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Multilevel Resource Distribution and Health-Related Quality of Life

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Abstract

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Background The recent dynamics of population aging and economic development have drawn renewed interest to the health paradigm. Rather than a quantitative indicator, such as a prolonged life, qualitative indicators, such as health-related quality of life (HRQoL), have become of interest. However, concepts of economic or human capital cannot fully explain the quality of life. Moreover, it is not only the amount of resources owned per se but also mechanisms of generation, distribution, and availability of valuable resources that are important for understanding the social determinants of HRQoL. In general, social determinants of health cumulatively operate over long periods of time and are more effectively investigated by longitudinal perspectives. These resources can be multidimensional, ranging from the material environment to social relationships, and can be distributed within a family or among communities. Ecological differentiation stems from community

characteristics and is very much a spatial affair. Here, this thesis aims to evaluate the broader concept of resources using a subjective measure of social status and social resource indicators. Then, it aims to capture the structure of multilevel resource distribution as it is dispersed over time and space. Finally, this aims to expand the framework of social determinants of HRQoL and reveal the health inequalities embedded in our society.

The study objectives are as follows. First, the determinants of subjective social status (SSS) were investigated among household members, focusing on the household environment. Then, differences in SSS among members and gaps between objective income and SSS levels were assessed. Second, changing patterns of socioeconomic status were investigated over time and longitudinal effects of socioeconomic status on HRQoL trajectories were assessed. Then, combined changes in patterns of objective and subjective status (i.e., multiple socioeconomic status trajectories) and the HRQoL trajectories were derived, with time gaps. The prospective effects of socioeconomic transition on HRQoL trajectories were analyzed. Third, the resource composite was defined at the community level by combining healthcare resources, cultural infrastructure, and social capital, such as social networks, as well as the neighborhood environment. Then, types of outdoor resources that are crucial to population health were investigated. Finally, spatial correlations in HRQoL were determined and effects of social resources on HRQoL were investigated, considering geographical variations.

Methods The study population was adults over 18 years old in the eighth wave (2013) of the Korea Health Panel Survey for the first study, composed of 3,984 households and 8,330 individuals. As the second was a longitudinal study, we made the dataset a balanced panel that respondents answered in all ten waves of the Korea Health Panel (2009–2018). As the third and fourth were ecological studies, we collected community variables via two types of data libraries—OSIS and the Community Health Survey website. We then aggregated overall data at the 250 community level.

The dependent variable of HRQoL was calculated using the EQ-5D index with the weights for Koreans. We used the MacArthur scale to measure household SSS. The other explanatory variables consisted of social resources (trust, social network, and social participation), cultural resources (cultural and sports infrastructures and parks), healthcare resources (doctors, essential medical clinics, tertiary hospitals, and nursing hospitals), and community's socioeconomic status.

Regarding methodologies, we applied the intra-class correlation coefficient to investigate the response reliabilities on household SSS among household members for the first study. In addition, we assessed the importance of determinants on SSS using variance decomposition. For the second study, we used group-based trajectory modeling to identify health trajectories and group-based multi-trajectory modeling to draw multi-SES trajectories. The third study was analyzed using principal component analysis and principal component regression modeling. For the spatial analysis, the

fourth study used the geographically weighted regression (GWR) and k-means clustering of the GWR coefficients. We used the STATA 16, SAS software 9.4 version, R version of 4.1.3., QGIS 3.24 and GeoDa 1.18.0 in the adequate analysis.

Results For the first study, Housing safety and household wealth, which contributed to 65.7% of the variance in SSS, act as a buffer to downgrade one's SSS. However, there were significant differences between household members according to the dynamics of relational resource sharing. In particular, the perceptions of married couples were consistent, although this decreased as they nurtured more underage children. There are SSS gaps across generations between the ages of the head of household's parents, head of household, and children.

For the second study of trajectory modeling, four types of multi-SES trajectories were derived from 2009 to 2013. In the multi-SES trajectories, the richer in 2009 had steeper income growth during the period, while the shapes of the SSS were kept unchangeable over time. The following HRQoL trajectories from 2013 to 2018 showed three distinctive patterns—the 4.3% of individuals showed a low and declining pattern while the other two trajectories remained high and stable. The objective and subjective socioeconomic status, respectively, at baseline were strongly associated with the following health trajectories.

For the third study, the communities can be categorized into several principal components (PC). The seven PCs explicitly represent the

community characteristics such as (1) structural environments regarding facilities and physical structure; (2)-(3) the set of demand and supply in healthcare; (4) bridging; (5) cognitive; (6) bonding social capital; and (7) economic affluence of the community. These first to seventh PCs explain 46.4% of the HRQoL variance at the community level and are distinctively associated with the HRQoL level. In particular, the structural environment significantly influences population health, implying the neighborhood effect on health.

The fourth spatial analysis study showed that HRQoL at the community level has spatial autocorrelation, which means healthy regions are geographically clustered with healthy ones. Moreover, resources do or do not exert effectiveness depending on the regions. Social trust effectively increases HRQoL only in the Seoul and Gyeonggi-do regions. Meanwhile, the religious activities in the Busan and Gyunsang-do regions unexpectedly showed a negative association with health. Unmet medical needs have become a critical health agenda, specifically in the eastern and interior regions of South Korea. Urbanization of the city was positively associated with health on the west side. The aging index is negatively associated with the north and interior regions. The single-person household has become a risk factor in Jeollanam-do and Gangwon-do regions. This differential effectiveness can be spatially clustered and distinguished into five clusters based on the GWR coefficients. That is, the effectiveness of the resources works collectively with some degree of administrative spatial range.

Conclusion This study investigated the distribution of multiple levels of resources across households and communities and their health impacts. Taken together, the results indicate that South Korea is a risk-bearing society. The HRQoL patterns were either stable or decreased, but not increased. In addition, HRQoL was spatially clustered at high and low levels of HRQoL. These health patterns suggest longitudinal deterioration and geographical disparities in health. The availability of resources differed according to household environment and family roles. Furthermore, the effectiveness of social resources in the community, such as social capital, differed according to region. This geographical pattern of resource effects on health indicates a spatially shaped social process that gives rise to social inequality. In sum, these findings suggest that the originating family, and where a person lives, determines their health status, highlighting the importance of resource redistribution in enhancing population health. Considering that the administrative district boundary is an effective policy target, the regional-specific healthcare policy for communities should allocate limited resources to areas and households in need, and not focus on equalizing the resources.

Keywords: health inequality; subjective social status; resource allocation; family characteristics; social capital; neighborhood effect; health-related quality of life

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Chapter 1.
Overall introduction

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Overall introduction

1.1. Study Background

1.1.1. Growing inequalities in society

Mainstream ideology regarding social class has changed over time. For decades, there has been strong emphasis on one's beliefs and lifestyle in defining social class (Centers, 1949; Jackman, 1979). Meritocracy has become increasingly prevalent. Individual abilities and effort are believed to be pathways to success and achievement. These beliefs have spread throughout many educational systems, increasing the worldwide prevalence of ideology related to social mobility.

However, school systems contribute to the reproduction of social class differences (Bourdieu & Passeron, 1990), and underlying class backgrounds continue to modulate the opportunities that an individual may encounter and the degree to which his or her abilities may be cultivated (Manstead, 2018). As this "meritocratic inequality" grows, it damages opportunities as well as outcomes for those from poor or even middle-class households. Furthermore, meritocracy restricts social mobility and reinforces a cycle of exclusion as it transfers wealth and privilege down through generations (Markovits, 2020).

In this connection, growing inequality and its consequences are a

persistent concern. More than two-thirds (71%) of the global population live in areas where income inequality has increased (UnitedNations, 2020), p. 26). Within-country income inequality remains high and has tended to increase in the last two decades (Roser & Ortiz-Ospina, 2013)2016. This situation undermines individuals' opportunities to be educated, get full employment and decent work, and to stay healthy (Dabla-Norris et al., 2015). The economist Thomas Piketty (2015) pointed out that wealth is highly concentrated in a few top wealth holders. The rate of return on capital being higher than the economic growth rate has amplified wealth inequalities in developed countries in the 21st Century (Piketty, 2015).

Population health or quality of life rises substantially only in the early stages of economic growth. In affluent developed counties, however, additional economic growth adds nothing further to objective outcomes like life expectancy or subjective ones like happiness. Instead, inequality within a society explains differences in health (Wilkinson & Pickett, 2010).

1.1.2. Social class, socioeconomic status, and subjective social status

We begin our discussion by distinguishing the notions and properties of social class and status. ***Social class*** arises from interdependent economic and legal relationships among people within a society's economic structure. Classes are forged by one another and only exist in within these relationships, which are determined by the possession of property, ownership, and labor, and by connections between production, distribution, and the consumption of goods,

services, and knowledge (Krieger et al., 1997). Social class does not function as a unitary construct. Instead, it consists of two distinct components; objective and subjective social class, which are highly correlated (Loignon & Woehr, 2018). Material resources and the perception of social class rank in relation to others are two independent aspects that shape the context of social class (Michael W Kraus et al., 2012).

Socioeconomic status **(i.e., *SES*)** and social class differ in terms of construction and utilization (Williams, 1990). SES is typically defined as "differences in the possession of resources" (Glymour et al., 2014) or "differential access to desired resources" (Oakes & Rossi, 2003). Unlike social class, people do not share a specific group consciousness of others within the SES framework. This is the case even for those in similar economic positions because SES is a temporary position that can change with respect to the hierarchical structure of society (Liu et al., 2004). Furthermore, one's SES cannot be causally attributed to that of another person (Glymour et al., 2014).

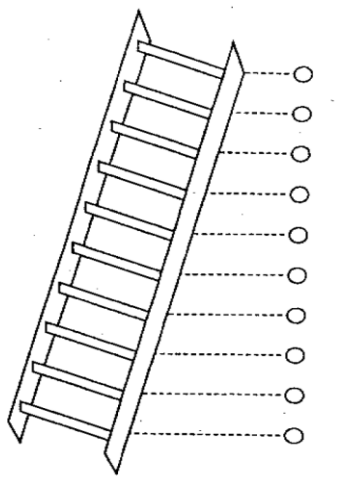
By contrast, ***socioeconomic position*** **(i.e., *SEP*)** is a relational concept that represents "how groups stand in relation to each other." For instance, economic inequality between the owner and employees in a workplace occurs as a result of the higher position of the owner, which arises from class relations (Glymour et al., 2014). Compositional and contextual measures of SEP have been utilized in studies that examine the implications of SEP for health (Lee & Lee, 2019).

However, the differentiations between social class/ status/ position have blurred with respect to measurement methodologies. Objective social class is measured according to individual resources that compose one's socioeconomic status, such as income, education level, and occupational prestige (Diemer et al., 2013; Michael W Kraus et al., 2012). However, the measurement of objective status or class using income, educational status, or occupational indicators is not sufficient to capture the complexity of class identity (Kraus et al., 2009).

The complex and relative character of social class has led researchers to more carefully consider subjective measurements - ***subjective social status* (i.e., *SSS*)**. Social class includes rank comparisons with others in a social hierarchy (Kraus et al., 2009). Indeed, persistent perceptions of one's rank relative to others are fundamental in shaping the context of social class (Michael W Kraus et al., 2012). Accordingly, the MacArthur Network on SES & Health developed a measure of SSS, called the MacArthur scale. The scale can be used to assess one's sense of their relative standing using social ladders that encompass multiple dimensions of SES (Adler & Stewart, 2007).

There are four types of ladders, depending on what is set as a comparison referent and the target being evaluated. For the 'SES ladder,' the comparison reference is set as the overall society, and for the 'community ladder' the reference is set as the local community. In the 'youth version,' adolescents are asked to estimate their family's position on the ladder, while

in the ‘adult version,’ individuals are asked about their own position (Goodman et al., 2001).



Source: Goodman et al. (2001).

Imagine that this ladder pictures how American society is set up.

- At the top of the ladder are the people who are the best off – they have the most money, the highest amount of schooling, and the jobs that bring the most respect.
- At the bottom are people who are the worst off – they have the least money, little or no education, no job or jobs that no one wants or respects.

Now think about your family. Please tell us where you think your family would be on this ladder. Fill in the circle that best represents where your family would be on this ladder.

Figure 1-1. MacArthur scale of Subjective Social Status–Youth Version

1.1.3. Social relations and social capital

Definitions. *Social capital* is a collective asset that comes from social relations. The concept of social capital differs according to scholars and research domains based on its historical foundation. Lin (2001) explains that resources can be classified into personal and social resources (i.e., the notion of social capital). The social resources embedded in social connections and relations play essential roles for individuals, social groups, and communities in achieving goals (Lin, 2001).

According to Bourdieu's definition, social capital is the aggregate of resources that comes from networks of institutionalized connections with mutual acquaintance (Bourdieu, 1986).

Coleman (1988) defined Social capital as a part of the social structure itself, and at the same time, it becomes a valuable resource for actions, which can promote the person or corporate actors to take specific behaviors within the social structure (Coleman, 1988).

On the other hand, as Putnam (1993) states; social capital can be defined as "features of social organization, such as trust, norms, and networks, which can improve the efficiency of society by facilitating coordinated actions (Putnam, 1993) p.167."

Similarly, Kawachi and colleagues (1997) borrowed Putnam and Coleman's definition, mentioning it as trust in others, a norm of reciprocity, and civic participation, which facilitates collective action for mutual benefit (Kawachi et al., 1997).

Social capital is a public good created as a by-product of social relationships, rather than private goods of physical or human capital. (Coleman, 1990). Therefore, social capital has "non-excludability" as a property of public goods. Everyone in the community can enjoy its benefits, and its availability and accessibility are not restricted to someone (Kawachi et al., 1997).

Typology of social capital. Berkman and colleagues (2000) characterized the social network structure that comes from the web of social relationships. They are identified as the size (number) of network members; density—how many members are connected to each other; boundedness of network groups—such as family, workplace, and neighborhood; and homogeneity, which means the similarity of members (Berkman et al., 2000).

The social capital is categorized according to the strength and direction of ties. Szreter and Woolcock (2004) distinguished several concepts of social capital into *bonding, bridging, and linking* social capital. Bonding social capital comes from the relationships between similar people regarding socioeconomic conditions. Bridging social capital is derived from relationships with dissimilar people but at the same level of social hierarchy. Instead, linking social capital is related to people across power levels and social hierarchies (Szreter & Woolcock, 2004).

Another distinction is *relational, structural, and cognitive* social capital. The structural dimension indicates the social relationships, networks, associations, and institutions that link people together. The cognitive dimension is related to shared goals and values among the members (Tsai & Ghoshal, 1998). For instance, religious activities are closely related to social capital as a cognitive dimension rather than a structural dimension (Kaasa, 2013).

Social capital can be measured and examined at the community level (i.e., ecological) as aggregate resources (Kawachi et al., 1999; Kawachi et al., 1997), as well as at the individual level (Kim & Kawachi, 2006).

Mechanism by which social capital works. The macro-social structure of the economy, politics, social changes, and culture determine the structure of social networks. In turn, it provides the psychosocial mechanism that determines the biological response regarding stress control, health-related behaviors, susceptibility to disease, and individual traits, including self-efficacy and coping effectiveness. (Berkman et al., 2000).

At the community level, social capital affects health by providing information channels related to health, maintaining healthy behavior norms, or suppressing risky behaviors, enhancing the ability of people to undertake collective action (i.e., collective efficacy). That is, social capital improves self-government in disaster resilience and recovery (Kawachi & Berkman, 2000). Social capital motivate people to modify healthy behaviors by enhancing self-care efficacy and providing psychosocial stability (Wilson, 1997).

Considering by type of social capital, bridging ties facilitates access to information and resources, enhancing one's ability to solve problems and promoting the spread of healthy norms (Kawachi et al., 1997). Bonding capital (i.e., social support) acts as a buffer against stressors related to social disadvantages (Henly et al., 2005). Cognitive social capital provides more opportunities for network members to integrate and exchange resources based

on strong ties and trusting relationships (Tsai & Ghoshal, 1998).

Collective efficacy, neighborhood cohesion, a sense of community, and community competence are not exact definitions of social capital. However, these aspects are to some degree overlapped with social capital, suggesting the possibility of a proxy for social capital (Lochner et al., 1999).

