$). SII also showed a significant U-shaped trend ($p = 0.001$), peaking in 2016/2017. Notably, the SII value in the 2016/2017 period was significantly higher when compared to other years. For women in this age group, no specific trends were found for PDs or SII; however, results indicated a constant absolute health gap exists between individuals at the lowest and highest SEP ranks.

Table 8. Trend in absolute disparities in high CVD risk among older adults from 2008 to 2017

	2008 – 2009	2010 – 2011	2012 – 2013	2014 - 2015	2016 – 2017	*p*-trend	
						linear	polynomial
65-74 years							
Men							
PD (95% CI)							
Quartile1vs2	-3.7	3.1	-0.5	0.6	4.3	0.139	0.945
	(-9.9 - 2.5)	(-4.8 - 10.9)	(-7.7 – 6.7)	(-4.4 - 5.7)	(-1.2 - 9.8)		
Quartile1vs3	0.9	3.4	5.0	2.9	4.0	0.625	0.652
	(-5.7 – 7.7)	(-4.2 - 10.9)	(-3.6 - 13.6)	(-2.6 - 8.3)	(-2.1 - 10.0)		
Quartile1vs4	-1.9	1.4	0.8	4.0	5.5	0.089	0.979
	(-8.3 - 4.5)	(-6.2 - 8.9)	(-7.3 – 8.8)	(-2.4 - 10.5)	(-0.8 - 11.8)		
Quartile1vs	-1.2	-0.4	-3.7	7.7	13.5	0.167	0.397
Medicaid	(-10.4 - 7.9)	(-12.1 - 11.3)	(-15.0 - 7.6)	(-4.9 - 20.2)	(-8.3 - 35.3)		
SII[a] (95% CI)	-.032	.019	-.005	.026	.073	0.071	0.983
	(-.105 - .040)	(-.082 - .119)	(-.082 - .072)	(-.026 - .078)	(-.014 - .160)		
Women							
PD (95% CI)							
Quartile1vs2	5.9	0.8	-0.8	0.4	2.9	0.695	0.096
	(0.3 – 11.5)	(-6.1 - 7.6)	(-7.8 - 6.1)	(-4.0 – 5.4)	(-1.7 - 7.6)		
Quartile1vs3	6.9	2.5	-1.6	-0.3	7.1	0.739	**0.007****
	(1.1 – 12.8)	(-5.0 - 10.0)	(-8.0 - 4.9)	(-4.9 - 4.3)	(1.6 – 12.7)		
Quartile1vs4	4.9	-0.2	-1.1	4.2	4.2	0.648	0.212
	(-1.4 – 11.3)	(-7.4 - 7.0)	(-7.8 - 5.5)	(-1.2 - 9.6)	(-1.2 – 9.5)		
Quartile1vs	9.6	3.8	13.5	4.5	15.5	0.323	0.570
Medicaid	(1.8 – 17.4)	(-8.2 - 15.8)	(-0.2 - 29.6)	(-4.5 – 13.5)	(3.0 – 27.9)		
SII[b] (95% CI)	.060	.029	.014	.018	.123	0.357	0.072
	(-.001 - .122)	(-.050 - .108)	(-.070 - .097)	(-.038 - .074)	(.066 - .180)		
75+ years							
Men							
PD (95% CI)							
Quartile1vs2	5.3	1.3	0.3	2.2	10.2	0.085	0.072
	(-4.1 - 14.7)	(-0.7 - 9.8)	(-9.3 - 9.4)	(-5.4 – 9.7)	(4.2 - 16.2)		
Quartile1vs3	12.7	6.3	-4.3	1.2	4.7	0.624	**0.032***
	(0.5 - 24.8)	(-0.3 - 15.9)	(-12.9 - 4.2)	(-6.9 - 9.3)	(0.1 - 9.2)		
Quartile1vs4	5.1	5.4	-0.8	7.6	16.8	**0.013***	**0.037***
	(-0.5 - 14.8)	(-0.4 - 14.4)	(-8.8 - 7.1)	(-1.3 – 16.4)	(8.1 - 25.5)		
Quartile1vs	10.5	-5.9	-5.6	-3.0	16.5	0.327	**0.008****
Medicaid	(-0.7 - 28.1)	(-12.0 - -0.1)	(-14.7 - 3.4)	(-11.9 - 5.9)	(1.7 - 31.3)		
SII[c] (95% CI)	.140	.047	-.047	.064	.188	0.078	**0.001****
	(.009 - .271)	(-.064 - .157)	(-.148 - .054)	(-.053 - .159)	(.102 - .275)		
Women							
PD (95% CI)							
Quartile1vs2	9.4	-1.7	-2.8	1.5	-3.5	0.086	0.332
	(0.7 – 18.0)	(-13.1 - 9.8)	(-8.3 – 2.8)	(-6.7 - 9.6)	(-9.6 - 2.5)		
Quartile1vs3	3.0	-4.3	2.8	-3.0	0.1	0.767	0.566
	(-5.3 – 11.2)	(-15.2 – 6.7)	(-3.5 - 9.0)	(-9.8 - 3.8)	(-7.1 - 7.3)		
Quartile1vs4	2.7	-4.9	0.8	-1.9	-0.2	0.548	0.660
	(-5.0 – 10.4)	(-15.9 - 6.1)	(-5.6 - 7.3)	(-8.1 - 4.4)	(-8.2 - 4.1)		
Quartile1vs	9.4	4.1	7.2	2.2	8.6	0.861	0.444
Medicaid	(-1.1 – 20.0)	(-11.9 - 20.0)	(-2.7 – 17.0)	(-6.2 - 10.5)	(-4.1 - 21.3)		
SII[d] (95% CI)	.068	-.010	.050	.001	.029	0.843	0.643
	(-.034 - .168)	(-.142 - .120)	(-.032 -.133)	(-.078 - .080)	(-.057 - .115)		

[a]adjusted for regular physical activity, weight control, and regular health check-up; [b]adjusted for activity limitation, weight control, and regular health check-up; [c]adjusted for activity limitation and geographical location; [d]adjusted for regular physical activity, weight control, and geographical location

*$p < 0.05$, **$p < 0.01$

CI, confidence interval; CVD, cardiovascular disease; PD, prevalence difference; SII, slope index of inequality

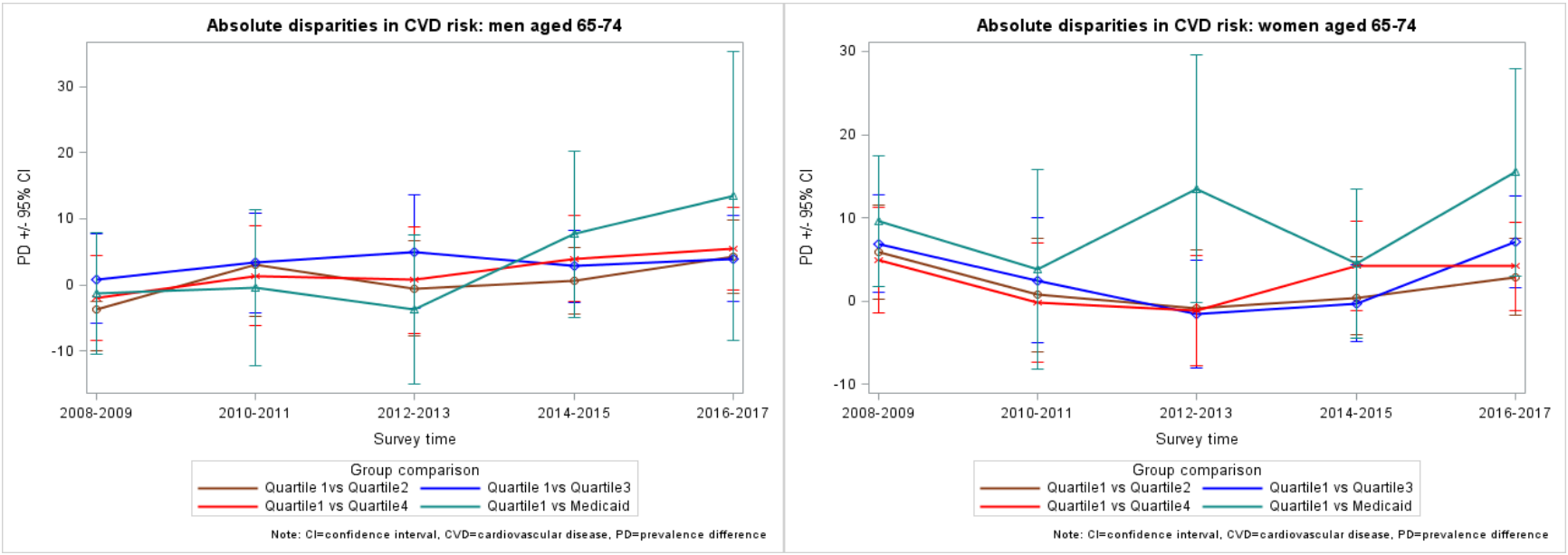

Figure 6. Trend in absolute disparities in high CVD risk prevalence difference among older adults from 2008 to 2017: 65-74 years