1.1.4. Relationships between SSS, social capital, and social class

Subjective social status (SSS) is highly correlated with conventional ***socioeconomic status (SES).*** Oakes and Rossi (2003) proposed a framework that refers to SES as a function of (1) material, (2) human, and (3) social capital. Furthermore, they suggested that self-ratings of SES (i.e., SSS) could act as indicator variables for SES (Oakes & Rossi, 2003). A recent meta-analysis of methods for measuring SSS demonstrated that (1) occupational prestige, (2) income, (3) wealth, (4) cultural capital, and (5) social capital accounted for over two-thirds of the variability in an individual's SSS. These five are distinct incremental predictors of subjective social class (Loignon & Woehr, 2018).

Subjective social status and social class. The complex and relative character of social class has led researchers to more carefully consider subjective measurements. Social class includes rank comparisons with others in a social hierarchy (Kraus et al., 2009). Indeed, persistent perceptions of one's rank relative to others are fundamental in shaping the context of social class (Michael W Kraus et al., 2012).

SSS is closely connected to the everyday experience of social class (Kraus et al., 2013; Liu et al., 2004; Wright & Steptoe, 2005). When answering questions about subjective measures, people consider retained resources in various life-domains as well as the impacts of events throughout their entire lifetime (Veenhoven, 2002). That is, SSS refers to the combined value of one's evaluation of their own status and the actual implications of objective indicators of status (Adler & Stewart, 2007). In this respect, SSS is regarded as a better synthesis of the components of SES (Singh-Manoux et al., 2005).

Social capital and social class. Socializing, an integral part of social capital, is unequally distributed across social classes. Differences in cultural capital are primarily derived from class differences, contributing to the reproduction of social structure. Capital, which takes time to accumulate, can produce profits and reproduce capital in identical form (e.g., economic property enables earning more money) or expanded forms (e.g., economic capital is transmitted to cultural or social capital) (Bourdieu, 1986). Indeed, the material, human, and social capital replicate one's location in the social hierarchy and ultimately allow social reproduction to take place from one generation to the next (Doob, 2019)p.16).

Taken together, these characteristics result in the capital's proclivity to persist. Social capital is a product of a social formation and, in turn, produces and reproduces the valuable relationships that can bring material or nonmaterial profits. In this regard, the distribution of capital represents

society's embedded structure and functioning at that time. (Bourdieu, 1986).

1.1.5. Social determinants of health research

Social class is inevitably related to the economic structure and determines health. However, income alone is insufficient to explain the health disparities and social determinants of health.

Social conditions can provide additional answers. Social environments determine the risk of disease onset and response to treatment by putting people under constant stress or by increasing the vulnerability to unhealthy behavior (Marmot, 2005; Marmot, 2006). The World Health Organization (WHO) reviewed the social determinants of health and summarized them into ten topics for improving public policy; they cover social gradient, stress, social exclusion, social support, early life, work, unemployment, addiction, food, and transport (Wilkinson & Marmot, 2003). In 2010, the WHO developed a conceptual framework of social determinants of health (SDH), outlining the main components, their functions, and how they are organized in the intricate structure of society.

Compared to the other framework of SDH, this one is conspicuously distinct regarding the adoption and logic of "social capital." Social capital and social cohesion are set as cross-cutting themes that cut across structural and intermediary determinants. They provide a linkage between socioeconomic position and behavioral and psychosocial factors. Enhanced participation and empowerment of citizens by social capital give rise to the redistribution of

power and allow communities to develop policies for increasing well-being and quality of life. (World-Health-Organization, 2010).

Indeed, social gradients in health can be conciliated by social capital. Michael Marmot (2004) introduced the term “status syndrome,” which refers to the social gradient in health. The relative position in the social hierarchy explains the socioeconomic differences in health. Not only people in absolute poverty but also people who are not poor are likely to suffer illness compared to those in a higher position. This relative position determines the disproportionate life chances and a person's capabilities. Therefore, autonomy and full social participation, which are fundamental human needs, are much more salient. In other words, controlling one's life, having social networks, receiving social support, and reciprocity toward each other benefit population health in a way that reduces health inequalities caused by social hierarchy (Marmot, 2004; Marmot, 2006).

1.1.6. Household context: unit of stratification and resource sharing

Units of stratification. Families hold a central position in the initiation of cultural cycles of social class because they regulate access to critical resources such as financial and social support, education, and healthcare. That is, families function as a gateway to specific social and economic contexts, which then give rise to unique patterns of social cognition, emotion, and behaviors.

Thus, one's family background can have a strong impact on their socialization, culture, and educational achievement (Manstead, 2018; Singh-Manoux et al., 2003; Stephens et al., 2014). Indeed, status includes factors associated with family reputation, such as those associated with one's family of origin or the family that an individual marries into, or the nature of a spouse's job (Singh-Manoux et al., 2003). For instance, the social class of an individual's father, socioeconomic circumstances during childhood, and household wealth are all associated with both an individual's objective and subjective SES (Singh-Manoux et al., 2005).

Furthermore, family's social class influences the operating mechanism of the social networks. People from less-educated and low-income households lean on sparse connections concentrated mainly within their own families, resulting in being socially isolated even from their neighbors.

Units of resource sharing. Given that SES is based on resources, the origins of resources and the way that they are shared are crucial elements. Each family member occupies a role (or multiple roles) such as parent, spouse, child, or sibling. Family roles indicate recurrent behavioral patterns by which individuals fulfill family functions and needs. The provision of physical resources (e.g., money, food, and shelter), emotional support, and nurturance are related to the essential roles within a family (Epstein et al., 1983).

Moreover, several types of hierarchies can exist within a family, such as generational hierarchies or gender-based structures (American Academy

of Pediatrics[AAA], 2005). Conger et al. (2010) suggested that complicated causal dynamics exist between SES and family processes. Social class or SES is related to the quality and stability of family life, which incorporates both underlying principles of social causation and social selection perspectives (Conger et al., 2010). Furthermore, resource sharing occurs among family members across diverse dimensions, such that parents have kinship obligations as resource providers, while younger generations are the recipients of support (Rossi & Rossi, 1990).

Parents' social status and the children's one. Parents' educational background, occupations, and economic resources influence the children's social life **experiences** and **chances**. Therefore, parents' educational status determine the children's social capital as well as physical health. As higher educated parents, children are more prone to trustworthiness of surrounding and less suffer from adolescent obesity (Putnam, 2016) pp.220-2.

Depending on social classes, the parents' childrearing practices and strategies differ, and it determine the children's view and social connection, forming social capital in early stage. Upper-class parents actively attempt to cultivate their children's cognitive and social skills by exposing children to multiple organized leisure activities and connections with professionals (Lareau, 2002).

For the reasons stated above, social class and SES must be conceptualized and measured in a multilevel way across an individual's lifespan. Particularly when examining familial resources and standards of

living, measurements of social class at the household level are more relevant than those at the individual level (Krieger et al., 1997).

1.1.7. Community context: built environment, neighborhood effect and collective efficacy

There was an example of the large-scale randomized social experiment for housing mobility called “Moving to Opportunity (MTO)” organized by the U.S. Department of Housing and Urban Development. Starting in 1994, enrolled low-income families with children living in high poverty got vouchers that subsidized moving to less distressed areas (Goering et al., 1999). As a long-term effect of this program, it is revealed that neighborhood effects improve physical and mental health outcomes (such as extreme obesity, diabetes, and psychological distress) and the overall quality of life and well-being. These findings support the “safe-stress-health” hypothesis, which suggest that neighborhood safety ensures mental health and subsequent physical health (Katz et al., 2001; Ludwig et al., 2013).

There are four possible mechanisms of how neighborhood effects operate in residents' health outcomes such as depression and problematic behaviors such as adolescent delinquencies or crime. These social processes occur through *(1) social relations, (2) collective efficacy, (3) institutional resources, and (4) routine activities* (Leventhal & Brooks-Gunn, 2000; Sampson et al., 2002). First, the density of social ties or frequency of social relations with others mediates the neighborhood effects. Second, mutual trust

and shared expectations draw the willingness for residents to intervene for the public good and enable informal social control. Third, institutions—such as libraries, museums, child care centers, medical facilities, or family support centers—provide needy services. Lastly, land use patterns—such as the location of schools, shopping malls, vacant lots, or transportation nodes—generate daily strain and routine activities. (Sampson et al., 2002).

Social capital and place. Social capital is inherently related to the place. The source of social capital comes from family, school, community, company, civil society, public domain, gender, and race (Healy & Côté, 2001). Therefore, the concept can be extended from individual assets to community features, and even national level (Portes, 1998), and be influenced by multilevel attributes.

Built environment, the way of design the communities and neighborhoods, determines the resident's daily exposures, provide the stage for social interactions, and can eventually bring physical and mental health (D. A. Cohen et al., 2008).

Collective efficiency is a concept related to the benefits from the cognitive social capital in the community. Sampson and colleagues (1997) define neighborhood collective efficacy, which is formed independently of interpersonal ties, as "social cohesion and mutual trust combined with the willingness to intervene for the common good (Sampson et al., 1997)". Collective efficacy is cultivated by trust or cohesion among neighbors and shared expectations in social disorders. These perceptions induce civic

engagement, enhance collective actions, and make social regulations efficient (Sampson, 2012) pp. 367-9).

1.1.8. Spatial context: geographical proximity

The first law of geography states: "everything is related to everything else, but near things are more related than distant things (Tobler, 1970)". Thus, distance-decay effects in space have been incorporated into much spatial research.

Furthermore, based on the spatial dynamics, neighborhood characteristics determine the ease of ***diffusing*** delinquent behaviors and the extent to which ***exposure*** to health-risky environments, over time and space. Consequently, this spatial interdependence results in spatial patterning in residential stability, perceived disorders, crime rates such as homicide or incarceration rates, and collective efficacy (Sampson, 2012) pp. 238-43).

1.1.9. Longitudinal perspectives on the social determinants of health

Regarding the social stressor to health, the psychosocial process is correlated with the timing effect across the lifespan. How long and when the stressors are exposed to an individual is critical to manifesting chronic diseases (Braveman & Gottlieb, 2014).

Chronic exposures to stress in social environments activate the pro-inflammatory process, neuro-endocrine mechanisms, and metabolic systems. These induce long-term dysregulation of the stress control process and

increase the risk of chronic diseases (McEwen & Gianaros, 2010; Seeman et al., 2010). Exposure at an early stage also matters. Past experiences or a family's socioeconomic status in childhood can account for one's changes in socioeconomic status over time. These early exposures reinforce or prevent vulnerability to exposures in later life, which is linked to disease outcomes (Berkman, 2009).

From the life course perspective, SSS—one of the primary concerns of this study—offers advantages to the longitudinal study design because SSS adequately summarizes the socioeconomic circumstances in different periods of life. SSS combines an individual's present socioeconomic situation, past achievements, and future prospects according to the components of their socioeconomic trajectory (Singh-Manoux et al., 2003).

Furthermore, the neighborhood effects cumulatively work over long periods. Collective efficacy nurtured in the community is relatively stable and kept for a long time and determines the trajectories of community health and well-being for the following years (Sampson, 2012), p.368. The neighborhoods exert the child development and intergenerational mobility through childhood exposure. In the cases where families move to a better neighborhood, children's positive outcomes linearly rise by 4% per year for the time children spent growing up in that area (Chetty & Hendren, 2018). In low-income families, long-term neighborhood effects significantly affect physical and mental health, such as obesity, diabetes, and distress. (Ludwig et al., 2013).

1.1.10. Health as a consequence

Social conditions are fundamental cause of disease (Link & Phelan, 1995). A great deal of previous research has revealed the association between social conditions and health. This section mainly addressed the effects of SSS, social capital, and health.

SSS determines health via sociological, psychological, and biological pathways (Hoebel & Lampert, 2020). Lower SSS is related to both infectious diseases such as the common cold (S. Cohen et al., 2008) and non-communicable diseases. In particular, a high prevalence of depression, diabetes, (Demakakos et al., 2008), cardiovascular diseases (Tang et al., 2016), heart rate, sleep latency, abdominal fat distribution (Adler et al., 2000), adolescent obesity (Goodman et al., 2003), and poor self-rated health (Demakakos et al., 2008; Operario et al., 2004; Singh-Manoux et al., 2003; Singh-Manoux et al., 2005) are correlated with lower SSS. Furthermore, a recent longitudinal study of aging revealed that SSS is associated with mortality resulting from cardiovascular, cancer, and all-causes (Demakakos et al., 2018). After adjusting for conventional socioeconomic status (i.e., SES) in terms of education, occupation, and income factors, most health outcomes remain associated with SSS, suggesting an effect on health beyond SES (Tang et al., 2016).

Social capital and health. A great deal of previous research on social capital and health has revealed the mechanism and their positive relationships.

A recently updated review paper on social capital and physical health stated that most studies at least partially showed the protective effect on health in terms of self-reported health, cardiovascular diseases, obesity, diabetes, infectious diseases, cancers, and mortality (Rodgers et al., 2019). Emotional support from intimate ties, such as family members, helped stroke and cardiovascular patients recover. Social cohesion and connectedness to others in the community reduced the risk of death from all causes compared to socially isolated people (Berkman, 2000). Social trust and participation in voluntary groups also influenced the mortality (Kawachi et al., 1997).

At the individual and community level, and even at the state level, social capital influences health. Social capital measured at the state-level in the U.S. showed protective effects on individual HRQoL (Kim & Kawachi, 2007). The contextual effect of social trust in the community benefited self-rated health, even after controlling individual factors (Kawachi et al., 1999; Subramanian, 2002), In addition, individual-level access to social capital was associated with self-rated health. The degree of these associations varied according to sex. (Kobayashi et al., 2013).

In particular, social capital has become a crucial resource for health in the elderly. In a review paper targeted at those 50 years and older, social capital positively influenced mental well-being (e.g., life satisfaction, happiness, quality of life, and emotional health) (Nyqvist et al., 2013). For Chinese older adults, social capital made differences in health risk behaviors and HRQoL. The role of social capital was similar to the SES effect as a

determinant. When people had a high social capital or SES level, they were less likely to be associated with smoking, physical inactivity, unhealthy dietary behaviors, and sleep disorders; therefore, these combined effects increased the HRQoL (Yang et al., 2020).

Collective efficacy, frequently regarded as a form of social capital at the community level, is associated with the prevalence of violent crime (Sampson et al., 1997), all-cause of premature mortality, and mortality from cardiovascular disease (Cohen et al., 2003), and obesity (Cohen et al., 2006).

1.1.11. Previous limitations

When dealing with the income and poverty domains, the capital of individuals merely explains a small portion of the poverty puzzle (Narayan & Pritchett, 1999). In general, the conventional measures of SES cover educational achievement, occupational type, and income level. However, they have several limitations on observation and aggregation issues.

Firstly, "objective" indicators are not always measured objectively. It still has problems with the validity and reliability of measurements. Secondly, a single indicator provides only a part of the information rather than a comprehensive substance of social class. Although several attempts have been made to combine fragmented indicators into a composite index, this sum-score item still cannot reflect varying aspects. When combining indicators, it is also questionable how much weight should be applied to each indicator (Veenhoven, 2002).

In this context, this paper uses a subjective indicator that ensures an overall judgment of one's socioeconomic surroundings. This is a reasonable strategy because people report their subjective status based on a balancing spot between the plus and minus elements of overall life satisfaction.

Secondly, it is necessary to grasp the substance and mechanisms of social capital embedded in society. Even though social capital has become a prominent social determinant of health since the mid-to-late 1990s, the conceptualization, measurement, and practice issues around social capital remain (Moore & Carpiano, 2020). According to social capital dimensions (macro-, meso-, and miro-level), their relationships to health and the mechanisms differ (Carrillo Álvarez & Riera Romaní, 2017). These multiple and multidisciplinary adaptations of the concepts have made it challenging to draw consensus on their health impact (Moore & Kawachi, 2017). Indeed, understanding the extent of social capital's health effects is disorganized due to the heterogeneity in social capital concepts (Lochner et al., 1999).

1.2. Study design and objectives

A social class exists in a social context in which people reside and experience everyday social life in pervasive ways. The social context is defined and shaped by two independent processes. One is that of practical experiences derived from differences in *accessibility to material resources* (goods or services). The other is that of *subjective perceptions of rank* vis-à-vis others. In turn, social class contexts, such as scarce resources, reduced opportunities, and lower levels of perceived rank, affect social cognition, emotion, behavior, and health outcomes (Michael W. Kraus et al., 2012; Kraus et al., 2013; Loignon & Woehr, 2018). Furthermore, to date, realizations about class-based inequalities have rekindled interest in the role of the *household environment* in determining social class. Therefore, an *ecosocial* approach should be considered in social determinants of health (SDH) research, to confirm the diverse aspects of socioeconomic contexts (Krieger, 2001).