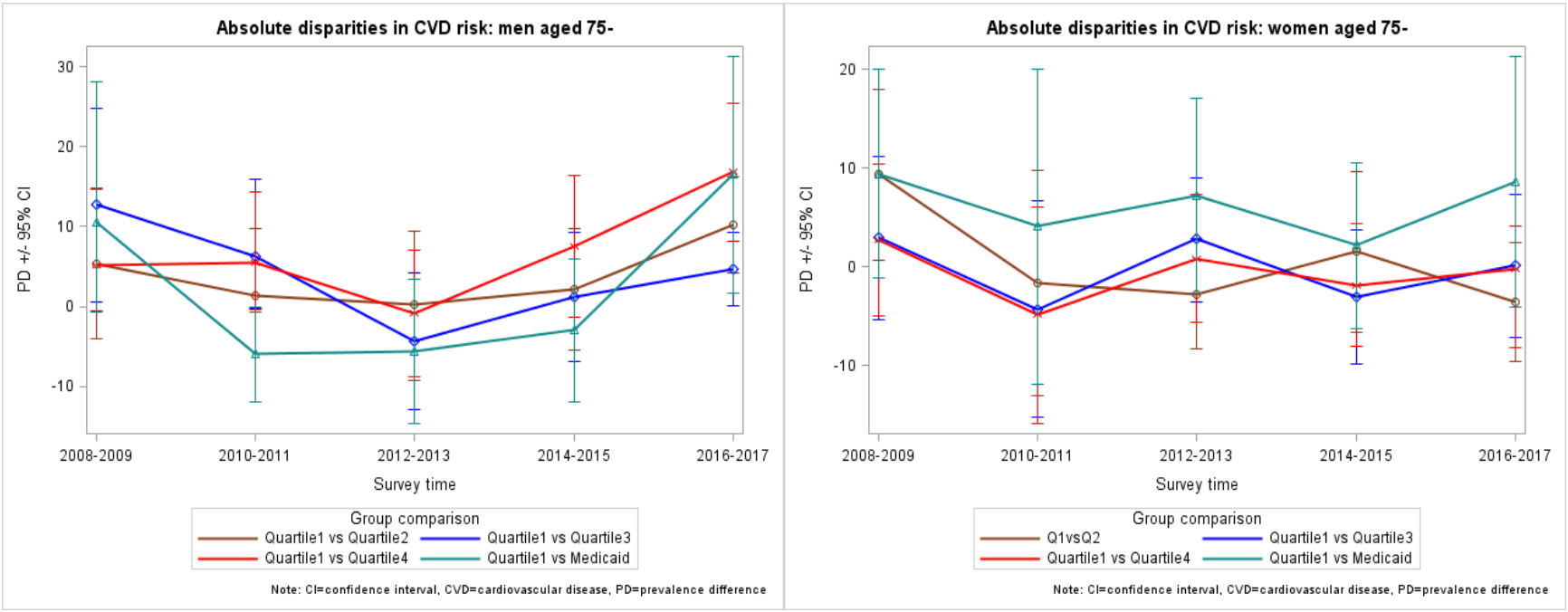

Figure 7. Trend in absolute disparities in high CVD risk among older adults from 2008 to 2017: ≥ 75 years

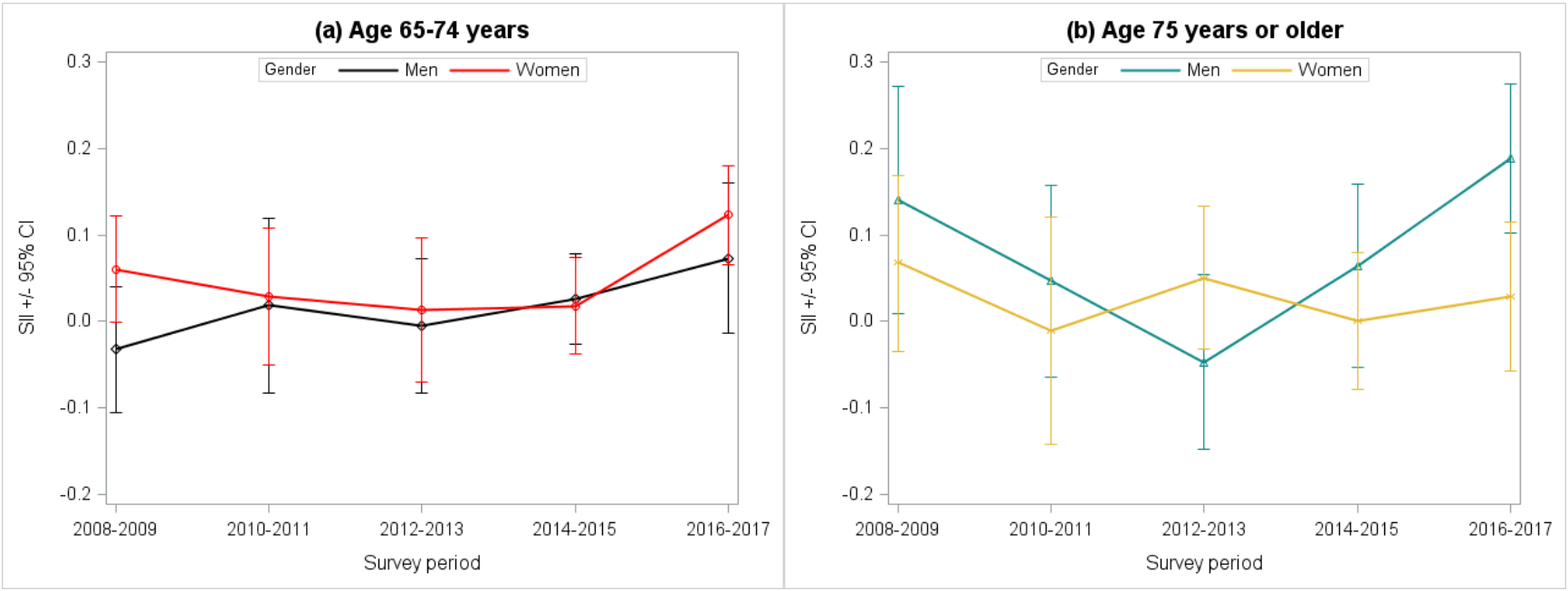

Figure 8. Trends in slope index of inequality over time by age group and gender

3.3.4 Trend in relative disparities in high CVD risk among older adults from 2008 to 2017 (Table 9, Figure 9-11)

A similar pattern was observed based on both the absolute and the relative measures for men aged 65–74 years; no specific trend was observed within the RRs for high CVD risk among different SEP groups. In addition, the relative magnitude of disparities measured by RII tended to increase over time, although this was not significant according to the trend analysis. For women aged 65–74 years, the RRs for the quartiles 1 vs 3 and RII revealed strong U-shaped trends ($p < 0.05$). The highest RII was observed in 2016/2017 for both genders.

For men aged 75 years and up, the RRs showed a significant U-shaped trend in all between-group comparisons ($p < 0.05$), all peaking in 2016/2017. The RII also showed a significant U-shaped trend ($p = 0.009$) with the value increasing significantly in recent years. On the other hand, the women of this age group showed no statistically significant trend. However, it is noteworthy that the highest RRs were reported between the quartile 1 and Medicaid groups over the analysis time periods.

Table 9. Trend in relative disparities in high CVD risk among older adults from 2008 to 2017