This study posited the importance of social context, and synthesized multidimensional SDH that have been described in various fields of study. It contains (1) social class context, derived particularly from the family; (2) social capital, such as social network, trust, and civic engagement; (3) the neighborhood context, and built environment.

Another outcome of this study regarding aspects of HRQoL determinants is to consider diversity over time and space. Furthermore, measures of social class should consider the spatiotemporal scale at multiple

levels (i.e., individual, household, and community levels) (Krieger, 2001; Krieger et al., 1997).

Detailed research objectives are as follows: This study set health-related quality of life (HRQoL) as a health outcome. The first study aimed to investigate the variations in and determinants of SSS, focusing on household environments. The differences in SSS among household members and the relative importance of individual and household factors on SSS were assessed. Then, the factors associated with gaps between objective and subjective status were examined.

The second study aimed to investigate the prospective effect of social determinants on HRQoL trajectories. The combined change patterns of objective and subjective status over time were derived to show the social inequalities. Then, the longitudinal relationship between changes in social status and changes in HRQoL was investigated with time gaps.

The third study aimed to measure and categorize the various social resources beyond the household. Resources were considered in terms of social capital, the built environment (such as cultural and medical facilities), and community characteristics. Then, the neighborhood effects of social resources on HRQoL were investigated.

The fourth study focused on revealing the resource effects on HRQoL concerning geographical proximity. The spatial distribution of HRQoL was examined to confirm the presence of spatial autocorrelation. Then, spatial analysis of the resource effect on HRQoL was conducted to explore the issue

of spatial non-stationarity of social processes. Finally, spatial clustering, which has become a significant policy target, was defined based on the homogenous resource effects.

Table 1-1. Summary of the research structure and objectives

	Study focus and objectives		Unit	Year
Ch.2	**[Intra-variation Within a household]** Household and individual resources → Subjective social status	Inter-personal variation	Household	2013
		Relative importance between individual and household factors	Individual	
		Determinants of discrepancies on objective and subjective social status	Individual	
Ch.3	**[Longitudinal pattern]** Change pattern of objective and subjective social status → HRQoL trajectories	Trajectory of HRQoL	Individual (Panel)	2009 ~ 2018
		Multi-trajectories of objective and subjective social status	Individual (Panel)	
		Association between baseline socioeconomic status and following HRQoL trajectories	Individual	
Ch.4	**[Feature extraction]** Multi-dimensional resources → (dimension reduction) → HRQoL	Feature detection of resources in the community	Community	2019
		Effect of community resources on HRQoL	Community	
Ch.5	**[Spatial heterogeneity]** Social resources → HRQoL	Spatial autocorrelation in HRQoL	Community	2011, 2015, 2019
		Effect of social resources on HRQoL with spatial non- stationarity	Community	

Chapter 2.
Resource sharing model for subjective social status at the household level

Chapter 2.
Resource sharing model for subjective social status at the household level

2.1. Introduction

Subjective measures of social status are accepted as valid indicators of resource availability and social inequality. Individuals receive resources through their family household as the primary unit of social stratification. However, few studies have examined whether household members perceive their social status as being at the same level. Here, we investigate which resources among individual and household factors primarily determine one's perception of social hierarchies and what mechanisms of resource distribution work within a household.

2.1.1. Study background

Resources determining one's social position. Conventional socioeconomic measures cover education, occupation, or income in general. However, social class is likely to be interpreted as a social or cultural indicator as much as an economic affinity (Jackman, 1979). In addition to the typical elements of SES, the following have been correlated with class identification or rank perception: basic demographic factors, such as race (Jackman, 1979; Jackman & Jackman, 1983; Wolff et al., 2010) and marital status (Vanneman & Pampel, 1977);

household factors, such as a breadwinner's occupation, family income (Hodge & Treiman, 1968), household wealth (Singh-Manoux et al., 2003), and family background and childhood factors (Coleman et al., 1979); work environment, such as whether an individual has a part-time or full-time job (Vanneman & Pampel, 1977), the opportunity to develop skills, and a high or low psychological workload (Marmot et al., 1991); and cultural or expressive factors, such as an individual's beliefs, lifestyle, and socialization habits (Centers, 1949; Jackman, 1979).

Furthermore, SSS covers additional economic dimensions, such as debt, wealth, rises in the price of property owned, and inheritance (Hoebel & Lampert, 2020; Singh-Manoux et al., 2003). Furthermore, it captures comprehensive phenomena including not only objective socioeconomic characteristics but also detailed information about lifestyle, beliefs, and family background (Centers, 1949; Jackman, 1979), as well as nuanced judgments regarding socially prestigious achievements that may enhance one's opportunities in life (Singh-Manoux et al., 2005).

Social comparison mechanism. When considering the formation of subjective social status (SSS), it is important to understand a person's perception of their 'relative' versus 'absolute' position in the social hierarchy (Singh-Manoux et al., 2005). In social comparison theory, which was coined by Leon Festinger in 1954, people compare themselves with others for precise self-evaluation, and this becomes a fundamental process in social life (Festinger, 1954). Because SSS is a product of social comparison processes

(Mcleod, 2013a). SSS can vary depending on how people set their reference groups, even within the same objective SES (Hoebel & Lampert, 2020). In an experimental social class manipulation study in which people were randomly assigned to groups, SSS temporarily shifted according to the members of the comparison group (Kraus et al., 2010).

Male-driven identity in household SSS. Previously, male-driven identities were a dominant element of family class identification. Indeed, Max Weber defined class in terms of one's position in the labor market. Thus, a family's social class was derived from the husband's social position in the workplace, and wives (who were mostly unemployed) were indirectly connected to class structure through their husbands' positions (Davis & Robinson, 1988; Jackman & Jackman, 1983; Rossi et al., 1974). In the 1970s, married women placed more weight on their husbands' characteristics when evaluating their family's class, while married men considered only their own status. Children who never married took into account their own characteristics and those of their father, but not those of their mother when evaluating class. After the 1980s, economic shifts and changing attitudes about women's contributions throughout society led women to be more independent in identifying their class position, instead of immediately adopting their husband or father's position (Davis & Robinson, 1988; Jackman & Jackman, 1983). Thus, new configurations of power within families can arise according to changing historical contexts, and such transformations can affect one's self-identity.

2.1.2. Study design and objectives

Previous studies have frequently ignored the effects of household environment or distinctive household identity on SSS. Given that a parents' social class may not be entirely extended to their children, subjective measures should be examined across age groups and beyond adult-focused indices (Liu et al., 2004). Indeed, several studies analyzed the reliability of SSS data collected from mothers and children (Goodman et al., 2001; Goodman et al., 2015) or compared the perception of a family's social standing between husbands and wives (Davis & Robinson, 1988; Jackman & Jackman, 1983; Rossi et al., 1974).

However, these studies provided only fragmentary and limited interpretations because they did not consider all of the members of each household. To the best of our knowledge, no studies have distinguished perceptions of SSS among each family member in a household. To address this in the present study, we examined perceptions of SSS among household members in a representative sample by considering a broad range of household contexts, along with data regarding sex, age, and occupation.

Specifically, we investigated variation in SSS and the determinants of SSS disparities with a primary focus on household environments. Then we developed a new model to explore the multilevel context in which household SSS is constructed. We examined the reliability of perceptions of SSS among household members according to household composition, assessed the

relative importance of various factors on individual and household determinants of SSS, and identified the factors associated with discrepancies between subjective and objective social status.

2.2. Methods

2.2.1. Data and study population

We used data from representative samples of South Korean adults aged 18 and over. The data were collected from the 8th wave of participants in the 2013 Korea Health Panel Survey (KHPS), which is conducted annually by a consortium of the Korea Institute for Health and Social Affairs and the National Health Insurance Service. Sample households were chosen by probability proportionate and stratified cluster sampling methods across the 16 provinces in South Korea. Skilled interviewers visited the homes of the participants using a computer-assisted personal interviewing (CAPI) system (KIHASA & NHIS).

The dataset comprised 5,200 households and 11,300 individuals. We excluded data collected from relatives or friends and only included the households in which all of the eligible members had provided comprehensive answers to the survey questions. As a result, 10,563 participants satisfied the eligibility criteria at the initial screening. Then we excluded household units with missing data, those with influential data based on Cook's distance criteria, and those from unexpected survey districts (2,233 individuals in total). The final study sample included 3,984 households and 8,330 individuals, with 3,864 men (46.4%) and 4,466 women (53.6%). The

institutional review board of Seoul National University approved the research protocol.

2.2.2. Measures

We used subjective and objective measures of individual and household characteristics. *Household SSS* was measured using the MacArthur scale of subjective social status, which assess familial placement in society (i.e., the youth version of the SES ladder). Participants are shown a simple drawing of a ladder with ten rungs, which represents society. Those who are the most advantaged in society (in terms of income, education, and occupational prestige) occupy the top rung, and those who are the least advantaged are at the bottom. In the present study, each household member was asked to pinpoint his or her household's position on the ladder (Adler & Stewart, 2007; Goodman et al., 2001).

Objective household status was measured in terms of household income level. We calculated this value by summing all income sources, such as earnings, benefits, pensions, interests, allowance, and assets from all household members earned in the previous year. To account for the size of the household, we applied an equivalence scale, called a square root scale, which divided the total household income by the square root of the number of household members (Organisation for Economic Co-operation and Development[OECD], 2012).

Additional indicators of ***household environment*** were included as follows: The number of household members, family role (i.e., the head of the household or their spouse, children, or parents), household composition (i.e., one-, two-, or three-generation household), type of house (i.e., house or apartment), and homeownership (i.e., owner-occupied, chartered (long-term rent with lump-sum deposit), rented monthly, or free accommodation).

Concerning **individual characteristics**, we measured sex, age, individual earned income, occupation, and years of education as elements of *individual SES*. Occupations were classified as follows: administrator or expert, officer, service worker, or salesman, agriculture and fisheries, machinery operator, manual worker, and unemployed. We converted categorical education variables into a numerical value (years of education ranging from 0–22 years). Finally, self-rated health, social views, and the presence of a social safety net (i.e., social insurance) were included as covariates to control for possible confounding variables.

2.2.3. Statistical analyses

We assessed the reliability of SSSs among household members using ***intra-class correlation coefficients (ICCs)*** with 95% confidence intervals. For households with two or more people, we classified the type of household composition by the family role. We only included a type if it occurred more than 30 times in the dataset. ICCs were calculated using the formula labeled "ICC (3,1)" in Shrout and Fleiss (1979), which was expressed in Koo and Li

(2016) as below. When interpreting the results, the level of reliability was considered poor for ICC values less than 0.5, moderate for values between 0.5 and 0.75, good for values between 0.75 and 0.9, and excellent for values greater than 0.90 (Koo & Li, 2016; Shrout & Fleiss, 1979).

$$\mathbf{ICC} = \frac{\boldsymbol{MS_{members} - MS_{error}}}{\boldsymbol{MS_{members} + (k-1)MS_{error}}}$$

$MS_{members}$ = mean square for members; MS_{error}= mean square for error;

k = number of members(raters)

Multiple linear regression with the ordinary least squared (OLS) method was conducted to determine the relative importance of the factors on household SSS. Then we performed variance decomposition using Owen's value, which explained the variance of the independent variables in the model and inferred the relative importance of the factors in terms of explained variance (R^2) (Huettner & Sunder, 2012). As the "rego" STATA module for Owen's value does not yet permit the use of weight options, we estimated the values without survey weights.

Multinomial logistic regression analyses were performed to identify the determinants of the discrepancies between subjective and objective status. As a dependent variable, we classified the participants into three non-ordinal groups based on SSS quartile and household income quartile (as shown in Appendix B). People whose subjective and objective quartiles were consistent

were classified as the ‘consistent’ group. Those with inconsistent quartiles such that the subjective quartile was lower than the objective quartile were classified as the ‘lower perception’ group (i.e., subjective < objective quartile), and those with a higher subjective quartile were classified as the ‘higher perception’ group (i.e., subjective > objective quartile). Then we calculated the predicted probabilities (i.e., margins) of each group at each level of the selected independent variables, holding all other covariates in the model at their means. Finally, we generated plots of the multinomial predicted probability (i.e., margin plots) to examine how the independent variables influenced each probability. All analyses were carried out using the STATA software package, version 15.

2.3. Results

The distribution of socioeconomic characteristics by household members is shown in Table 2-1. The husbands and wives had nearly the same number of years of education (10.9 years). The heads of households were engaged in diverse industries and only 27.4% of them were unemployed, while 48.6% of their spouses were unemployed. The gap between household and individual income was the smallest ($3 per month) among the heads of households, but was about $1,300 for the spouse and children, and $1,578 for the parents of the heads of households.

Table 2-1. Sociodemographic characteristics of the participants by household members

	Head of Household		Spouse		Dependents				Total	
					Children*		Parents**			
	n	%	n	%	n	%	n	%	n	%
Total	3,984	100	2,956	100	1,186	100	204	100	8,330	100
Sex										
Male	3,208	80.5	15	0.5	608	51.3	33	16.2	3,864	46.4
Female	776	19.5	2,941	99.5	578	48.7	171	83.8	4,466	53.6
Age										
Mean ± SD	57.3	14.6	51.8	13.2	27.7	7.7	75.7	8.3	51.6	16.9
Education year										
Mean ± SD	10.9	4.6	10.9	4.0	13.7	2.0	4.8	4.1	11.1	4.4
Occupational type										
Administrator, Expert	604	15.2	289	9.8	180	15.2	–	0.0	1,073	12.9
Officer, Service & Salesman	651	16.3	569	19.3	249	21.0	6	2.9	1,475	17.7
Agriculture, Fisheries	448	11.2	283	9.6	7	0.6	11	5.4	749	9.0
Machinery operator	813	20.4	89	3.0	111	9.4	2	1.0	1,015	12.2
Manual worker	378	9.5	289	9.8	65	5.5	11	5.4	743	8.9
Unemployed	1,090	27.4	1,437	48.6	574	48.4	174	85.3	3,275	39.3
Individual wage & salary income (USD, Monthly)†										
Mean ± sd	1,632	1,694	514	841	764	970	61	201	1,073	1,434
Household total income (USD, Monthly)‡										
Mean ± sd	1,629	1,092	1,814	1,104	2,039	1,057	1,639	787	1,753	1,094
Household composition										
1 Single person	746	18.7	–	0.0	–	0.0	–	0.0	746	9.0
1 generation: Couple-only	1,004	25.2	1,004	34.0	–	0.0	–	0.0	2,008	24.1
2 generation	2,077	52.1	1,826	61.8	1,065	89.8	68	33.3	5,036	60.5
3 generation	157	3.9	126	4.3	121	10.2	136	66.7	540	6.5

†Individual income was calculated including individuals with no economic activity (housewife, student, unemployed, and so forth)

‡Household income was equivalized based on the household size.

*Children or spouses were included. Children under 18 years old were excluded from the survey

**Parents or parents-in-law of the head of the household were included.

The mean SSS varied among the household members according to the composition of the household (Figure 2-1.). Parents of the heads of households reported significantly lower SSSs, that is, 3.4 in two-generation and 3.9 in three-generation households. However, children reported high SSS values, that is, 4.5 in two-generation and 4.4 in three-generation households.

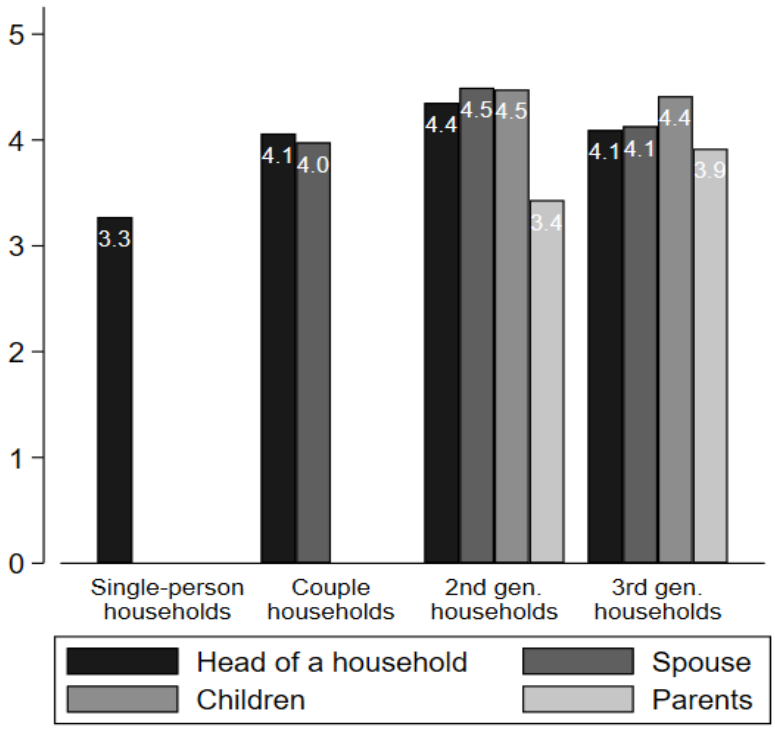


Figure 2-1. Mean of SSS by household composition and members

*Weighted means with sampling weight

Figure 2-2 illustrates the extent to which the perceptions of household members correlated and agreed with the ICC value, according to the household composition. Members of couple-only households showed good consistency, with an ICC value above 0.75 points. However, the response consistency of husbands and wives decreased as the number of underage children increased. Detailed ICCs values are given in Appendix C.