	2008 – 2009	2010 – 2011	2012 – 2013	2014 – 2015	2016 – 2017	*p*-trend	
						linear	polynomial
65-74 years							
Men							
RR (95% CI)							
Quartile1vs2	0.67	1.34	0.95	1.11	1.84	0.115	0.849
	(0.33 - 1.35)	(0.62 - 2.90)	(0.47 – 1.91)	(0.49 - 2.50)	(0.85 – 3.97)		
Quartile1vs3	1.09	1.37	1.47	1.48	1.77	0.340	0.875
	(0.06 - 1.95)	(0.65 – 2.90)	(0.75 - 2.92)	(0.69 - 3.18)	(0.76 - 4.14)		
Quartile1vs4	0.83	1.10	1.07	1.68	2.07	0.809	0.078
	(0.44 - 1.57)	(1.08 - 1.11)	(0.52 - 2.24)	(0.78 – 3.61)	(0.93 - 4.62)		
Quartile1vs	0.89	0.96	0.65	2.29	3.62	0.075	0.372
Medicaid	(0.36 – 2.21)	(0.25 - 3.64)	(0.14 - 2.95)	(0.79 - 6.62)	(0.97 - 13.57)		
RII[a] (95% CI)	0.74	1.13	0.95	1.61	2.58	0.069	0.793
	(0.35 – 1.57)	(0.47 – 2.72)	(0.41 - 2.19)	(0.66 – 3.92)	(0.97 - 6.86)		
Women							
RR (95% CI)							
Quartile1vs2	1.93	1.07	0.92	1.07	1.68	0.767	0.091
	(1.04 – 3.60)	(0.59 - 1.91)	(0.46 – 1.86)	(0.50 – 2.28)	(0.71 – 3.96)		
Quartile1vs3	2.09	1.22	0.85	0.95	2.69	0.666	**0.009****
	(1.12 – 3.90)	(0.67 – 2.21)	(0.43 – 1.67)	(0.45 – 2.02)	(1.17 - 6.00)		
Quartile1vs4	1.78	0.98	0.89	1.68	1.96	0.575	0.111
	(0.89 - 3.54)	(0.52 - 1.85)	(0.45 – 1.76)	(0.78 – 3.61)	(0.81 - 4.71)		
Quartile1vs	2.51	1.33	2.32	1.71	4.58	0.180	0.183
Medicaid	(1.29 – 4.88)	(0.57 – 3.09)	(1.03 – 5.23)	(0.68 – 4.34)	(1.78 – 11.76)		
RII[b] (95% CI)	1.95	1.03	1.25	1.60	3.03	0.284	**0.008****
	(1.07 - 3.57)	(0.50 - 2.11)	(0.52 - 3.01)	(0.69 - 3.74)	(1.28 - 7.16)		
75+ years							
Men							
RR (95% CI)							
Quartile1vs2	1.82	1.20	1.00	1.32	9.28	0.084	**0.028***
	(0.64 - 5.24)	(0.36 - 4.08)	(0.36 - 2.82)	(0.50 - 3.49)	(1.51 – 57.00)		
Quartile1vs3	2.98	2.11	0.52	1.18	4.77	0.731	**0.025***
	(1.08 - 8.26)	(2.04 - 2.17)	(0.12 – 2.21)	(0.39 - 3.50)	(0.75 – 30.24)		
Quartile1vs4	1.79	2.00	0.90	2.11	14.65	**0.011***	**0.019***
	(0.60 - 5.34)	(0.68 - 5.91)	(0.36 - 2.26)	(0.85 - 5.19)	(2.47 - 86.74)		
Quartile1vs	2.65	0.07	0.38	0.55	14.36	0.230	**0.003****
Medicaid	(0.71 - 9.94)	(0.01 - 0.69)	(0.05 - 2.99)	(0.07 - 4.42)	(2.13 - 96.77)		
RII[c] (95% CI)	2.21	1.44	0.54	1.95	7.32	**0.046***	**0.009****
	(0.77 - 6.39)	(0.43 – 4.77)	(0.15 - 1.95)	(0.54 - 7.03)	(2.57 - 20.9)		
Women							
RR (95% CI)							
Quartile1vs2	2.14	0.89	0.64	1.17	0.62	0.062	0.431
	(1.06 – 4.31)	(0.41 - 1.95)	(0.26 – 1.55)	(0.51 – 2.68)	(0.27 – 1.40)		
Quartile1vs3	1.36	0.72	1.37	0.66	1.01	0.742	0.613
	(0.59 – 3.13)	(0.32 – 1.63)	(0.68 – 2.74)	(0.24 – 1.80)	(0.46 – 2.20)		
Quartile1vs4	1.33	0.68	1.11	0.80	0.78	0.478	0.734
	(0.60 – 2.94)	(0.29 – 1.60)	(0.49 – 2.50)	(0.36 – 1.75)	(0.37 – 1.64)		
Quartile1vs	2.15	1.27	1.95	1.24	1.93	0.928	0.479
Medicaid	(0.98 – 4.7)	(0.5 – 3.11)	(0.84 – 4.51)	(0.55 – 2.8)	(0.83 – 4.53)		
RII[d] (95% CI)	1.67	0.83	2.15	0.91	1.56	0.972	0.667
	(0.77 - 3.65)	(0.29 - 2.34)	(0.83 - 5.59)	(0.36 – 2.31)	(0.57 – 4.30)		

[a]adjusted for regular physical activity, weight control, and regular health check-up; [b]adjusted for activity limitation, weight control, and regular health check-up; [c]adjusted for activity limitation and geographical location; [d]adjusted for regular physical activity, weight control, and geographical location

*$p < 0.05$, **$p < 0.01$

CI, confidence interval; CVD, cardiovascular disease; RR, risk ratio; RII, relative index of inequality

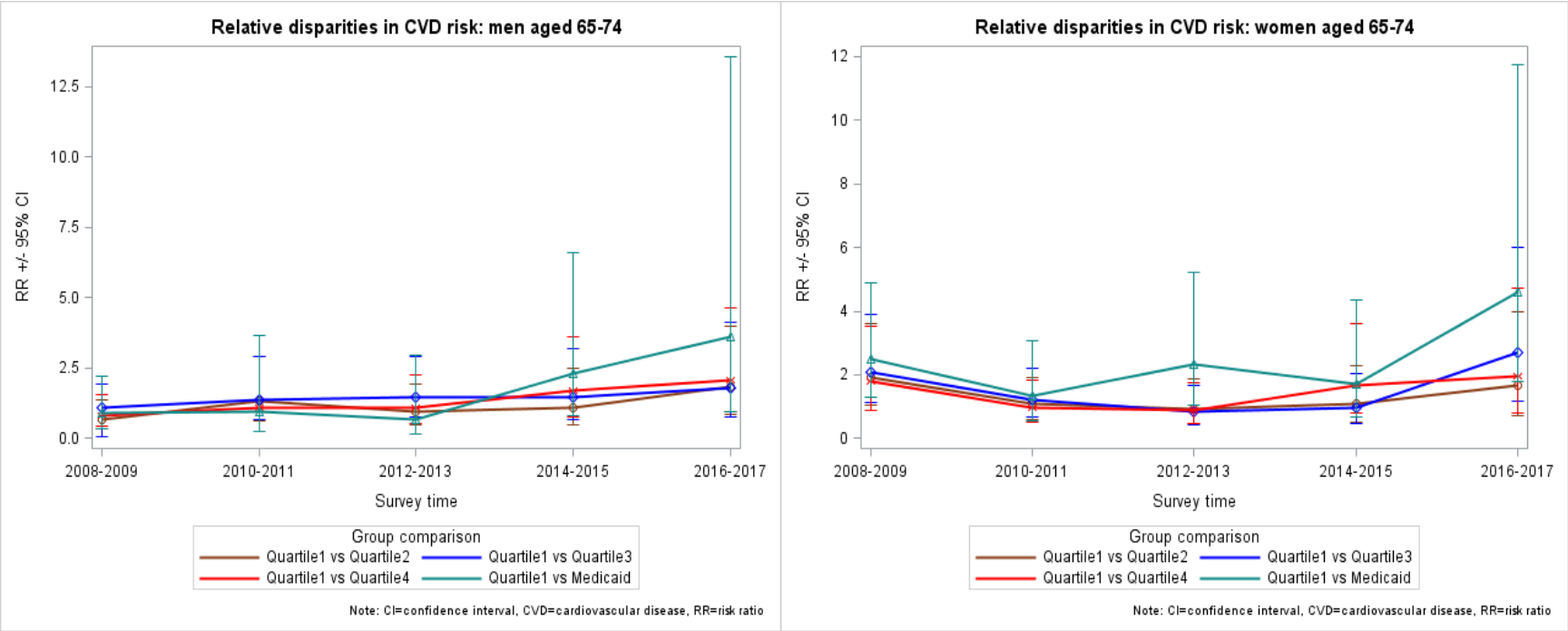

Figure 9. Trend in relative disparities in high CVD risk among older adults from 2008 to 2017: 65-74 years

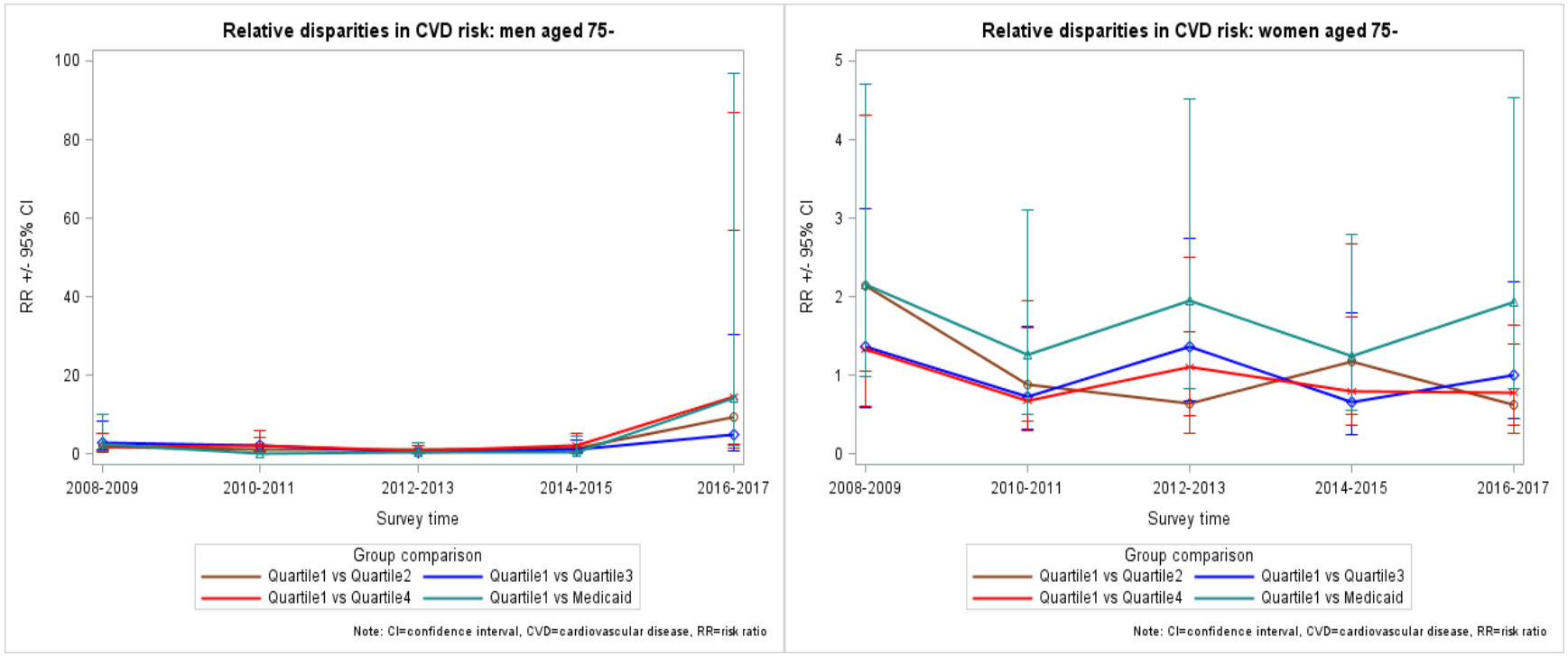

Figure 10. Trend in relative disparities in high CVD risk among older adults from 2008 to 2017: ≥ 75 years