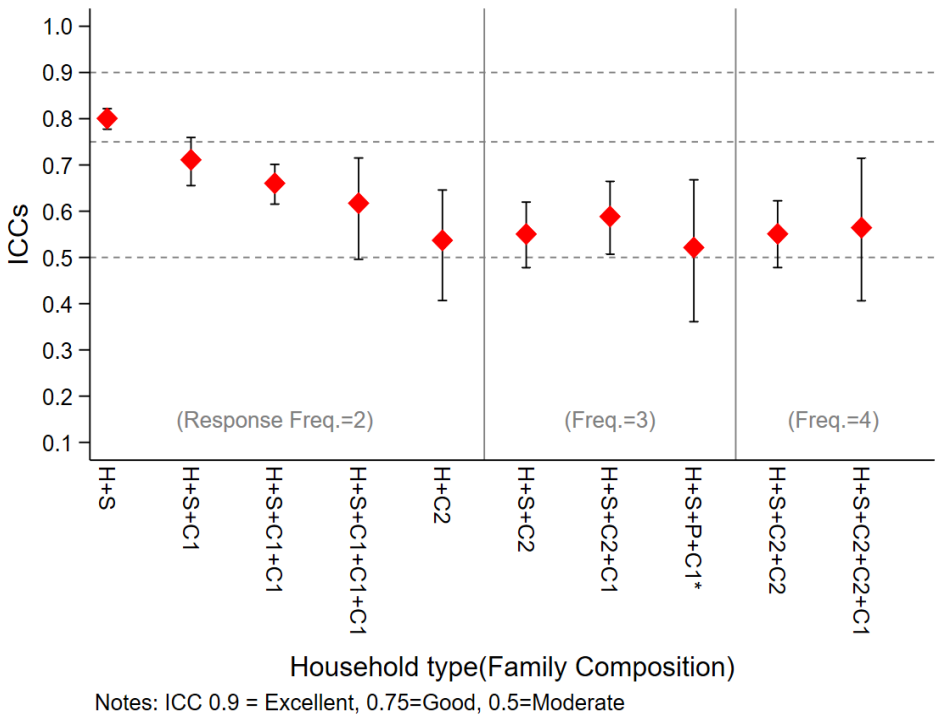


Figure 2-2. Intra-class correlation coefficients of household SSS by household composition

**Abbreviations: H: Head of Household, S: Spouse, C1: Child under 18 years old, C2: Child over 18 years old, P: Parents

***ICC values were based on a two-way mixed effect model. Consistency was measured for each single rater, i.e., single rater vs. k-means of the ICC value.

We analyzed which determinants most strongly influenced household SSS among individual and household characteristics (Table 2-2). Although sex did not influence SSS, older individuals reported lower SSS values such that each cumulative year decreased SSS by 0.005 points. Individuals who had completed college reported SSS values that were 0.469 points higher than those who had only completed middle school or who had a lower education level. Individuals involved in agriculture or fisheries gave the highest SSS values, with scores that were 0.227 points higher than those in administration.

Regarding household environments, couple-only households reported SSS values that were 0.279 points higher than those given by single-person households, 0.211 points higher than two-generation households, and 0.197 points higher than three-generation households. People living in apartments reported SSS values that were 0.201 points higher than those living in houses. When individuals lived in houses that were owner-occupied, their coefficients were 0.189 higher than for those who lived in chartered houses and 0.522 higher than for those who paid monthly rent.

According to variance decomposition, household income accounted for the majority of the variation at 45.37%. Household composition, house type, and homeownership type explained 5.37%, 6.55%, and 6.51% of the r-square value, respectively. By contrast, individual components such as age (5.26%), education level (11.47%), and occupation type (5.91%) explained a relatively small amount of the variation.

Table 2-2. Multiple linear regression analysis for the determinants of household subjective social status with variance decomposition

	OLS			Variance Decomposition	
	Coef.	Std. Err.	P > t	Ind. %R2	Group %R2
Sex (ref: male)					
Female	0.001	(0.047)	0.989	0.36	**0.36**
Age					
Age	-0.005***	(0.001)	0.000	5.26	**5.26**
Education (ref: middle school or lower)					
High school	0.267***	(0.040)	0.000	2.44	**11.47**
College or higher	0.469***	(0.047)	0.000	9.03	
Occupation type (ref: administrator, expert)					
Clerk, service & salesman	-0.107*	(0.049)	0.028	0.41	**5.91**
Agriculture, fisheries	0.227**	(0.065)	0.001	0.97	
Machinery operator	-0.238***	(0.056)	0.000	0.88	
Manual worker	-0.271***	(0.061)	0.000	2.25	
Unemployed	0.054	(0.050)	0.275	1.40	
Household total income					
Ln (income) (USD, monthly)	0.925***	(0.026)	0.000	45.37	**45.37**
Family role (ref: head of household)					
Spouse	0.039	(0.054)	0.464	0.97	**1.92**
Child	-0.102	(0.058)	0.077	0.76	
Parent	-0.021	(0.103)	0.841	0.18	
Household composition (ref: couple-only)					
1 generation: single person	-0.279***	(0.068)	0.000	3.12	**5.37**
2 generation	-0.211***	(0.050)	0.000	2.09	
3 generation	-0.197**	(0.090)	0.030	0.16	
Type of house (ref: house)					
Apartment	0.201***	(0.029)	0.000	6.55	**6.55**
Home ownership (ref: owner-occupied)					
Chartered†	-0.189***	(0.039)	0.000	0.39	**6.51**
Monthly rent	-0.522***	(0.049)	0.000	5.31	
Free accommodation	-0.066	(0.055)	0.226	0.81	

Self-rated health					
SRH score (1–5)	0.172***	(0.017)	0.000	6.30	**6.30**
Social view (ref: negative)					
Positive	0.326***	(0.028)	0.000	3.14	**3.14**
Social Insurance (ref: uninsured)					
Insured	0.069*	(0.031)	0.027	1.83	**1.83**
Intercept	-3.454	(0.230)	-	-	**-**
Observations	8,330				
R2	0.342				
F-stat. Model	133.102***				

†'Chartered' indicates South Korea's unique housing rental system of long-term rent with lump-sum deposit. *p < 0.05, **p < 0.01, ***p < 0.001

Notes: Coefficients were unweighted due to a limitation in the weighting variance decomposition analysis.

Next, we explored the factors that led people to set their household standing as higher or lower than their actual household income level, with the other variables in the model held constant (Table 2-3 & Figure 2-3). Each additional year of age decreased the relative risks of having a positive perception instead of a consistent perception. That is, as people aged, they were more likely to have consistent perceptions when all other variables in the model were constant. Each additional year of education increased the relative risks of having a positive versus consistent perception by 1.049 times. Compared to administrators or experts, agriculture or fishery workers were 2.104 times more likely to have a positive perception instead of a consistent perception (Table 2-3). Further, Individuals with blue-collar occupations (i.e.,

machinery operators or manual workers) were significantly more likely to perceive their SSS as lower than the objective level (Figure 2-3).

Respondents with a high household income level tended to report a SSS that was lower than that reflected by their actual income level. In terms of family role, the risk for being in the lower perception group versus the consistent group was 1.766 times greater for dependent parents relative to the head of the household. That risk increased by 1.304 times for respondents from two-generation households compared to married couples without dependents. Living in an apartment compared to a house protected people from having a lower perception of their SSS. Likewise, living in an owner-occupied home compared to a chartered or monthly rented home increased the relative risks of being in the positive perception group versus the consistent group.

Table 2-3. Relative risk ratios of a lower or higher perception versus a consistent perception of subjective social status and objective income level

	Group 2: Sbj < Obj (Ref. Group1; Sbj = Obj)			Group 3: Sbj > Obj (Ref. Group1; Sbj = Obj)		
	RRR	[95%CI]		RRR	[95%CI]	
Sex (ref: male)						
Female	0.973	0.789	1.199	0.962	0.745	1.243
Age						
Age	0.997	0.989	1.004	0.985**	0.976	0.995
Education year						
Education (years)	0.952***	0.931	0.973	1.049***	1.020	1.078
Occupation type (ref: administrator, expert)						
Clerk, service & salesman	1.238	0.993	1.542	1.168	0.866	1.575
Agriculture, fisheries	0.949	0.687	1.309	2.104***	1.427	3.102
Machinery operator	2.284***	1.789	2.915	1.914***	1.373	2.668
Manual worker	1.836***	1.427	2.361	1.534*	1.061	2.217
Unemployed	1.033	0.834	1.279	1.491**	1.128	1.970
Household total income						
Ln (Income) (USD, monthly)	3.719***	3.098	4.465	0.313***	0.258	0.381
Family role (ref: head of household)						
Spouse	1.174	0.935	1.475	1.303	0.982	1.728
Child	1.076	0.812	1.426	0.999	0.708	1.410
Parent	1.766*	1.136	2.744	1.859	0.974	3.549
Household composition (ref: couple-only)						
1 generation: single person	0.977	0.720	1.326	0.597**	0.422	0.846
2 generation	1.304*	1.048	1.624	0.769*	0.591	1.000
3 generation	1.169	0.828	1.650	0.924	0.579	1.477
Type of house (ref: house)						
Apartment	0.691***	0.586	0.814	1.120	0.917	1.368
Home ownership (ref: owner-occupied)						
Chartered	1.063	0.852	1.324	0.742*	0.560	0.983
Monthly rent	1.235	0.953	1.600	0.670*	0.475	0.945
Free accommodation	0.857	0.636	1.155	0.946	0.670	1.336
Self-rated health						
SRH score (1–5)	0.948	0.872	1.032	1.196***	1.081	1.322

Social view (ref: negative)						
Positive	0.624***	0.546	0.713	1.154	0.968	1.376
Social Insurance (ref: uninsured)						
Insured	1.147	0.996	1.321	1.366***	1.147	1.628

*p < 0.05, **p < 0.01, ***p < 0.001

Notes: The model considers variance estimation as survey data. It was weighted using a survey setting where the primary sampling unit (PSU) was 3,984 households and 16 districts were set as strata.

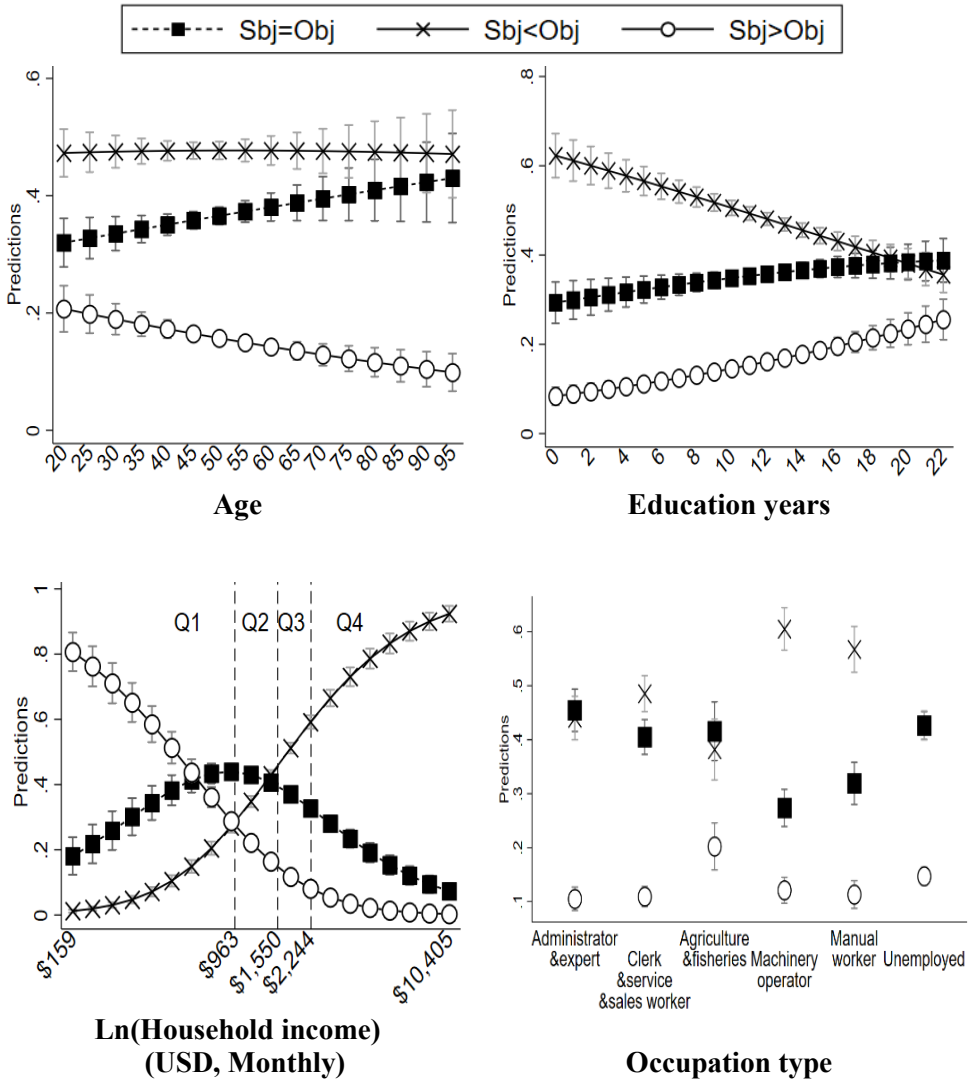


Figure 2-3. Multinomial predicted probability plots by individual and household characteristics for each type of subjective perception

Notes: Each margin plot shows the predicted probability when the other covariates are adjusted.

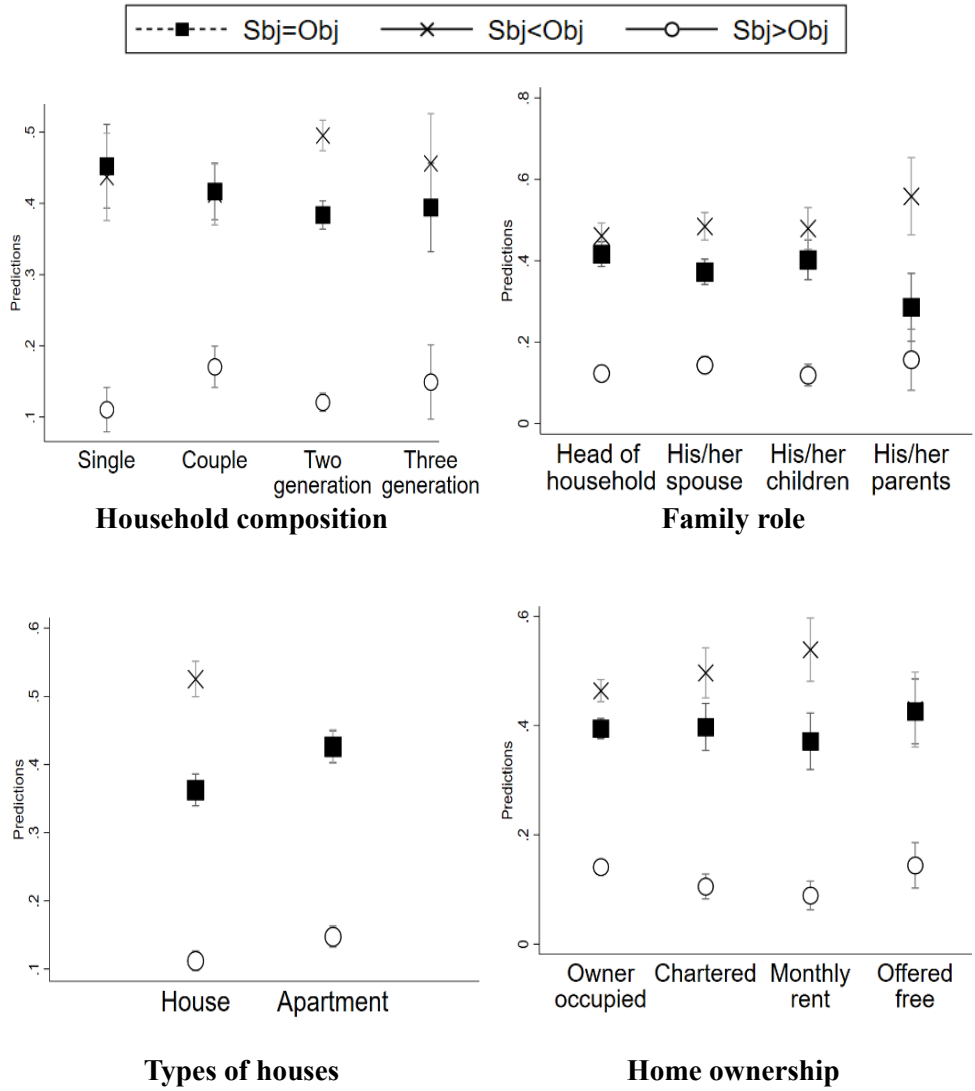


Figure 2-4. Multinomial predicted probability plots by individual and household characteristics for each type of subjective perception (Cont'd.)