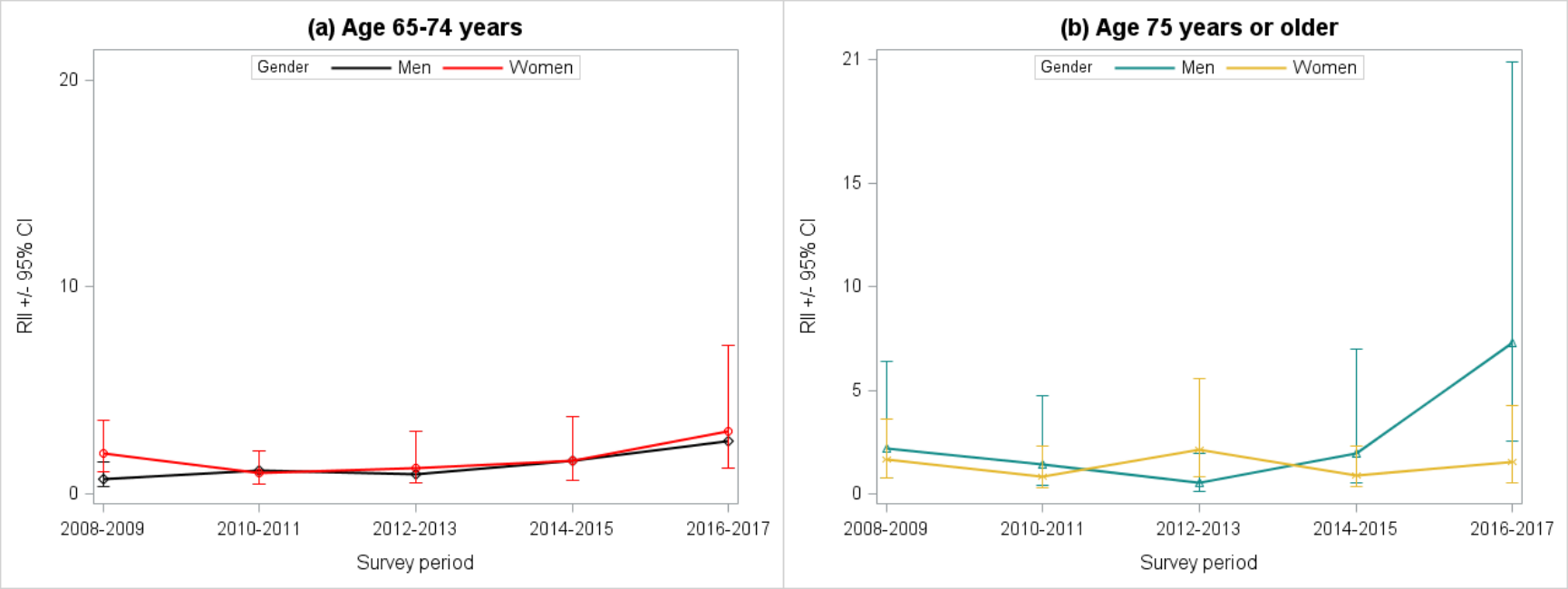

Figure 11. Trends in relative index of inequality over time by age group and gender

3.4 Discussion

3.4.1 The failure to achieve an equitable reduction in high CVD risk

This study described the 10-year trends of income disparities in CVD risk among older Koreans. In general, the proportion of the older adults with a high-CVD risk followed a declining trend over time across all age and gender groups. The large decline of high CVD risk individuals in more affluent individuals seem to contribute significantly to this trend. Indeed, the proportion of the high CVD risk adults increased in the lower-income groups such as Quartile 4 and Medicaid. These results are consistent with the findings of recent trend studies in the US (Beckman et al., 2017; Odutayo et al., 2017; Valero-Elizondo et al., 2018); they commonly reported that the percentage of adults with high CVD risk declined in the high-income stratum but remained unchanged for the lower income groups despite the overall improvements in controlling CVD risk factors.

National CVD management programs and advances in cardiovascular care may have contributed to the overall decrease of the high CVD risk population seen in the analysis. However, our findings indicate that such efforts may have not equally benefited older adults of all socioeconomic statuses. In fact, a prior study reported that many lower-income Koreans of older age have been excluded from national health and welfare plans due to limited access to public resources and insufficient information (Cho & Chu, 2016). Challenges have also persisted due to the financial burden of health care expenditures faced by low-income elders (Jeon et al., 2017). Although national programs such as the Korean National Cardio-

Cerebrovascular Disease Plan ("Korea Centers for Disease Control and Prevention," n.d.) has worked to provide accessible and affordable health care for older adults, additional progress is needed.

3.4.2 An increasing absolute and relative disparities in high CVD risk

Both the absolute and relative disparities among younger-old men showed an increasing linear trend over time although not it was not statistically significant. This result is partially in agreement with the study of Yang et al. (2015), which reported that both types of disparities in predicted 10-year CVD risk persisted from 2009 when examined using similar methods. Previous studies have reported that income disparities for major CVD risk factors were either decreased (Shin & Kang, 2018) or remained stable (Kim et al., 2017) among Korean men aged 25–64 years. These contrasting observations prompt the need to carefully examine the health policies to identify factors that may have led to the health disparities in older adults.

The overall rates of high CVD risk have declined in younger-old women. However, their relative disparity decreased in 2008–2011 and then has increased from 2012. Although further investigation is needed to explain this polynomial trend, it should be noted that the relative health gap between higher-income groups and the Medicaid group was still evident even in 2008-2011 where RII showed a decreasing trend (RII > 1; 2008-2017). Indeed, Moon et al. (2019) found CVD risk in female Medicaid recipients aged over 60 years was consistently

higher during 2008–2012 when compared to health insurance subscribers of those with the same demographics (Moon et al., 2019).

Among older-old men, both the absolute and relative income disparities in CVD risk have drastically increased in recent years (2016/2017: SII > 0.18, RII > 7), more so than for any of the other groups. The increasing income inequality among older adults has recently been a great concern in Korea; according to Statistics Korea (2017), the income quintile share ratio and disposable income Gini coefficient, which had begun to decrease in early 2012, dramatically increased from 2015 among those aged over 66. Although the temporal relationships between income inequality and disparities in cardiovascular health are complex, these sobering statistics warn that health policies should treat unequal income distribution seriously to improve cardiovascular health among the low-income, older-old male group. This has a particular importance in Korea because economic equity has not been achieved despite the government efforts to reduce poverty in older populations (e.g., the Basic Pension [2014]; Yoon, 2013).

Our findings regarding disparities among older-old men may not be directly generalized to other countries. However, they provide valuable insights into addressing income disparities in health outcomes that remain profound in many countries despite national and local efforts (OECD, 2015).

3.4.3 The high burden of CVD risk for Korean Medicaid group

Although the trends vary by age and gender, a clear socioeconomic gradient in CVD risk was discernible for every survey period, with an exceptionally high burden for the Medicaid group. These findings may help evaluate the Korean healthcare system, which has been structured to in a way that substantially disadvantages older impoverished adults on Medicaid. Problems include limited benefits coverage, high out-of-pocket payments, an immature pension system, and the designated doctor system, all of which create barriers to healthcare utilization (Choi & Oh, 2012; Park, 2012). Indeed, a previous study reported that Medicaid accounts for a large share of CVD-related health expenditures, while hospital admissions for CVD have also been increasing (Lee et al., 2016b).

Several political efforts have attempted to establish universal health care in Korea. For example, CVD cost-sharing policies have been altered twice within the past 15 years. In September 2005 (Policy 1), the individual share of costs for CVD prevention were reduced from 20% to 10%, and January 2010 (Policy 2) they were further reduced from 10% → 5% in in an effort to decrease financial burdens associated with out-of-pocket payments. However, according to Jang (2018), these efforts produced little change in most income quintiles, except for a significant CVD mortality risk reduction only in the 1st income quintile during Policy 2. Separate from health insurance, the government also introduced a new social insurance scheme for long-term care in 2008

aimed at easing burdens on the aging population. However, this initiative has yielded limited improvements to health care access for poorer groups (Park, 2012).