Notes: Each margin plot shows the predicted probability when the other covariates are adjusted.

2.4. Discussion

We investigated individual perceptions of household social status while considering disparities among the perceptions of different household members. We found that after accounting for individual SES, perceptions of household social status varied widely according to the household environment and family role. Married couples without dependents had significant advantages in perceiving their household SSS, although the response consistency between couples decreased as their parenting burden increased. Even for individuals with the same income level, a two-generation family structure, identity as an elder dependent, and residential instability led people to perceive their status as lower than that reflected in their objective income level.

Our results do not support the traditional theory of male-driven class identity. Previously, an individual's father's education was used as a proxy indicator of a child's objective SES or as a representative of family-based SES (Goodman et al., 2001). Further, the "sharing/borrowing" model (Davis & Robinson, 1988; Jackman & Jackman, 1983) proposes that people share their social status with other family members such that wives equate their social position with that of their husbands instead of depending on their own characteristics.

Instead, our findings advocate for resource-based explanations and cultural perspectives in interpreting SSS. SSS is determined by multiple

resources at multiple levels (Manstead, 2018; Oakes & Rossi, 2003). Continuing societal conditions shape rank perception by infusing daily experiences and signs of social class with cultural perspectives (Kraus et al., 2013). Interpersonal variation in the way that individuals rate their vignettes (i.e., households) are due to the differential weighting of particular resources in estimating one's social standing (Rossi et al., 1974). Beyond the mere presence or volume of resources, individuals may undergo constrained resource availability that brings a "cycle of disadvantages (Manstead, 2018)". In this respect, even family members who share common assets and living spaces and who undergo significant experiences together may enjoy different levels of benefits from social and cultural capital. Furthermore, resources may be concentrated or sparse for specific family members. Thus, we propose that the interpretation of such differences be extended to include distinctive phenomena derived from an individual's efficacy in perceiving, possessing, and enjoying resources, and household resource sharing.

2.4.1. Individual resource efficacy

Our results indicate that the younger generation in a household retained affluent socioeconomic resources compared to the older generation. This was particularly true if the younger family members received a high level of education and rarely engaged in blue-collar labor. As a result, these younger and more highly educated people were more likely to perceive their

household status in a positive way, while those who worked as machinery operators or manual workers perceived a lower SSS.

People who have less authority and power to control their daily conditions in stratified hierarchies have disadvantages in the social evaluation process. Having less power in such contexts can lead to fewer economic and social resources, which can shape beliefs regarding low efficacy in one's social life. Access to few motives for self-enhancement can influence one's perception of their relative social standing (Mcleod, 2013a). Lower SSS indicates diminished access to resources, fewer opportunities, and a reduced sense of personal control (Kraus et al., 2009; Stephens et al., 2014). Taken together, individual success in terms of SES may protect people from negative self-evaluation, while SSS may reflect the degree of efficacy an individual has in maximizing the availability of resources at an individual level.

2.4.2. Resource sharing between household members

We found that couple-only households had high SSS with good reliability, while people in two-generation households reported lower social status relative to objective income level. With regards to family roles, heads of households, mostly men, acted as the primary breadwinners and their dependents (including his/her elder parents) relied entirely on the household income without making individual contributions. These elderly dependents tended to perceive their household position as lower than their objective status.

These findings correspond with a study on sharing resources within households. From the perspective of kinship obligations, immediate family members are expected to share almost all types of resources (Rossi & Rossi, 1990). Indeed, married couples, compared to single households, have advantages in terms of broader social networks and more pleasant living arrangements (Cornwell, 2014) as well as more financial resources (Waite & Gallagher, 2001).

However, married couples living with their children experience multiple resource deficits because they have high kinship obligations in terms of offering comfort and emotional support to their children across many dimensions. This tendency to experience multiple deficits remains in single elderly people living with their children or grandchildren (Kim & Waite, 2016).

Consequently, limited resources may lead resource-providers to perceive themselves as having a lower status, and to perceive others who receive support as having a higher status. Accordingly, households in which particular members have multiple resource deficits may show large variance in SSS among members.

2.4.3. Upward social mobility between generations

Interpreting variation in SSS between generations requires an understanding of cultural contexts and historical backdrops people have experienced. Previous experiences can influence SSS reporting patterns. For instance,

Evans et al. (1992) suggested that elderly people who lived during oppressive times (e.g., during communism) may have felt that they should assign themselves several steps down on the social ladder due to the imagined presence of an imposing layer of officials at the top of the hierarchy (Evans, 2004). This psychological legacy may explain some of the generational disparities. South Korea (where the data were collected) was previously a dictatorship, but since the 1980s has experienced a rapid transition to a democratic era. Further, the increasing education level in young generations, observed in the present study, may imply potential social mobility. Because educational achievement can act as a driving force of intergenerational upward mobility (Chetty et al., 2017), the variation in SSS observed between generations may be interpreted as an indicator of upward social mobility.

2.4.4. Wealth as a buffer against devalued SSS

Interestingly, we found that household wealth acted as a buffer against the effects of lower SSS, independent of individual resource efficacy or pressure regarding household resource sharing. Household income determined the vast majority of household SSS. Furthermore, several housing environments elevated the SSS of the household against the actual household income level. This was the case for families living in an apartment rather than a house, and those with stable homeownership (i.e., owner-occupied) rather than chartered or monthly rent. These results are aligned with previous findings that SSS is significantly determined by satisfaction with one's standard of living or one's

feeling of financial security (Singh-Manoux et al., 2003), and call attention to the importance of housing policies.

2.4.5. Limitations

There were several limitations to this study. First, household SSS was measured using the youth version of the MacArthur scale. This may cause problems when comparing our results with those from other studies that used the individual SSS measure.

In addition, due to the survey design, responses from children under 18 years were excluded. Thus, it is challenging to capture the aspects influencing intergenerational differences comprehensively.

Finally, as SSS is based on a self-reported measure, it cannot be excluded the possibility of measurement errors related to confounding variables (Hoebel & Lampert, 2020), and it may create intrinsic problems concerning validity and reliability. However, despite these limitations, previous reliability tests on SSS have shown high performance and adequate reliability (Giatti et al., 2012; Goodman et al., 2001; Liu et al., 2004; Operario et al., 2004).

2.5. Supplementary data

Appendix A. Distribution of household income and subjective social status among the study population

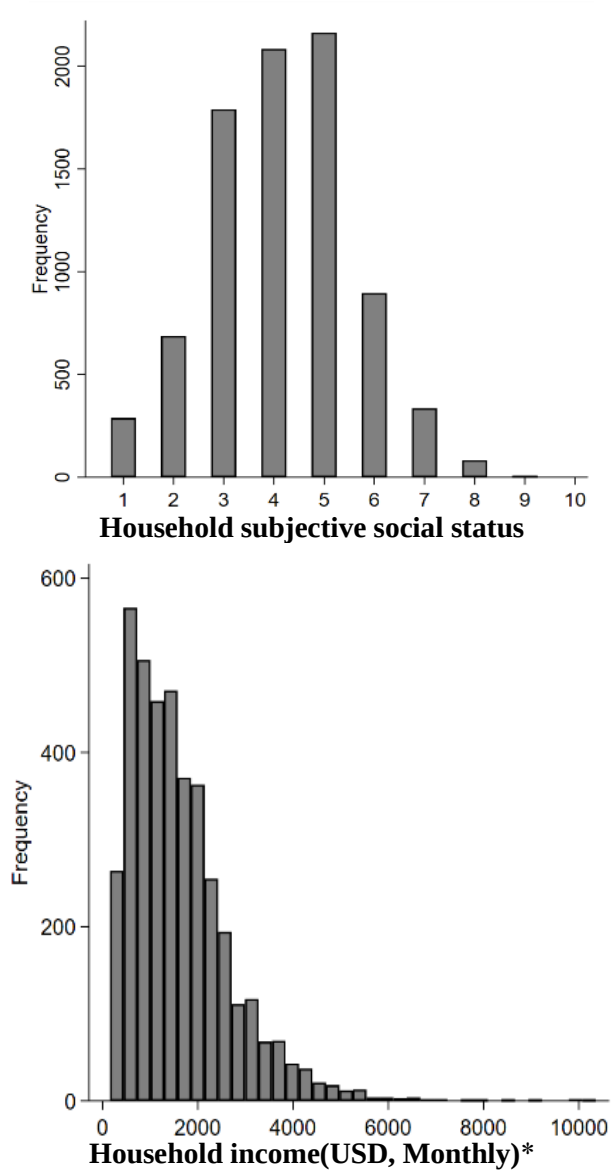


Figure S2-1. Histogram of subjective social status and household income

Note: Household income was equivalized based on the household size.

We divided the sample into three categories based on the quartile of subjective social status (SBJ) and objective household income (OBJ) and used them as a dependent variable in the multinomial logistic regression analysis in Table 2-3; lower perception (i.e., SBJ < OBJ quartile), higher perception (i.e., SBJ > OBJ quartile), and a consistent perception group (i.e., SBJ = OBJ quartile). Each quartile range and membership in the four-by-four groups were described in Figure S2-2.

		Household Subjective Social Status**(SBJ)			
		Q1	Q2	Q3	Q4
Objective Household Income Level* (OBJ)	Q1	1,099	289	167	29
	Q2	829	601	476	165
	Q3	564	670	700	348
	Q4	273	524	820	776

Figure S2-2. Frequencies divided into three groups by quartiles of subjective and objective status

Notes: *Equivalized household income quartiles: Q1($159.3171–$807.8052), Q2($808.1486–$1406.933), Q3($1407.796–$2130.96), Q4 ($2131.708–$10355.73)

**Household SSS quartiles: Q1 (score ≤ 3), Q2 (score = 4), Q3 (score = 5), Q4 (score ≥ 6)

Appendix B. Detailed information on the intra-class correlation coefficients of subjective social status

Table S2-1. Intra-class correlation coefficients of household subjective social status by household composition

Household Composition (family structure)						Response Frequency		Individual SSS values (weighted)		ICC between SSSs by household composition		
Gene-ration Type	H	S	C1	C2	P	# of raters (respon-dents)	# of targets (house-holds)	mean	s. d.	ICCs	95% Conf. Interval	
1 gen.	1	1	0	0	0	2	1,004	4.02	1.63	0.80	0.78	0.82
2 gen.	1	1	1	0	0	2	349	4.54	1.18	0.71	0.66	0.76
	1	1	2	0	0	2	663	4.55	1.27	0.66	0.62	0.70
	1	1	3	0	0	2	125	4.56	1.23	0.62	0.50	0.72
	1	1	0	1	0	3	227	4.20	1.25	0.55	0.48	0.62
	1	1	0	2	0	4	174	4.47	1.28	0.55	0.48	0.62
	1	1	1	1	0	3	166	4.73	1.30	0.59	0.51	0.66
	1	1	1	2	0	4	37	4.34	1.21	0.56	0.41	0.71
	1	0	0	1	0	2	138	3.66	1.43	0.54	0.41	0.65
3 gen.	1	1	1+	0	1	3	52	4.04	1.36	0.52	0.36	0.67
Etc.	.	.	.	.	.	.	1,049			.	.	.
Total			.			.	3,984	4.26	1.42	.	.	.

Abbreviations: H: Head of Household, S: Spouse, C1: Child under 18 years old, C2: Child over 18 years old, P: Parents, 1+: one or more

Notes: We calculated ICC values only where the number of targets for each household type was over 30 (to ensure the reliability for the analyses). ICCs were based on a two-way mixed effect model, measuring the consistency of each single rater.

Appendix C. Post hoc analyses

According to the multinomial regression results (Tables 2-2 and 2-3), family roles and individual socioeconomic status were significantly correlated with household subjective social status. Therefore, we distinguished the characteristics to capture and interpret each effect.

Family factors **.** Marital and parenting states strongly influenced one's SSS. We specified the group of young adults aged 30 to 49 (N = 3,087). This subgroup has a diverse identity as a household member, and they are likely to encounter changes in family members by marriage or giving birth. Therefore, we divided the young adult group across household compositions and family roles and assessed the objective and subjective social status. Table 2S-2 showed that family support obligations lowered SSS, and the presence of a spouse protected it. Couple-only households without dependents reported the highest SSS. Instead, couples from two- or three-generation households with dependents had lower SSS. Furthermore, the SSS was the lowest in divorced families raising children alone without a spouse, indicating that spouses worked with complementary relationships in supporting dependents.

Individual factors. SSS varied depending on individual ages or occupations, independent of household factors. Considering economic activities by age, each subgroup indicated different aspects of objective and subjective social status. Young adults reported relatively high SSS regardless of their economic status. In particular, when comparing the unemployed young adults and the elderly, both rarely contributed to household income.

However, the former perceived themselves somewhat high, and the latter reported the lowest SSS (Table 2S-3).

Table S2-2. Objective and subjective social status by household compositions and family roles among young adults (Age of 30-49)

Subgroup composition			Total	Individual earned income	Household total income	Subjective social status
Generation	**Marital status**	**Family role**	**N**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
1 Gen.	Never/ Formerly married	HH	80	1,868 (1056)	2,045 (1,046)	3.98 (1.30)
1 Gen.	Currently married	HH/ Spouse	104	1,773 (1163)	2,566 (1,162)	4.75 (1.31)
2 Gen.	Formerly married	HH	85	1,369 (1154)	1,390 (1,067)	3.52 (1.24)
2 Gen.	Currently Married	HH	1,064	30,645 (1595)	2,006 (974)	4.54 (1.34)
2 Gen.	Currently Married	Spouse	1,235	680 (986)	2,037 (1,028)	4.57 (1.31)
3 Gen.	Currently Married	HH/ Spouse	140	1,676 (1414)	1,714 (754)	4.28 (1.33)
2 or 3 Gen.	Never/ Currently/ Formerly married	Depen-dents	379	1,363 (966)	2,003 (1051)	4.14 (1.29)
Total (Age:30-49)			3,087	1,225 (1492)	1,904 (1,119)	4.26 (1.42)
P-value				Kruskal-Wallis Rank Sum Test : Pr <0.001	ANOVA (logged data) : Pr <0.001	ANOVA : Pr <0.001

Notes: Weighted means.

Abbreviations: HH=Head of Household

Table S2-3. Objective and subjective social status by age and economic activity.

Economic activities by ages		Total	Individual earned income	Household total income	Subjective social status
Age	**Economic activities**	**N**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Youth (18-39)	Economic activity	1,277	1,887 (1,027)	2,215 (906)	4.52 (1.13)
Youth (18-39)	Unemployed	878	85 (273)	1,843 (852)	4.51 (1.22)
Adult (40-64)	Economic activity	2,949	2,059 (1,628)	2,083 (1,074)	4.32 (1.36)
Adult (40-64)	Unemployed	986	110 (350)	1,921 (1,233)	4.24 (1.44)
Elder (65-)	Economic activity	829	629 (942)	1,176 (1,060)	3.74 (1.68)
Elder (65-)	Unemployed	1,411	31 (305)	1,094 (1,126)	3.49 (1.88)
Total		8,330	1,225 (1,492)	1,904 (1,119)	4.26 (1.42)
P-value			Kruskal-Wallis Rank Sum Test : Pr <0.001	ANOVA (logged data) : Pr <0.001	ANOVA : Pr <0.001

Notes: Weighted means

Chapter 3.
Trajectories of health-related quality of life by change pattern of objective and subjective social status [1]

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Chapter 3.
Trajectories of health-related quality of life by change pattern of objective and subjective social status

3.1. Introduction

Social determinants of health (SDH) tend to be long-term and cumulative in formation and in terms of their effect on health. Therefore, study for SDH is more effectively investigated by longitudinal rather than cross-sectional studies.