Although the results of this study do not establish a causal relationship between such Korean initiatives and the widening national disparity in cardiovascular health, they indicate that a more specific policy is needed for improving the cardiovascular health of Medicaid recipients. This is also an important consideration globally, and particularly for countries without established universal health care for the elderly (Murata et al., 2010; Kido & Tsukamoto, 2020).

3.4.4 Methodological aspects of the study

For younger-old women, although both types of disparity notably exhibited a similar trend, the change in the absolute disparity was not significant. Changes in population-level and social inequalities related to the associated health risks can manifest differently depending on the analysis methods – i.e., whether the absolute or relative terms are considered (Houweling et al., 2007). Previous research has shown that absolute inequalities decrease more substantially than relative inequalities under a wider range of conditions (Mackenbach et al., 2015); in the case of declining overall rates, relative inequalities can increase while absolute inequalities do not. This explains the results of this study where the change in RII was significant while both RII and SII showed a similar increasing trend and the overall rates of high CVD risk declined.

Accordingly, it is important to consider both the absolute and relative terms when examining the trends in inequality over time.

No specific disparity trend was found among older-old women. There can be a few explanations for this pattern. First, income may not be the best SEP indicator for this group when considering the gendered divisions of household labor and power in Korean culture (Lee & Lee, 2019). Second, their lifelong lower SEP and generally homogenous health characteristics may hinder the identification of specific disparity patterns (Lee & Lee, 2019). Thus, our study suggests that more sensitive SEP indicators are needed to improve accuracy in assessing cardiovascular health disparities among older-old women.

3.4.5 Limitations & strengths

This study has several limitations. First, the datasets analyzed in this study are derived from periodic cross-sectional surveys. Therefore, it was not feasible to analyze the trajectory of high CVD risk, which would require longitudinal follow-up data. Second, the intervals between surveys were not annually based, which may have potentially biased the results for time trends. Third, while this study controlled for major confounders of the exposure-outcome association, there may have been others that were not accounted for (e.g., early life or neighborhood SEP, which may influence CVD risk), thus leading to results bias. Third, the monthly income variable used in this study may not accurately reflect the true economic status of the sample, as it was taken as an

estimated average for the given year. Lastly, the single imputation used in this study may reduce data variability, resulting in the underestimation of variances and standard errors.

Despite these concerns, one of this study's strengths was its use of population-based data, which reduces the likelihood of selection bias. Moreover, this study considered both absolute and relative disparities, which show a more complete picture of the disparity trends. This study also addressed disparities in CVD risk through the cardiovascular risk model (Jee et al., 2014), which is widely accepted as a primary preventive tool for CVD. The findings of this study will provide crucial insights into designing early interventions that effectively address socioeconomic disparities in cardiovascular health.

3.5 Conclusion of Chapter 3

This study investigated time trends of income disparities in CVD risk among Korean older adults from 2008-2017. While results showed that the proportion of high CVD risk individuals generally declined over time, this can be attributed to the large decrease in more affluent groups. We also found overall strong evidence of persisting and increasing absolute and relative disparities in high CVD risk across groups, with a worsening trend for Medicaid recipients, especially in older-old men.

Our results have global implications, especially for countries with increasing income inequality, including Korea. First, the failure to achieve an equitable reduction in

high CVD risk highlights the need to improve CVD risk management services offered to the economically disadvantaged. Second, social policies need to pay more attention to alleviating poverty in older adults especially among the older-old men to reduce income-related health disparities. Lastly, it is important to improve overall accessibility to social and healthcare resources for older adults on Medicaid to address their CVD burden.

4. The contribution of material, behavioral, psychological, and social-relational factors to income-related disparities in cardiovascular risk among older adults in Korea

This study explored how material, behavioral, psychological, and social-relational factors contribute to income-related disparities in cardiovascular risk. This was a secondary analysis of a Korean national survey, targeting 7347 older adults. Disparities were measured using RII. The contributions of material, behavioral, psychological, and social-relational factors were estimated by calculating the percent reduction in RII when adjusted for these factors. Among men aged 65-74 years and women 75 years or older, the largest reductions in RII were achieved after adjusting for social-relational factors. Among women aged 65-74 years and men 75 years or older, adjusting for material factors resulted in the largest reductions in RII. Adjustments for behavioral factors also greatly reduced RII for both genders aged 65-74 years. Improving the social, material, and behavioral circumstances of lower-income older adults may help address income-related disparities in cardiovascular risk in old age.

4.1 Introduction

Health disparities disproportionately affecting people of lower SEP has been an ongoing concern in cardiovascular health globally (Coke, 2018). 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 (de Mestral & Stringhini, 2017; Glymour et al., 2014).

The CSDH proposed by the WHO (2010) has been particularly useful to address a range of factors that underlie disparities (see Figure 1). The framework explains how SEP affects populations' health through a set of *intermediary determinants of health*. Notably, material, behavioral, and psychosocial factors have been identified as the main intermediary determinants. Studies have successfully explained socioeconomic disparities in cardiovascular health using these factors (Piccolo et al., 2016; Kershaw et al., 2013; Robertson et al., 2015).

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 (Schmitz & Pförtner, 2017; Van Lenthe et al., 2002). In addition, the behavioral hypothesis postulates that negative health behaviors, found more often in socioeconomically deprived people, lead to cardiovascular health problems (Jackson et al., 2015; Ruiz & Brondolo, 2016). The psychosocial hypothesis suggests that prolonged exposure to adverse psychosocial conditions with perceived socioeconomic inequality can manifest as chronic cardiovascular disorders (Berkman et al., 2000; Everson-Rose & Lewis, 2005).

The material, behavioral, and psychosocial (both psychological and social-relational) intermediary factors may play especially a crucial role in accounting for how

SEP affects cardiovascular health among *older adults*. For instance, health insurance provides impoverished older adults the capacity to manage their cardiac problems with financial security after retirement by helping with the financial burden of expensive care. Interventions that address behavioral factors such as promoting physical activity and healthy diet have been shown to reduce cardiovascular disparities among low-income older adults in western countries (Record et al., 2015; Schulz et al., 2015). Likewise, studies have demonstrated the importance of managing psychosocial factors such as stress, depression, and social-relational factors such as weak social support, or social isolation as they are strongly linked to cardiovascular health outcomes among older adults (Boehm et al. 2017; Petersen et al., 2016).

In South Korea (hereafter "Korea"), older adults are the most vulnerable to health problems and have greater socioeconomic disadvantages. A high percentage of the aging population is suffering from CVD or is at risk. Many studies have reported that such cardiovascular health conditions are closely related to low SEP (Choi et al., 2019; Kim et al., 2016; Lee & Im, 2020). However, few Korean studies have comprehensively investigated the role of the above-mentioned intermediary factors in explaining the effects of SEP to cardiovascular outcomes among older adults.

This study explored how the material, behavioral, psychological, and social-relational factors affect 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.

4.2 Methods

4.2.1 Design/sample

This is a secondary analysis of data from the KNHANES. The detailed design of the KNHANES was described in a previous chapter (see 3.2.2). This study received IRB approval from the institution with which the authors are affiliated.

The study population was limited to adults aged 65 years or older. To explore the underlying factors contributing to cardiovascular health disparities, data collected from January 2013–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 (Lee & Im, 2020). From the initial sample of 7812, 7311 (57.5 %, female) were included in this analysis after we removed those with prior history of CVD (n = 104) and those with missing data for cardiovascular risk assessment components (n = 397). Power analysis was not undertaken given that the study was designed to generate, rather than to test, hypotheses.

4.2.2 Measures

Cardiovascular health. The target outcome was cardiovascular risk, which was measured by the 10-year CVD risk model developed for the Korean population (Jee et

al., 2014). In the current study, binary levels of CVD risk were generated using the risk score (defined as low-level risk and high-level risk). The detailed information of this measure was described in a previous chapter (see 3.2.3).

SEP 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 of the differences in a household's size and composition ("OECD," n.d.). Equivalized income was divided into quartiles following the criteria for categorizing the income level provided by the annual KNHANES report. Education and occupation were not considered due to their relative inability to detect socioeconomic disparities in health due to a prolonged gap, thereby having less influence on health in old age (Khang & Cho, 2007).

Intermediary factors. Material, behavioral, psychological, and social-relational intermediary factors were defined based on the items proposed in Moor et al. (2017) and the availability of the relevant variables in the KNHANES dataset.

1) *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 three categories of "one home", "more than one home", or "no home". Barriers to accessing health care[1] were assessed with a binary

[1] e.g., financial handicap, lack of transportation, the complexity of the health care system, and poor understanding of how to access health services, etc.

question "Have you encountered any barriers when accessing the health care 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?"

2) *Behavioral factors.* Three types of health behavior were considered: alcohol consumption, regular exercise, attendance at health check-ups. The item "alcohol consumption" was categorized into two levels as moderate (≤ 1 time/week and ≤ 2 drinks/one occasion) and heavy (≥ 2 times/week or > 2 drinks/one occasion) based on the NIAAA criteria (https://www.niaaa.nih.gov). Regular exercise and attendance at health check-ups took a binary answer of "yes" or "no".

3) *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. The KNHANES dataset includes one question on anxiety/depression adopted from the EQ-5D subscale (https://euroqol.org/) that takes one of three ordinary scale answers: "I don't 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".