3.1.1. Backgrounds

The everyday experience of social class influences chronic perceptions of relative standing, which shape how an individual evaluates the self (Kraus & Park, 2014). In addition, individual SES was formerly determined by the childhood environment or by the parent's SES through generations (Davis-Kean, 2005). Therefore, the effect of social determinants of health can manifest over decades, resulting from chronic exposure to socio-environmental stressors through a complex and long causal pathway (Braveman & Gottlieb, 2014). Furthermore, the strength of social determinants of health may change when evaluated longitudinally (Wilkinson, 1992).

Even though SSS is a good measure of chronic social experiences, few SSS studies have been of population-based longitudinal designs (Hoebel

& Lampert, 2020). A group-based trajectory modeling method (i.e., GBTM) can identify developmental trajectories of the variables of interest over time (Nagin & Odgers, 2010) and provide longitudinal evidence for causal inferences among SSS, SES, and health.

Because social determinants interact, an innovative approach is needed to model complicated relationships (Braveman & Gottlieb, 2014). Objective and subjective status cannot be divided because SES is a determinant of SSS (Singh-Manoux et al., 2003) and SSS can be used as an indicator variable of SES (Oakes & Rossi, 2003). SSS and SES indicators were formerly entered simultaneously into a multiple regression model as the independent variable and covariate, respectively, to account for their interaction (Adler et al., 2000; S. Cohen et al., 2008; Demakakos et al., 2018; Demakakos et al., 2008; Goodman et al., 2003; Operario et al., 2004; Singh-Manoux et al., 2003; Singh-Manoux et al., 2005). Class discrepancy or status inconsistency can be applied to examine how a combination of factors influence health. A prior work compared the subjective class identification (e.g., which class people think they belong to [lower, working, middle, or upper class]) to the actual SES (Hodge & Treiman, 1968; Hout, 2008). Macleod et al. (2005) investigated contradictory class locations and how they affect mortality and morbidity (Macleod et al., 2005). Recently, status inconsistency using a scale of self-anchoring at the 10-rung social ladder, rather than class identification, has been applied in health research (Zang & Bardo, 2019).

SSS has a direct affect on health outcomes, and thus acts as a strong predictor of morbidity and mortality. It influences one's thoughts, emotions, behavior, and thereby mental and physical health through social-psychological, psycho-neurobiological, and other combined pathways (Hoebel & Lampert, 2020). Compared to conventional SES measures, SSS is a strong predictor of health status and changes in health over time (Adler et al., 2000; Singh-Manoux et al., 2005). These data indicate that SSS may act on health via pathways that are independent from those of objective SES measures.

However, approaches using subjective measures have been criticized for ambiguity and ambivalence. Unlike those of very high or low SES, status inconsistency often appears in the middle class, who objectively have mixed and complicated attributes. Depending on how survey questions are organized, people give double-sided answers, and those near class borders have an ambiguous subjective class (Hout, 2008). By contrast, group-based multi-trajectory modeling can identify trajectory groups across multiple indicators and detect interrelationships of relevant indicators, revealing combined change patterns (Nagin et al., 2018).

3.1.2. Study design and objectives

To our knowledge, few studies have evaluated the longitudinal effect of combined objective and subjective social status on health inequalities. Therefore, we investigated the longitudinal relationship between changes in

multiple social status indicators and changes in health-related quality of life (HRQoL). We verified several SES measures to identify determinants of changes in HRQoL over time. The research hypotheses were as follows.

(1) The change pattern of HRQoL over time can be identified as distinct trajectories that include the disadvantaged.

(2) New socioeconomic groups can be identified by tracing the combination of objective and subjective social status over time.

(3) The underlying SES trajectory determines the subsequent pattern of changes in health.

(4) Subjective or relative measures of SES predict changes in health more accurately than objective SES measures. Furthermore, the combined longitudinal patterns of objective and subjective social status provide a better explanation for changes in health over time than cross-sectional measures.

3.2. Methods

3.2.1. Data and study population

We used the Korea Health Panel Survey (KHPS) data from 2009 to 2018, which is conducted annually by the Korea Institute for Health and Social Affairs (KIHASA) and the National Health Insurance Service (NHIS) consortium. This survey is nationally representative of South Korea, being based on Population and Housing Census data from 16 districts nationwide. It investigates medical usage, health behaviors, outcomes, and socioeconomic characteristics. Trained surveyors collect the data during a home visit every February to June (KIHASA & NHIS). The raw data are accessible to all and may be obtained by submitting a requisition form via the official KHPS website (www.khp.re.kr:444/).

We appended nine waves of the KHPS (2009–2018) by individual identification key variable. There was a total of 26,507 respondents, including those who were underage. We excluded the data of the underage respondents because they did not answer health-related domains. There were 21,497adults over 18 years of age. The dataset was balanced and comprised individuals who responded to all nine waves of the survey. These 7,432 individuals were included in the analysis.

3.2.2. Measures

To assess ***HRQoL***, we used the Euro-QoL-5 Dimension (*i.e.*, EQ-5D) indicators. The EQ-5D questionnaire comprises five health dimensions—mobility, ability to self-care, ability to undertake usual activities, pain and discomfort, and anxiety and depression. Each response had three levels—no problem, some problems, and extreme problems. The EQ-5D indicators were summarized and scored using weights based on South Korean studies. The estimation equation is described elsewhere (Lee et al., 2009).

Household income was the sum of the labor income of all household members and capital income for the last year and was equivalized by the square root of the number of household members (Organisation for Economic Co-operation and Development[OECD], 2012). This equivalent income had several extremes, up to more than sevenfold the interquartile range. These values showed substantial decreases or increases compared to the next year in repeated observations. We, therefore, regard these extremes (30 households) as reporting errors and treated them as missing values.

To define ***relative income***, we sorted equivalized income of a household unit in order and computed its rank using the Weibull formula. This income rank, calculated at the household level, was assigned to each household member.

To measure ***subjective social status***, the survey uses the same image as the youth version of the MacArthur scale. It depicts a 10-rung ladder picture of the structure of society, i.e., best off at the top and worst off at the

bottom. Participants are asked where they think their family would be on the ladder (Goodman et al., 2001). The comparison reference is overall society, and the evaluated target is the familial situation rather than their own as individuals.

We composed a measure of ***status inconsistency***—the combined household income quartiles (SES quartile) and SSS quartiles of 2009. By comparing quartiles, we identified groups with a consistent status (*i.e.*, SSS = SES) and inconsistent status (*i.e.*, SSS > SES or SSS < SES).

The ***baseline covariates*** were those in 2009. They comprised sex, age, years of education, occupational type, health behaviors (*i.e.*, smoking, risky drinking, obesity, sleeping time), and household environment (*i.e.*, family role, household composition, house type, home-ownership). Also, we considered comorbid conditions by calculating the Charlson Comorbidity Index (CCI) according to Quan's ICD-10 classification with updated weights (Quan et al., 2011; Quan et al., 2005).

3.2.3. Statistical analysis

To identify clusters of trajectories, we applied group-based trajectory modeling (*i.e.*, GBTM), a form of finite mixture modeling (Nagin & Odgers, 2010). Change patterns in HRQoL were analyzed for the periods 2009 to 2018 and 2013 to 2018 using GBTM. The combined change patterns of SES and SSS from 2009 to 2013 (*i.e.*, multi-SES trajectories) were evaluated by group-based multi-trajectory modeling (Nagin et al., 2018). A censored normal

distribution was assumed for each analysis because HRQoL, SES, and SSS are continuous scales censored by minimum or maximum. We allowed different standard deviations for the trajectory groups. The criteria for the optimal number of groups and polynomial types for each group were based on entropy, the Bayesian information criterion, and others (Nagin, 2009; Van Der Nest et al., 2020), as detailed in the Appendix.

Next, multinomial regression was used to identify determinants of the probability of a health trajectory. We repeated multinomial regressions on health trajectories by changing the SES measure of interest, with the same set of covariates. That is, household income, relative income, SSS, status inconsistency, and multi-SES trajectory indicators were used to compare the probabilities of the various health trajectories by indicator type.

Data were analyzed using STATA version 15.1 with the plugin for GBTM (Jones & Nagin, 2012).

3.3. Results

Health status as assessed by the five dimensions of the EQ-5D decreased slightly over time, where the EQ-5D summation index (*i.e.*, HRQoL) plateaued, being 0.945 points in 2009 and 0.931 points in 2018 (Table 1).

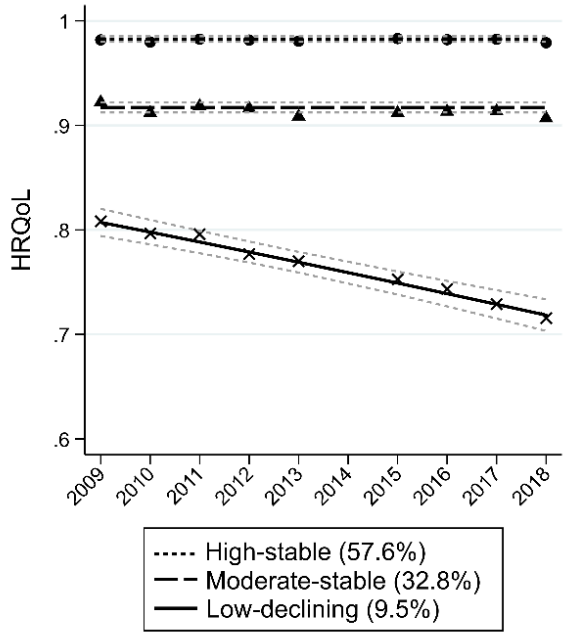
Figure 3-1 shows the HRQoL trajectories from 2009–2018 and 2013–2018. The criteria for optimal model selection are provided in Appendices D and E. Three health trajectories composed of intercept and linear terms were selected as the final model. The trajectory patterns were of similar shapes but had different group membership rates. From 2009 to 2018, the majority (57.6%) were classified as near maximum and stable, 32.8% were moderate (> 0.9 points), and 9.5% had a low status in 2009 that decreased over time. From 2013 to 2018, less participants (4.2%) were classified as having a low-declining health trajectory than during 2009 to 2018.

Table 3-1. Distribution of health-related quality of life from 2009 to 2018

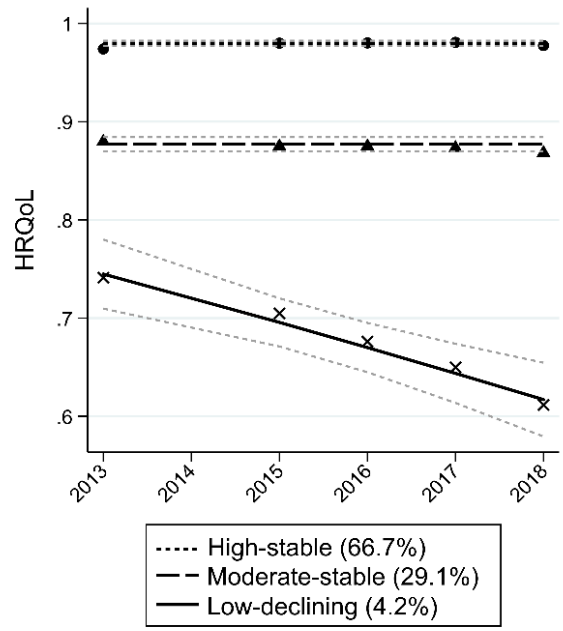
	2009	2010	2011	2012	2013	2015	2016	2017	2018
	N = 6,979	N = 7,125	N = 7,122	N = 7,128	N = 7,144	N = 7,254	N = 7,245	N = 7,276	N = 7,249
EQ-5D indicators									
Mobility (%)	87.9	89.1	88.5	87.9	86.1	85.9	86.1	85.4	84.5
Self-Care (%)	98.5	97.7	97.5	96.3	95.5	95.4	95.3	94.9	93.9
Usual Activities (%)	93.1	92.5	93.3	92.3	90.8	90.8	90.5	89.9	88.6
Pain & Discomfort (%)	68.6	67.1	69.5	68.0	66.7	67.7	68.1	66.7	65.6
Anxiety & Depression (%)	86.9	83.5	84.7	85.1	85.4	86.3	84.3	87.9	86.4
HRQoL (EQ-5D index)									
Mean	0.945	0.940	0.944	0.940	0.937	0.938	0.937	0.936	0.931
SD	0.090	0.098	0.096	0.100	0.103	0.105	0.109	0.112	0.119

*Total N =7,432

Note: Possible responses were: No problem, some problems, and extreme problems. Values are the proportions of 'No problem' responses. The EQ-5D questionnaires were excluded in the 2014 survey.



(A)



(B)

Figure 3-1. Trajectories of health-related quality of life from (A) 2009 to 2018 and (B) 2013 to 2018

Note: EQ-5D indicators were not collected in the 2014 survey. We used a balanced panel for 2009–2018 containing 7,432 individuals.

Table 3-2 shows the likelihoods of the three HRQoL trajectories in 2013 to 2018 according to baseline characteristics in 2009. Those who were female, older, or less educated were more likely to be in the low-declining or moderate-stable health trajectory group than the maximum-stable trajectory group. Compared to the head of household, the parents of the head of household were at a 2.22-fold greater risk of having a low-declining health trajectory than a maximum-stable health trajectory. An increase of one unit in SSS or household income (scaled as log(income)) reduced the risk of a low-declining health trajectory by 0.74- and 0.71-fold, respectively. Living in an apartment was related to a maximum-stable health trajectory. Obesity, insufficient sleep, and chronic diseases were linked to a low-declining health trajectory.

Table 3-2. Multinomial logistic regression for the 2013 to 2018 health-related quality of life trajectories (baseline, 2009)

(Baseline: 2009 year)	**Low-declining vs High-stable**		**Moderate-stable vs High-stable**	
	RRR(95%CI)	P-value	RRR(95%CI)	P-value
sex				
Male	1.00 (Ref)		1.00 (Ref)	
Female	1.98 (1.02-3.85)	0.045	2.33 (1.75-3.11)	<0.001
Age	1.13 (1.11-1.16)	<0.001	1.07 (1.06-1.08)	<0.001
Education year	0.94 (0.91-0.97)	<0.001	0.96 (0.94-0.97)	<0.001
Occupation				
Administrator, Expert	1.00 (Ref)		1.00 (Ref)	
Officer, Service, Salesman	0.85 (0.18-4)	0.837	1.03 (0.76-1.4)	0.825
Agriculture, Fisheries	1.58 (0.35-7.05)	0.548	1.81 (1.3-2.51)	<0.001
Machinery operator	0.92 (0.18-4.71)	0.915	1.04 (0.75-1.45)	0.798
Manual worker	1.05 (0.23-4.8)	0.949	1.28 (0.93-1.76)	0.136
Unemployed	2.35 (0.55-10)	0.249	1.30 (0.98-1.73)	0.073
Ln(Household income) (USD, monthly)	0.71 (0.56-0.89)	0.003	0.79 (0.71-0.87)	<0.001
Subjective social status	0.74 (0.66-0.83)	<0.001	0.87 (0.83-0.91)	<0.001
Family role				
Head of Household	1.00 (Ref)		1.00 (Ref)	
Spouse	1.05 (0.53-2.05)	0.893	0.84 (0.63-1.11)	0.229
Children	4.17 (1.08-16.16)	0.039	1.13 (0.76-1.68)	0.549
Grand Parents	2.22 (0.9-5.49)	0.085	1.58 (0.91-2.72)	0.103
Household-composition				
Single	1.00 (Ref)		1.00 (Ref)	
Couple	0.85 (0.41-1.76)	0.657	0.90 (0.64-1.28)	0.562
2Generation	1.32 (0.64-2.7)	0.450	1.19 (0.85-1.67)	0.321
3Generation	1.62 (0.64-4.14)	0.311	1.21 (0.79-1.83)	0.379
House type				
House	1.00 (Ref)		1.00 (Ref)	
Apartment	0.57 (0.38-0.85)	0.006	0.87 (0.75-1)	0.054
Home-ownership				

Owner occupied	1.00 (Ref)		1.00 (Ref)	
Chartered	1.69 (1.06-2.71)	0.029	0.98 (0.8-1.21)	0.864
Monthly	2.39 (1.42-4.03)	0.001	1.22 (0.95-1.57)	0.115
Free-offered	1.14 (0.6-2.16)	0.693	0.87 (0.62-1.23)	0.439
Smoking prevalence: Yes	1.02 (0.63-1.65)	0.943	1.11 (0.91-1.35)	0.285
Risky drinking: Yes	1.15 (0.58-2.27)	0.689	1.12 (0.89-1.41)	0.335
Obesity				
Normal (18.5-23.0 BMI)	1.00 (Ref)		1.00 (Ref)	
Underweight (<18.5 BMI)	0.85 (0.42-1.74)	0.658	0.92 (0.64-1.33)	0.662
Overweight (23-25 BMI)	0.65 (0.44-0.97)	0.036	1.18 (1.01-1.38)	0.037
Obesity & Extreme obesity	1.18 (0.82-1.71)	0.368	1.60 (1.37-1.88)	<0.001
Sleeping time	0.88 (0.79-0.98)	0.022	0.94 (0.9-0.99)	0.029
Charlson Comorbidity Index	1.50 (1.3-1.74)	<0.001	1.16 (1.06-1.27)	0.001
Intercept	0.00 (0-0.02)	<0.001	0.11 (0.04-0.31)	<0.001
N				6285
AIC				7395.693
BIC				7773.465
Log likelihood				-3641.847

Notes: Obesity criteria were according to the Asia-Pacific standards of the World Health Organization guidelines, which defined obesity as a body mass index of more than 25 kg/m2 (WorldHealthOrganization, 2000).