4) *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 nonmarried/unpartnered. Living arrangement indicated whether the participants lived alone or lived with others at the time of survey (1 vs ≥ 2 people in the household).

4.2.3 Statistical analysis

All analyses were conducted separately by age (younger-old group: 65-74, older-old group: ≥ 75) and gender groups. We first described the distribution of the four intermediary factors separately by the income levels and examined statistical associations between intermediary factors and income level using the Chi-square test. In preliminary analyses, the prevalence and the RRs of high CVD risk were reported by the income levels and the intermediary factors. GLMs 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 four groups of intermediary factors to the explanation of income disparities in cardiovascular risk: 1) The RII was calculated to assess the magnitude of the association between income and the outcome variable (i.e., binary levels of CVD risk); 2) We estimated the extent of the reduction in the RII adjusted for intermediary factors; 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 Ridit-score, calculated based on the mid-point of the range in the cumulative distribution of sample in each stratum (Donaldson, 1998). This score was then used in GLMs, with a logarithmic link function to model RIIs. RII values 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 extent to which the RII was reduced was calculated according to the Equation (1). This method has been widely used to assess the mediating roles of intermediary factors in socioeconomic health disparities (Khang et al., 2009).

$$\textbf{Percent attenuation of RII} = 100 \times [(\textbf{RII in the baseline model}) - (\textbf{RII in the model with the intermediary factor})] \,/\, [(\textbf{RII in the baseline model}) - 1] \quad (1)$$

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

given factor. This method has been previously described and recommended (Skalická et al., 2009, van Oort et al., 2005), as the separate analysis (Eq.1) does not reveal the actual contribution of the intermediary factor.

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. Cases with missing data points were relatively few (< 10 % for all variables) thus the single imputation technique was used to preserve the sample size. Missing values on continuous variables were MAR thus replaced by means of the expectation-maximization method. Missing values on categorical variables, which were also MAR, were replaced with the most common response category for each variable.

4.3 Results

4.3.1 Distribution of intermediary factors for different income quartiles by age and gender (Table 10)

Younger-old group (65-74 years). The distributions of the material, psychological, and social-relational factors differed significantly across the income levels for both genders ($p < 0.001$); 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 (for men, 52.9% in highest income quartile v. 41.6% in the lowest income quartile; for women, 38.5% in highest income quartile v. 28.2% in the lowest income quartile; $p < 0.05$). The higher income groups

tended to have more regular heath check-ups than lower income groups in both genders but this tendency was statistically significantly only in men (84.7% in highest income quartile v. 68.8% in lowest income quartile; $p < 0.001$). No significant difference was observed in alcohol consumption across the income levels.

Older-old group (≥ 75 years). All material and social-relational factors differed significantly across the 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 ($p < 0.05$). Among the behavioral factors, only the moderate drinking showed significant association with the income level in men (37.1 % in highest income quartile v. 61.8 % in lowest income quartile; $p < 0.001$), while only the engaging in health check-ups was associated with the income level in women (37.5 % in highest income quartile v. 50.5 % in lowest income quartile; $p = 0.026$). There was no significant difference in the psychological factors across the income level in both genders.

Table 10. Distribution of intermediary factors for different income quartiles by age and gender

	Younger-old group (65-74 years)								Older-old group (≥ 75 years)							
	Men				Women				Men				Women			
	Income quartiles[a] (%)				Income quartiles[a] (%)				Income quartiles[a] (%)				Income quartiles[a] (%)			
Intermediary factors	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Material factors																
Home ownership																
No	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
One 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
More than one 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
p-value				0.000***				0.000***				0.000***				0.000***
Barriers to accessing health care																
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
p-value				0.000***				0.000***				0.000**				0.002**
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
p-value				0.000***				0.000***				0.000***				0.000***
Behavioral factors																
Alcohol consumption																
≤1 time/week and ≤2 drinks/one Occasion	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
≥2 times/week or >2 drinks/one Occasion	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
p-value				0.309				0.856				0.000**				0.288
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
p-value				0.026*				0.000***				0.362				0.124
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
p-value				0.000***				0.147				0.858				0.026*
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
p-value				0.030*				0.020*				0.643				0.068
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
p-value				0.000***				0.000***				0.247				0.076
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
p-value				0.000***				0.000***				0.142				0.080
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
Nonmarried/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
p-value				0.000***				0.000***				0.021*				0.035*
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
p-value				0.000***				0.000***				0.000***				0.000***

[a]Quartile 1 ($1801–), Quartile 2 ($1051–1800), Quartile 3 ($601–1050), and Quartile 4 (–$600)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.0$

4.3.2 Prevalence/RRs of high CVD risk according to different income quartiles and intermediary factors by age and gender (Table 11)

Younger-old group (65-74 years). For both genders, lower income was associated with greater RR for a high-CVD risk ($p < 0.01$). The RR was 2.96 times higher for men in the lowest income 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 nonmarried or unpartnered ($p < 0.001$) and 1.47 times greater for those who lived alone ($p = 0.044$). Those who had not engaged in health check-ups tended to have an increased RR ($p = 0.005$). The material factors and the psychological factors did not show any significant associations with RR in men.

For women, disadvantages in the two material factors were associated with increased risk; the RR was 1.27 times higher for those with no home ownership ($p = 0.035$) than those with one house and was 1.96 times higher ($p < 0.001$) for those without a private health insurance than those with a private health insurance. Those who had not engaged in regular exercise ($p = 0.020$) or health check-ups ($p < 0.001$) showed greater RRs. Further, higher RRs were observed for those with disadvantages in all social-relational factors ($p < 0.01$). Similar to men, no significant associations were found regarding psychological factors in women.

Older-old group (≥ 75 years). Similar to the younger-old groups, the RRs tend to increase as the income level decreases but this trend was significant only for men ($p =$

0.008); in men, the lowest income group had 5.29 times greater RRs than the highest income group.

The RRs increased significantly for men with barriers to health care access and higher levels of stress ($p = 0.003$). The RRs were significantly higher for women who had not engaged in health check-ups ($p = 0.008$) or had a suicidal ideation ($p = 0.027$). Although not significant, the RRs were higher for those who did not have partners or lived alone.

Table 11. Prevalence/RRs of high CVD risk according to different income quartiles and intermediary factors by age and gender

	Younger-old group (65-74 years)				Older-old group (≥ 75 years)			
	Men		Women		Men		Women	
	%	RR[b] (95 % CI)	%	RR[b] (95 % CI)	%	RR[b] (95 % CI)	%	RR[b] (95 % CI)
Income[a]								
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)
p-value for x^2 trend		0.002**		0.000***		0.008**		0.286
Intermediary factors								
Material factors								
Home ownership								
No	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)
One house	10.0	1.00	10.0	1.00	10.5	1.00	8.3	1.00
More than one 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)
p-value		0.639		0.035*		0.399		0.260
Barriers to accessing health care								
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)
p-value		0.457		0.271		0.003**		0.743
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)
p-value		0.412		0.000***		0.340		0.167
Behavioral factors								
Alcohol consumption								
≤1 time/week and ≤2 drinks/one occasion	10.7	1.00	9.7	1.00	10.9	1.00	9.7	1.00
≥2 times/week or >2 drinks/one occasion	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)
p-value		0.824		0.577		0.241		0.141
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)
p-value		0.222		0.020*		0.199		0.940
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)
p-value		0.005**		0.000**		0.370		0.008**
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)
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)
p-value		0.271		0.563		0.027*		0.130
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)
p-value		0.235		0.655		0.850		0.164
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)
p-value		0.166		0.050		0.857		0.027*
Social-relational factors								
Marital status								
Married/partnered	1.0	1.00	8.3	1.00	9.2	1.00	7.36	1.00
Nonmarried/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)
p-value		0.000***		0.009*		0.126		0.163
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)
p-value		0.044*		0.005**		0.151		0.056

[a]Quartile 1 ($1801–), Quartile 2 ($1051–1800), Quartile 3 ($601–1050), and Quartile 4 (–$600)

[b]adjusted for survey year (2013-2017)

RR, risk ratio *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

4.3.3 The percent reduction in RII when adjusted for intermediary factors by age and gender (Table 12, Figure 12)

Younger-old group (65-74 years). Among men, social-relational factors showed the highest impact on RII. When they were adjusted for in the regression, RII was reduced from 3.09 to 2.80; that is, RII was reduced by 13.7 %. Adjusting for the behavioral factors resulted in 13.5 % reduction in RII. The direct contributions of social-relational and behavioral factors to RIIs 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 %). When all factors were adjusted for, RII declined by 47.5 %.

Older-old group (≥ 75 years). Among men, adjusting for the material factors led to the largest reductions in RII (8.3 %) and their direct contribution was 6.8 %. RII dropped by 7.4 % when adjusted for behavioral factors. However, adjustments for psychological and social-relational factors led to smaller reductions in RIIs. RII was reduced by 16.8 % when all factors were adjusted for. Among women, the largest reduction 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 %.

Table 12. The percent reduction in RII when adjusted for intermediary factors by age and gender

	Younger-old group (65-74 years)				Older-old group (≥ 75 years)			
	RII[a] (95 % CI)	Percent reduction	Direct contributions[b]	Indirect contributions[c]	RII[a] (95 % CI)	Percent reduction	Direct contributions[b]	Indirect contributions[c]
Men								
Baseline 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								
Baseline 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		

[a]Adjusted for survey year (2013-2017)

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

[c]The indirect contribution was subsequently calculated by subtracting the direct contribution (of the given factor) from the total contribution of the given factor.

RII, relative index of inequality

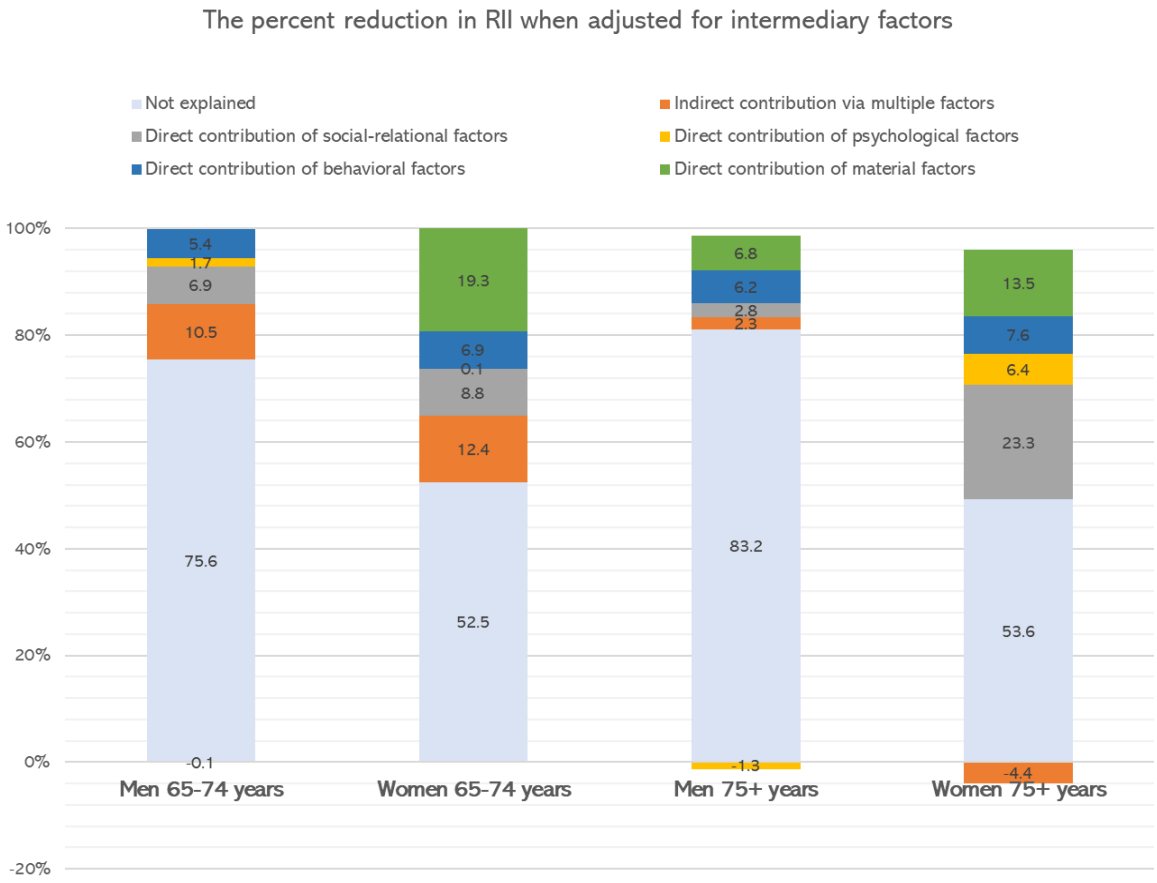

Figure 12. The percent reduction in RII when adjusted for intermediary factors

4.4 Discussion

This study demonstrates 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.

4.4.1 The importance of social-relational factors in reducing disparities

Among younger-old men, social-relational factors (i.e., marital status and living arrangement) seemed to have an important influence on income disparities in cardiovascular risk. Indeed, positive effects of marriage and family on health have been well-documented for older male adults with low incomes (Bahari et al., 2019; Sugisawa et al. 2019). They were also recognized as an important social support that benefits cardiovascular health as men aged (Dhindsa et al., 2019).

Although this study only investigated limited social-relational factors, this finding indicates the importance of developing a range of services designed to provide social support to younger-old men who are unable to draw on traditional family support resources. For example, physical activity interventions create social support by developing incidental social relationships; this is known to help prevent both short- and long-term adverse cardiovascular outcomes (Mitchell et al., 2018). In fact, in this study, both behavioral and social-relational factors contributed most significantly to income disparities in cardiovascular risk among younger-old men.

Social-relational factors also seemed to have a significant role in the income disparities of cardiovascular risk among older-old women. This was anticipated because most individuals who live alone were in the lower income groups. The close association of marriage and economic well-being in traditional paternal Korean culture has been well documented (Chun et al., 2006). Combined with less conjugal social support, such economic instability may negatively impact cardiovascular health management; similar finding have been reported in a previous Korean study (Chu et al., 2015).

While the above results cannot be generalized to other nations, the findings can contribute to shaping global perspectives on the health crisis with aging population, where increasing number of older adults are likely to live as widows for a longer period of time. Especially in Asian countries, the actual remarriage or cohabitation among oldest-old adults remains very rare due to traditional social norms and lower economic status (Phillips & Cheng, 2012; Zhu & Gu, 2010). Accordingly, a range of community and home-based services should be developed to provide social support, thereby buffering the effects of widowhood and reducing health disparities.

4.4.2 The importance of material factors in reducing disparities

Among younger-old women, material factors contributed to the largest portion of the income disparities in cardiovascular risk, which corroborates the findings of previous studies (Ploubidis et al., 2011; Schmitz & Pfortner, 2017). Among the material factors analyzed, private health insurance seemed most significantly affect these

disparities. This supports the health commodity hypothesis (Ross & Mirowsky, 2000); that is, higher SEP is partly associated with better health because people have better access to health insurance. Indeed, fee-for-service private insurance is fundamental to the health of older adults in Korea where there are relatively few public health insurance options available (Lim, 2016).

Many older Korean adults live without insurance due to retirement or unemployment (Bae & Lee, 2018). The inability to access or maintain private health insurance is especially prevalent among younger-old women in Korea, who generally have little income because they have been taking care of domestic issues instead of working for income (Oh et al., 2017). Private insurance providers need to diversify programs to offer affordable coverages to lower-income women to improve their cardiovascular health. Germany successfully addressed this issue with an aging reserve policy (Hofmann & Browne, 2013).

Material factors also explained the largest proportion of income disparities in cardiovascular risk among older-old men, and this effect comes mainly from the contribution of access to health care. This finding extends upon previous Korean studies that showed inadequate access to care has been associated with apparent disparities in cardiovascular health (Hong & Kang, 2014; Kim et al., 2014). Especially in Korea, many low-income oldest-old adults report inadequate access to their needed healthcare due to skyrocketing healthcare costs, limited noninsured services, and substantial out-of-pocket

payments (Jeon & Kwon, 2017, Park et al., 2015). Further, they have not benefitted from the equitable utilization of primary care and medical services as Korean society increasingly suffers residential segregation based on SEP (Lee et al., 2019). Accordingly, improving access to health care is critical for cardiovascular health equity in Korea.

4.4.3 The importance of behavioral factors in reducing disparities

Behavioral factors (i.e., regular exercise and health check-ups) contributed to much of the income disparities in cardiovascular risk for both younger-old men and women. 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 Korean older adults with low household incomes (average age 67.5 ± 3.7 years; Choi et al., 2015). A community-based CVD prevention program aimed at increasing physical activity have demonstrated promising results among low-income older adults with hypertension in Korea (average age 72.64 ± 8.17 years; Yang et al., 2016).

However, ensuring the access of healthcare service is a prerequisite to attending regular health check-ups. Indeed, it is important to acknowledge that income levels also affect the behavioral factors investigated in this study. 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, have equal opportunities to participate in health-promotion services (Choi et al., 2015).

4.4.4 Strengths & Limitations

This study used a population-based national sample, so the results are more robust and convincing without 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.

However, this study had some limitations. First, given the limitations of the 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 prior studies have reported the widening socioeconomic

disparities in mental illness, especially among older adults in Korea (Shin et al., 2018; Khang & Lee, 2012).

Interpretation of the main findings of this study needs caution. Although the analysis shows that intermediary factors can contribute to RII reduction, our estimates of the effect size may be imprecise; as in other studies that reported health disparities using RII (Hiyoshi et al., 2014; Guarnizo-Herreño et al., 2019), the RIIs estimated in this study show a wide CI, which overlap substantially between the baseline model and the factor adjusted models. Therefore, more targeted studies will be needed to verify their actual impact on health disparities. Lastly, although missing data was a relatively minor problem as about 90% of the data were present, the single imputation method may have introduced a bias as it does not consider uncertainty among imputed values.