Figure 3-2 shows the combined change pattern of objective and subjective social status from 2009 to 2013. The selection biases related to the optimal number of groups and the polynomial type of the trajectory are described in Appendix F. Four multi-SES trajectories were derived. Income tended to increase but had an uneven slope according to baseline income level. The higher the household income in 2009, the steeper the slope of income growth. SSS was stratified in each trajectory and maintained that level with little variation. We named the multi-SES trajectories subsistence level (16.4%), relative deprivation (30.1%), upper-middle (36.0%), and privileged (17.7%) in order (Appendix 3-G).

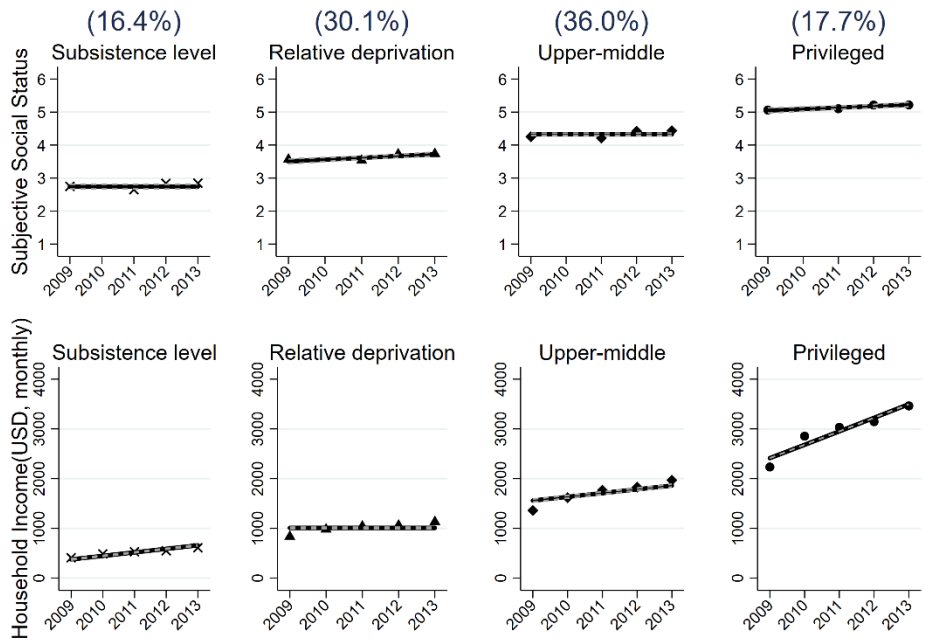


Figure 3-2. Group-based multi-trajectory modeling of longitudinal household income and subjective social status

***Notes*:** Household income was calculated by summing the incomes and assets of household members and equivalized by household size. The degree of a polynomial for SSS was 0 (intercept), 1 (linear), 0 (intercept), and 1 (intercept) in order, and all parameters were significant. The degree of a polynomial for household income was 1 (linear), 0 (intercept), 1 (linear), and 2 (quadratic) in order, and each was significant except the last term of a quadratic function.

Table 3-3 shows the group membership probabilities of multi-SES trajectories from 2009 to 2013 and health trajectories from 2013 to 2018. Individuals of subsistence level multi-SES were more likely to have a moderate-stable (0.539 probability) health trajectory. Among those of relative-deprivation multi-SES, the majority (62.4%) had a high-stable health trajectory. The probability of high-stable health trajectory increased with multi-SES status. The probability distribution was similar for individuals of upper-middle and privileged multi-SES.

Table 3-3. Average posterior probabilities of HRQoL and multi-SES trajectory group membership

		HRQoL trajectory (2013-2018)		
		Low-declining (N = 269)	Moderate-stable (N = 2,312)	High-stable (N = 4,851)
Multi-SES trajectory (in 2009-13) of SSS & Income				
Subsistence level	(N = 1,224)	0.139	0.539	0.322
Relative deprivation	(N = 2,213)	0.039	0.337	0.624
Upper-middle	(N = 2,707)	0.015	0.202	0.783
Privileged	(N = 1,288)	0.011	0.165	0.824
Total	(N = 7,432)	0.042	0.291	0.667

Notes: Values are probabilities of membership of four multi-SES trajectories (as exposure) by three HRQoL trajectories. Multi-SES trajectories are shown in Figure 2. Subsistence-level = low SSS and the lowest income; relative-deprivation = moderate SSS and low-stable income; upper-middle = moderate SSS and moderate-increasing income; privileged = high SSS and high-increasing income

Table 3-4 shows the strengths of the associations between SES indicators and health trajectories as determined by multinomial logistic regression analyses. The model using relative income had greater fitness (Model 3; BIC 7795) than that using objective household income (Model 1; BIC 7802) or subjective social status (Model 2; BIC 7867). After combining the objective and subjective indicators in the model, SSS remained strong and highly significant (Model 4). The status inconsistency measure (Model 5) did not show statistical significance with the prospective health trajectories. The multi-SES trajectory (Model 6), which indicates the combined change patterns of SES and SSS, showed the significant associations with the health trajectories. Compared to the multi-SES of the privileged group, the multi-SES of the subsistence level and relative deprivation groups had 5.92- and 2.36-fold higher risks of a low-declining health trajectory compared to a maximum-stable health trajectory. There were no significant differences in multi-SES between the upper-middle and privileged groups.

Table 3- 4. Associations between baseline socioeconomic measures and 2013 to 2018 HRQoL trajectory group membership

	HRQoL trajectory (in 2013-2018)						
	Low declining vs. High-stable			Moderate stable vs. High-stable			Model fit statistics
	RRR	(95%CI)	P-value	RRR	(95%CI)	P-value	
Model 1 (in 2009)							
Ln(Household income)	0.59	(0.48-0.73)	< 0.001	0.73	(0.66-0.8)	< 0.001	N = 6,286
							AIC = 7438.7
							BIC = 7802.9
Model 2 (in 2009)							
Subjective social status	0.71	(0.64-0.79)	< 0.001	0.85	(0.81-0.89)	< 0.001	N = 6,355
							AIC = 7502.5
							BIC = 7867.4
Model 3 (in 2009)							
Income rank	0.14	(0.07-0.29)	< 0.001	0.37	(0.29-0.49)	< 0.001	N = 6,293
							AIC = 7430.6
							BIC = 7795.0
Model 4 (in 2009)							
Ln(Household income)	0.71	(0.56-0.89)	0.003	0.79	(0.71-0.87)	< 0.001	N = 6,285
Subjective social status	0.74	(0.66-0.83)	< 0.001	0.87	(0.83-0.91)	< 0.001	AIC = 7395.7
							BIC = 7773.5
Model 5 (in 2009)							
Sbj>Obj	0.70	(0.48-1.01)	0.059	0.94	(0.8-1.11)	0.494	N = 6,292
Sbj<Obj	0.94	(0.64-1.38)	0.751	0.97	(0.83-1.13)	0.704	AIC = 7499.3
Sbj=Obj	1.00	(Ref)		1.00	(Ref)		BIC = 7877.1
Model 6 (in 2009-13)							
Subsistence level	5.92	(2.80-12.48)	< 0.001	2.76	(2.14-3.56)	< 0.001	N = 6,356
Relative deprivation	2.36	(1.15-4.83)	0.019	1.82	(1.47-2.24)	< 0.001	AIC = 7473.3
Upper-middle	1.20	(0.56-2.55)	0.642	1.14	(0.93-1.39)	0.205	BIC = 7865.3
Privileged	1.00	(Ref)		1.00	(Ref)		

***Notes**:* Each model is adjusted for the same set of covariates: age, sex, years of education, occupation, household environment (*e.g.*, family role, household composition, house type, homeownership), health behaviors (*e.g.*, smoking, risky drinking, obesity, and sleeping time), and chronic health conditions (*e.g.*, Charlson comorbidity index).

3.4. Discussion

Long-term and cumulative social experiences influence an individual's objective and subjective social status. We found that growing income inequality exacerbates health disparities, leading to better health for the better off. We identified a prolonged HRQoL pattern of low and declining over time, which was associated with underlying SES. By tracing the combined objective and subjective social status longitudinally, four multi-SES trajectories were derived. The longitudinal multi-SES indicator outperforms to predict the changing pattern of the HRQoL. That is, Social determinants of health are more effectively investigated by longitudinal rather than cross-sectional studies.

3.4.1. Health trajectories

The HRQoL of 13.7% of individuals deteriorated during the period 2013 to 2017, whereas that of the majority was unchanged. Recently, rather than extension of life duration, the quality of life has been a focus in that most countries have reached at least a reasonable degree of life expectancy, even in developing countries (Roser & Ortiz-Ospina, 2013) 2016). Given that South Korea was recently classified as a developed country (United-Nations-Conference-on-Trade-and-Development, 2021), the pattern of low and declining HRQoL over time suggests that the underprivileged are excluded from economic development and the social safety net. Therefore, those with

a longitudinally declining HRQoL trajectory should be targeted by health policies.

Furthermore, the declining HRQoL group was strongly associated with underlying household wealth, human capital, and SSS in 2009, even accounting for underlying health behaviors and chronic diseases. These results support the social causation hypothesis rather than the social drift hypothesis and emphasize life-course perspectives on health.

3.4.2. Combined objective and subjective social status trajectories

The multi group-based trajectory model of objective and subjective social status in the period 2009 to 2013 indicated interactions between the two characteristics. The rich earn more money, but regardless of income growth, people have a fixed perception of their social position over time; this has several possible interpretations.

SSS is a valid and reliable indicator of cumulative socioeconomic circumstances. In previous studies of test-retest reliability, SSS showed good reliability within an interval of 14 days (Giatti et al., 2012) and adequate reliability for 6 months (Operario et al., 2004). Furthermore, the developmental trajectories of SSS are consistent during the transition from adolescence to adulthood (Goodman et al., 2015). This reproducibility may be because SSS is a cognitive averaging of the standard markers of SES (Adler et al., 2000; Singh-Manoux et al., 2003). In particular, from the life-course perspective, SSS adequately summarizes the socioeconomic

circumstances in different periods of life (Singh-Manoux et al., 2005). SSS provides an aggregate estimate of one's social experiences over a lifetime, which is problematic using conventional SES indicators (Wright & Steptoe, 2005). That is, the comprehensive and summative nature of SSS could render the pattern of SSS trajectories consistent and stable when the income patterns tend to increase.

An alternative explanation is based on the psychological mechanism by which people perceive their status in the social hierarchy. The formation of SSS follows social comparison processes (Kraus et al., 2011; McLeod, 2013b). People set themselves on the social ladder by comparison with others—within society overall or a group to whom they feel they belong. Therefore, the reference group set is crucial for determining SSS (Wolff et al., 2010). According to our results, a growing income difference reduces the opportunity for economic mobility, leading to a fragmented society. Such a rigid society is likely to have consistent comparison standards and little variation within and between reference groups.

These combined trajectory patterns are likely to be a consequence of social structure, in which wealth inequality is embedded. The wealth inequalities of the pro-rich society in this sample may contribute to the shape of the SSS trajectories. Indeed, SSS is more strongly associated with wealth than with education or occupation type (Adler & Stewart, 2007; Demakakos et al., 2008). When reporting SSS, people take into account prestigious elements that provide more opportunities (Singh-Manoux et al., 2005). In sum,

the social structure pins down the SSS levels, restricting economic benefit largely to the privileged. Socioeconomic grouping depicts how an unequal society determines an individual's objective and subjective social status.

3.4.3. Association between health and SES trajectories

We also examined the association between multi-SES trajectories and temporally distinct health trajectories. The increased income inequalities during the period 2009 to 2013 affected health outcomes during 2013 to 2017 and damaged health equity. That is, low and declining HRQoL may be a by-product of stagnant inequalities and perception of a low social position. The rich enjoy the output of economic growth, earning more money, and have better health as a consequence.

This result is in contrast to that of Nobles et al. (2013), who reported that declines in health induce declines in SSS, and there are bi-directional effects on health and SSS (Nobles et al., 2013). Given that they used data in 2000 and 2007 from a developing country (Indonesia), this indicates the importance of cultural and economic differences between developed and developing countries. The psychological mechanism—comprising social class, social value, and social cognitive tendencies that influence SSS—varies across cultures and socio-political contexts (Michael W. Kraus et al., 2012). The prestigious elements inherent to SSS may elevate health trajectories in developed countries, but they are not active in developing countries.

Interestingly, the positive effect of the combined SES and SSS trajectories did not enhance the HRQoL for those with middle or higher incomes. Indeed, the subsistence-level and relative-deprivation trajectory groups were associated with a low-declining health trajectory. However, the upper-middle and privileged trajectory groups had similar probabilities of having enhanced health trajectories. These results are in agreement with those of Braveman and Gottlieb (2014), who suggested a positive association between social factors and health at thresholds above which greater income or other SES indicators no longer improve health (Braveman & Gottlieb, 2014).

3.4.4. Relative importance of the measures

We addressed a variety of SES indicators. The longitudinal combined pattern of SES and SSS had a greater effect on health than fixed-time status. Moreover, relative income and SSS had a consistent and robust association with health trajectories.

These findings are in accord with prior reports on the health effect of relative or subjective SES. Relative income is more important for morbidity and mortality than is the absolute level of SES (Wilkinson, 2002). It is not absolute income that affects general life satisfaction, but a higher rank position of income (Boyce et al., 2010). Anderson et al. (2012) defined sociometric status by local comparisons with others (friends, family, or coworkers), and concluded that the measure matters more to an individual's

subjective well-being than SES (Anderson et al., 2012). Compared to income or education, SSS is a more consistent and robust indicator of psychological functioning and physiological health (Adler et al., 2000; Wright & Steptoe, 2005) and a better predictor of changes in health over time (Singh-Manoux et al., 2005). In addition, the combined SES and SSS change patterns over time showed a stronger association with health outcomes than did the cross-sectional SES measures.

3.4.5. Strengths of this study

This study has three improved methodological aspects. First, this research overcomes the skewness and ceiling effect issues of the EQ-5D index, for which latent class mixture models are typically applied (Alava et al., 2012). We applied a family of latent class growth analysis to the HRQoL.

Second, GBTM has efficient grouping and few uncertainties, being a person-centered approach that classifies individuals into groups with little within-group variation but considerable between-group variation (Jung & Wickrama, 2008). Furthermore, multi-GBTM enabled investigation of the compact and transparent interrelationship between SES and SSS. This is an improvement over conventional approaches relying on arbitrary decisions that define inequalities by calculating, for example, the Gini index or top 1% share of income.

Third, the dependent and independent variables were separated temporally using longitudinal datasets. A cross-sectional survey based on

self-reporting is subject to common method variance. When the self-report of the internal state is collected simultaneously with the previous status using the same instrument, outcomes and predictors are vulnerable to inflation of correlation (Lindell & Whitney, 2001).