4.5 Conclusion of Chapter 4

This study explored how material, behavioral, psychological, and social-relational factors contribute to income disparities in cardiovascular risk among older Korean adults. Study findings suggest that addressing income disparities in cardiovascular health among older adults requires multi-dimensional approaches encompassing material, behavioral, psychological, and social-relational aspects. Specifically, improving social support can be crucial to reduce the disparities in cardiovascular risk among younger-old men and older-old women in lower-income groups. Interventions strengthening social support is especially important as Korea is

undergoing major changes in the social landscape accompanied by reductions in household sizes and family caregiving resources. Additionally, ensuring the right level of access to healthcare services seems to be crucial in addressing cardiovascular risk among younger-old women and older-old men in lower incomes. Lastly, behavioral interventions specifically targeted at lower-income groups may also help reduce income disparities in cardiovascular health for younger-old men and women.

5. Conclusion

Chapters 1 through 4 of this dissertation investigated the unique challenges presented by income disparities in cardiovascular health using a nationally representative sample of older adults in Korea. Chapter 1 discussed the overarching research agenda and the conceptual framework of this dissertation. Chapter 2 systematically reviewed the existing literature and identified the gaps in the current research. Chapters 3 and 4 described the time trends in the income disparities in cardiovascular health and explored how material, behavioral, psychological, and social-relational factors may contribute to them. These chapters measured and represented the income disparities in cardiovascular health with RII and SII, the two widely used health disparity metrics.

The time trends of absolute and relative income disparities in CVD risk among older adults observed in Chapter 3 indicated that older adults with different income levels have not equally benefited from the governmental efforts to control CVD risk factors. That is, the intensified cardiovascular health promotion put forth by the Korean government have not drawn desirable effect for the older adults in lower-income groups. These trends were evident in both age groups and genders. In particular, health gaps between the higher-income and the Korean Medicaid groups seemed to have deepened in recent years in both absolute and relative terms among men aged 75 or older. Given that much greater CVD risks posed to those with lower incomes, these gaps

are likely to worsen until more comprehensive preventive measures are instituted. Accordingly, public health systems should offer expanded primary CVD prevention services that specifically target low-income older individuals. The next step should integrate the interventions proven to be effective into larger health systems and social policies.

Chapter 4 explored how material, behavioral, psychological, and social-relational factors contribute to income disparities in cardiovascular risk among older Korean adults. The results from Chapter 4 showed that material and social-relational factors affected the income disparities of cardiovascular risk. Such findings indicate that interventions focused on improving material and social living conditions can be an effective means of improving cardiovascular outcomes and reducing health disparities in old age. Especially among men aged 75 or older, material factors seemed to explain the largest proportion of income disparities in cardiovascular risk, and this effect comes mainly from the contribution of access to health care. Accordingly, an appropriate strategy to improve access to healthcare is needed for this group. In particular, policies should address the issues of rising costs of services, high out-of-pocket payments, and unequal distribution of primary care services, all of which create barriers to healthcare access for the poorest (Choi & Oh, 2012; Park, 2012). This is also an important global consideration in countries where social inequality in the access to health care has been a great concern among the oldest-old population (Almeida et al., 2017; Zhang et al., 2018).

Some limitations should be noted in our study. First, given the limitations of cross-sectional studies, all the results should be interpreted with some caution, and need to be confirmed in a longitudinal study. Second, traditional income indicators used in the current analysis may fail to capture information about income fluctuation, as they were measured cross-sectionally. As an alternative, lifetime earning capacity has been suggested (Jones et al., 2010) but a consensus has not yet been reached on the best approaches to measuring income in the cardiovascular research field. Future research needs to focus on developing income classifications that are more meaningful, which can capture the dynamic and actual impact of income on cardiovascular health.

Third, interpreting the relationship between income and cardiovascular risk with associated intermediary factors warrants caution. As discussed in Chapter 4, the selected intermediary factors were defined using the variables available in the dataset thus they may not be the most comprehensive and accurate representation of those factors. Future research needs to evaluate how different ways of defining the material, behavioral, psychological, and social-relational factors affect their impact on health disparities in old age. Moreover, although the measures in KNHANES have shown high predictive power for various health conditions in many large-scale surveys (Kweon et al., 2014), they may not be a reliable question to assess the areas represented by the four intermediary factors studied in this dissertation. In addition, by using a cross-sectional dataset, the

intermediary factors were measured only at the same single point in time. As such, their contributions to disparities should be interpreted in the given point in time only.

Despite its limitations, this dissertation has several strengths. First, it sets a starting point for discussing this unexplored area, providing a viable foundation from which health disparity research can produce useful insights into delivering equitable care and optimizing cardiovascular health for all older adults. Second, focusing on older adults, this dissertation addresses an important gap in research. Older adults are an understudied age group in the health disparity field. Health research in older adults is especially important in Korea, where the society is rapidly aging with the increasing share of the oldest old population.

5.1 Future implications

Khang and Lee stated that Korea is beyond the 'measurement' stage but not into the 'will to take action' stage in the field of health disparities (Khang & Lee, 2012). Taken together with a confluence of evidence, this statement applies to the field of cardiovascular research. This progress is more deeply contrasted to western societies, where substantial, robust research has clearly motivated and informed inventions as well as national health policy initiatives over the past two decades (Davis et al., 2007; Walton-Moss et al., 2014). Therefore, to bring about improvements, we need to produce more actionable and foundational knowledge in order to foster interventions or policies. For these to be realized, it is important to ensure increased awareness and active

participation among researchers to close the research gap, and make our existing knowledge more refined and developed.

This dissertation produced several important implications for the clinical sector. First, our results indicate that cardiovascular health is collectively influenced by low income for older Koreans. This implies that risk-factor screening is needed to better understand the increased cardiovascular risks associated with low income in older Koreans. For example, incorporating income into CVD risk calculations and screening tools may offer opportunities to understand better how income affect cardiovascular health in elderly and develop more effective interventions. This is important because traditional methods of calculating CVD risk ignore the step-wise negative effects of SEP on CVD risk, which may compromise the effectiveness of screening and potentially widen existing health disparities (Clark, 2009). Second, the use of "integrated CVD risk" evaluation in our analysis was meaningful because existing clinical guidelines commonly recommend the strategy of applying primary interventions according to the magnitude of an integrated risk (Chobanian et al., 2003; Stone et al., 2014). For instance, it is advocated that separate management guidelines for hypertension and diabetes should be replaced by integrated CVD risk management guidelines, because individuals with given blood pressure may have a 20-fold variation in CVD risk due to other factors such as smoking, age, body mass index and diabetes status (Jackson et al, 2005). This risk

assessment tool thus may help design interventions that more effectively address disparities in cardiovascular risk in the future.

Third, our findings suggest that improving access to health care is critical for cardiovascular health equity in Korea. Indeed, reliable access to healthcare is one of the leading health indicators used by Healthy People 2020 to monitor progress in disparities in cardiovascular health (Healthy People, 2020); they particularly emphasized the importance of better access to affordable health care, including a regular primary care provider, a healthcare center providing routine counseling/medical services, and rapid pre-hospital emergency care. Therefore, measures should be taken to provide the continuity, coordination, and comprehensiveness of delivered healthcare services, specific healthcare system features such as staffing, management, and organizational culture substantially accounted for cardiovascular outcomes among older adults in Korea.

This dissertation also produced important implications for the policy sector. First, the findings of this study highlight the importance of improving the weak financial protection plans and inadequate health insurance coverage to ensure equitable service provisions for those on Korean Medicaid. This is a crucial lesson considering the number of societal changes such as increasing Korean Medicaid recipients, rapidly aging population, changing family structure, and insufficient national financial reserves (Lee & Cheong, 2018). Second, with a rapidly aging population and the disproportionately

increasing elderly poverty in Korea (Ku & Kim, 2018), concerted political actions are needed to mitigate future income inequality (Khang & Lee, 2012). In particular, these interventions should prioritize men aged 75 or older, who tend to experience the worst income-related disparities in health outcomes, according to the findings of this study.

5.2 Summary

In sum, the epidemiologic and economic burdens of CVD will reach enormous proportions in Korea if the income-based disparities in cardiovascular risk continue to worsen among older adults. Long-term solutions and distinct social policies, therefore, are much needed to address the income disparities and improve cardiovascular health for this group. At the same time, changes in the income disparities should be continuously monitored to inform current and future policies. Future studies should follow addressing the limitations of this study in understanding the role of intermediary factors underlying disparities in order to provide better evidence for developing more effective interventions. Based on further research findings, appropriate interventions should be tested and applied in real-world settings to improve cardiovascular health among the socioeconomically disadvantaged.

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Biography

Chiyoung Lee earned her Bachelor's degree in nursing (2013) and Master's degree in nursing (2017) from Seoul National University. After earning her master's degree, she worked as a lecturer and participated as a research assistant of Chronic Care Research Team at the College of Nursing, Seoul National University. She also has worked as a nurse in the Emergency Department and Cardiac Intensive Care Unit at Samsung Medical Center at South Korea from 2013 to 2017. She started her Ph.D. from 2017 at Duke University. During her graduate studies at Duke under professor Hyeoneui Kim, she has constantly developed a wealth of experience in conducting health disparities research for vulnerable and minority populations. In addition, she has worked as a research assistant, interventionist, and study coordinator in an NIH-funded R01 project that adopted internet and computer technologies to eliminate gender and ethnic disparities in healthcare among Asian American breast cancer survivors. The idea of her Ph.D. dissertation is framed within the relationship of social determinants to cardiovascular health with particular focus on exploring the trends, pathways, and mechanisms that underlie disparities in cardiovascular health among the older adult population.