3.4.6. Limitations

This study also had several limitations. The youth version of the MacArthur Scale was used to measure subjective social status, which assesses one's familial placement. This hampers comparison with studies using the adult version of the scale, which evaluates one's own position.

In addition, SSS was measured at the individual level, whereas household income was measured at the household level. This income measure does not fully reflect the distribution of income within a household, or differences in resource availability among household members.

These measure-related limitations notwithstanding, it is to some degree reasonable that we combined household income and perception of family status in the analysis of multi-group-based trajectories.

3.5. Supplementary data

Appendix A. Sensitivity analyses for missing using MCAR and MAR test

We tested for panel attrition and missingness at random in the dataset. To guarantee that the results were not biased by missingness, we tested for panel attrition and applied Little's missing completely at random (MCAR) test. The results indicated that each wave of panel data was, at least, missing at random (MAR). Accordingly, we used balanced panel data in the analysis.

We set our study eligibility as the respondents from the first-period original panel because one of the primary interest variables—subjective social status—was included only in the 2009, 2011, 2012, and 2013 KHPS. Therefore, our study population comprised 13,821 individuals (included a balanced subset of 7,432 individuals). Missing panel data occurred due to non-completion of the survey in certain waves and non-responses to specific sensitive questions. Therefore, we tested for panel attrition bias by analyzing the complete set of unbalanced panel data. Furthermore, we assessed the randomness of the missing data [i.e., missing completely at random (MCAR) or missing at random (MAR)] within each wave. The detailed results are as follows.

Firstly, we compared the means of variables of interest by year between the entire unbalanced (N = 13,821) and balanced panel (N = 7,432) datasets. This showed small differences, with overlapping 95% confidence intervals (see Figure S3-1).

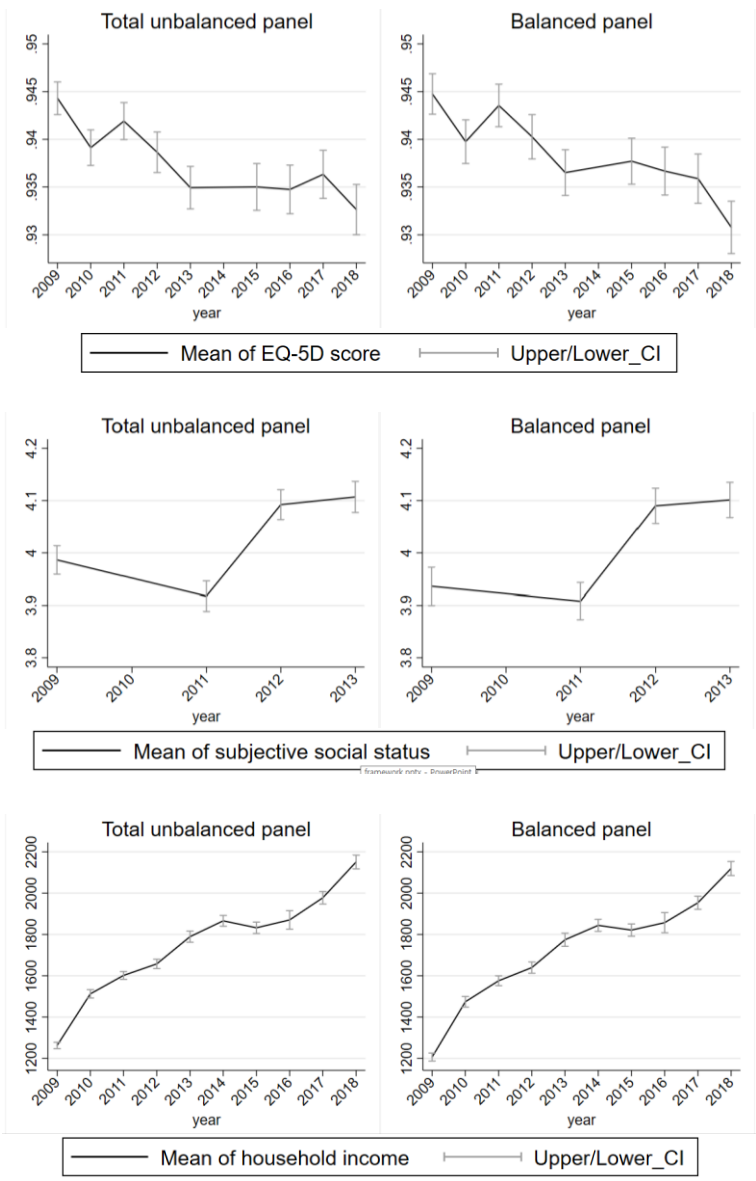


Figure S3-1. Distribution of variables of interest during 2009-2018 across unbalanced and balanced panel data

Secondly, we applied a fixed-effect model to the overall unbalanced panel dataset. We tested for the significance of a term that we refer to here as "time period just before attrition for each individual". Under the null hypothesis, the error term is not correlated with attrition, and the effect of the previous time period should not be significant (Wooldridge, 2010). The non-significance of the result ($p > 0.05$) indicated that there was no specific pattern in the panel attrition, supporting MCAR (see Table S3-1).

Table S3-1. Fixed-effect (within) regression on HRQoL to test panel attrition using unbalanced panel

	Coef.	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
Age	0.004	0.004	1.20	0.229	-0.003	0.011
Household income	0.000	0.001	0.28	0.776	-0.002	0.003
Subjective social status	0.002	0.000	4.02	0.000	0.001	0.003
r.F1. *	**0.007**	**0.004**	**1.88**	**0.060**	**0.000**	**0.014**
_cons	0.676	0.201	3.37	0.001	0.283	1.070

*This r-term indicates panel attrition pattern.

Notes: Standard error was adjusted for the individual clusters.

Thirdly, we performed Little's MCAR test on the variables of interest (Li, 2013; Little, 1995). Except for the 2009 and 2015 waves, all waves were characterized by MCAR (see Table S3-2). For the 2009 and 2015 waves, we conducted Little's covariate-dependent missingness (CDM) test, which is a special case of MAR. We included age, sex, years of education, and occupation as covariates. This test shows whether missing data for variables of interest (household income, SSS, and HRQoL) are dependent or independent of missing data for observed covariates (Fitzmaurice et al., 2008; Li, 2013). The non-significant results for each wave implied that the missing data can be considered to be MAR (see Table S3-3).

In summary, the overall results indicated that the panel attrition data can be removed without causing bias, based on the MAR assumption. These processes are described only briefly in the Method section due to the word limit.

Table S3-2. Little's MCAR test on each panel wave (2009-2018)

Data structure by missing-value pattern				Year									
	Income	**HRQoL**	**SSS**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Type A	1	1	1	12,477		10,811	9,985	9,377					
	1	.	.	1,188		723	660	542					
	.	1	1	123		5	10	5					
	1	1	.	6		-	1	5					
	1	.	1	1		-	-	2					
	.	.	.	26*		2282*	3165*	3890*					
Type B	1	1	NA		11,477					8,424	8,009	7,904	7,715
	1	.	NA		814					294	264	212	210
	.	1	NA		24					-	-	-	-
	.	.	NA		1506*					5103*	5548*	5705*	5,896*
Type C	1	NA	NA						9,270				
	.	NA	NA						4551*				
Little's MCAR test													
Number of observation				13,795	12,315	11,539	10,656	9,931	-	8,718	8,273	8,116	7,925
Chi-square distance				18.17	2.17	4.97	5.80	7.12	-	4.98	0.00	0.13	0.75
Degrees of freedom				7	2	3	5	7	-	1	1	1	1
Prob > chi-square				**0.011**	**0.338**	**0.174**	**0.326**	**0.416**	**-**	**0.026**	**0.965**	**0.714**	**0.386**

Note: *Observations omitted from Expectation-maximization estimation because of all imputation variables.

Table S3-3. Little's CDM test for 2009 and 2015 waves

	Little's CDM test	
	2009 wave	**2015 wave**
Number of observations	13,761	8,711
Chi-square distance	50.8	14.1
Degrees of freedom	63	9
Prob > chi-square	**0.866**	**0.117**

Appendix B. Selection criteria for the optimal trajectory model

When determining the optimal number of groups in GBTM, we followed the criteria of Nagin (2009) and Van Der Nest and colleagues (2020). At least 5% of the study population should be classified in each trajectory. Entropy, which refers to the model classification quality, is close to 1.0 point. Log-likelihood statistics such as the Bayesian information criterion (BIC) and Akaike information criterion (AIC) should have smaller values than other measures. The average posterior probability of assignment is greater than 0.7 for all classes.

To select the best order of polynomial terms (*e.g.*, intercept, linear, quadratic, or cubic type) for each trajectory, it is recommended to refer to prior reports and perform a visual inspection. We first assumed a polynomial order large enough (i.e., cubic polynomial type) within the range that models can be convergence. Next, we discarded the nonsignificant polynomial terms one by one, from highest to lowest significance. The process of pruning polynomial terms was considered in conjunction with the BIC criteria.

Table S3-4. Summary of model fit statistics by the 2009 to 2018 HRQoL trajectory model

Trajectory structure		**Model convergence**		**Model fit statistics**			
Number of groups	Order of polynomial terms	Proportion of the smallest group (%)	Variance matrix for parameter estimates	Entropy	BIC (N = 7,425)	AIC	Log Likelihood
1	3	100.0	error	.	- 34,072	- 34,055	- 34,050
2	3,3	31.0	error	0.896	- 19,804	- 19,769	- 19,759
3	3,3,3	15.2	error	0.811	- 16,936	- 16,884	- 16,869
4	3,3,3,3	10.7	error	0.703	- 16,144	- 16,074	- 16,054
5	3,3,3,3,3	9.0	error	0.610	- 15,792	- 15,705	- 15,680
3*	**1,0,0**	**9.5**	**.**	**0.820**	**-12,295**	**-12,264**	**-12,255**

***** We selected this model based on the model fit statistics, in particular higher entropy, including a visual inspection.

Note: The optimal number of trajectory groups was three; use of more would not capture additional trajectories. Models not in the table have a non-symmetrical or highly singular variance matrix.

Table S3-5. Summary of model fit statistics by the 2013 to 2018 HRQoL trajectory model

Trajectory structure		**Model convergence**			**Model fit statistics**		
Number of groups	Order of polynomial terms	Proportion of the smallest group (%)	Variance matrix for parameter estimates	Entropy	BIC (N = 7,416)	AIC	Log Likelihood
1	3	100.0	error	.	- 17,722	- 17,704	- 17,699
2	3,3	35	error	0.815	- 10,680	- 10,642	- 10,631
3	3,3,3	19.5	error	0.685	- 9,525	- 9,466	- 9,449
4	3,3,3,3	14.6	error	0.617	- 9,068	- 8,988	- 8,965
5	3,3,3,3,3	10.8	error	0.508	- 8,853	- 8,752	- 8,723
3*	**1,0,0**	**4.2**	**.**	**0.837**	**-7,627**	**-7,595**	**-7,586**

***** We selected this model because the smallest group size is more than 5%, considering a visual inspection together.

Note: The optimal number of trajectory groups was three; more would not capture additional trajectories. Models not in the table have a non-symmetrical or highly singular variance matrix.

Table S3-6. Summary of model fit statistics by the 2009 to 2013 group-based multi-trajectory model for objective and subjective social status.

Trajectory structure			**Model convergence**		**Model fit statistics**			
No. of groups	Order of poly-nomial terms: subjective social status	Order of poly-nomial terms: income	Smallest group (%)	Variance - covariance matrix	Entropy	BIC (N = 7,402)	AIC	Log Likelihood
1	3	3	100.0	Error	.	- 371018	- 370984	- 370974
2	3,3	3,3	44.2	Error	0.749	- 364374	- 364302	- 364281
3	3,3,3	3,3,3	22.8	Error	0.717	- 363336	- 363225	- 363193
4	3,3,3,3	3,3,3,3	16.3	Error	0.614	- 362983	- 362834	- 362791
5	3,3,3,3,3	3,3,3,3,3	10.1	Error	0.572	- 362937	- 362750	- 362696
6	3,3,3,3,3,3	3,3,3,3,3,3	6.9	Error	0.528	- 362994	- 362768	- 362703
4*	**0,1,0,1**	**1,0,1,2**	**16.2**	.	**0.874**	**-335180**	**-335094**	**-335069**

***** We selected the model based on the model fit statistics, including a visual inspection.

Note: The optimal number of trajectory groups was four; more would not capture additional trajectories. Models not in the table have a non-symmetrical or highly singular variance matrix.

Table S3-7. Income characteristics of the study sample and household income of multi-SES trajectories

(Unit: monthly USD)

Year	**Korean Subsistence level** [1] (per capita)	**The study population** [2]			**2009-2013 Group-based multi-trajectories** [3]			
		Balanced panel (N = 7,432)			Subsistence level	Relative deprivation	Upper-middle	Privileged
		Q50	Q75	Q90	Mean	Mean	Mean	Mean
2009	378	1,047	1,588	2,187	409	833	1,361	2,248
2010	429	1,267	1,854	2,635	486	978	1,620	2,873
2011	472	1,370	2,007	2,801	528	1,039	1,771	3,053
2012	483	1,396	2,089	2,908	546	1,058	1,834	3,167
2013	514	1,525	2,239	3,178	610	1,125	1,975	3,490

Notes: 1) Subsistence level of South Korea reported by the government annually. We equivalized the value based on the number of household members and converted it to USD.

2) (Balanced panel data) Median, upper 75%, and upper 90% of equivalized household income.

3) Multi-trajectories are described in the Results section, which combine the change patterns of household income and subjective social status over time.

Chapter 4.
Diverse social resources for health-related quality of life in the communities

4.1. Introduction

Neighborhood environments mold people's life chances and outcomes by shaping exposure to shared norms and access to resources. Community environments inevitably determine the population Health. Resources can be generated at multi-levels, ranging from the community's physical environment to social relations among residents.

4.1.1. Study background

Even though income is evidently associated with health and social outcomes, the benefits from income growth get fewer and are limited as income reaches an upper level (Wilkinson & Pickett, 2009). Therefore, a broader concept of resources and social processes should be involved to understand health improvement for the whole society. Indeed, it is not mere income but the combination of material capital, human capital, and social capital that locates people in the social hierarchy (Oakes & Rossi, 2003). These social resources—not only the infrastructural, economic, or educational resources—are also essential to prepare and respond to crises (Reininger et al., 2013).

Beyond individual or household factors, multilevel and multi-sectoral resources determine one's quality of life and health. "Resources" have been broadly defined as diverse dimensions in social, economic, or psychological research fields.

Pierre Bourdieu, a prominent sociologist, asserted the need to reintroduce the forms of capital, not only in economic capital but also in cultural capital and social capital. Economic capital can be partially the basis of other types of capital, but it can never be immediately and entirely reducible to each form (Bourdieu, 1986).

Social capital is the resources from civic capacities and can enhance local economics via the community's collective cooperation and consensus building. Second, the values outside the market economy, such as ***culture***, skills, or wisdom, are also important resources in post-development and humanist research because they can eventually be transformed into cultural, political, and even material wealth. In addition, the need for human fulfillment, such as belonging, freedom, understanding, creativity, leisure, or affection, is also a source and driver of social energy (Hirschman, 2013; Wilson, 1996).

Through the social-psychological process, shared expectations for social control among residents shape the neighborhood environment, fostering the flow of housing movement so as to gather people with similar perceptions and consequently sustain and concentrate poverty (Sampson, 2012), pp365-366.

Instead of social-relational resources, the physical features of neighborhoods—***the "built environment***"—are also beneficial for improving social capital, collective efficacy, healthy behaviors, and health outcomes.

A review paper regarding the built environment and health consolidated pieces of evidence such that communities with walkability, green spaces, open spaces, land use mix (i.e., zoning), accessible recreation facilities, street connectivity, and convenient public transport are structures for better health (Renalds et al., 2010).

In particular, plenty of parks are strong predictor of neighborhood collective efficacy, while the number of off-sale alcohol outlets in communities lowered collective efficacy (D. A. Cohen et al., 2008). The geographical distribution of recreational facilities is associated with increased physical activity and decreased obesity patterns in communities. Furthermore, these facilities, such as parks, youth centers, sports clubs, public beaches, dance studios, and schools, were correlated with community SES and ethnic minority status. Therefore, unequal accessibility to recreational facilities occurred, worsening health inequalities regarding physical activity and obesity (Gordon-Larsen et al., 2006). Similarly, walkability, determined by street network design and land use diversity, affected physical activity, overweight, and obesity (Brown et al., 2009; Li et al., 2008).

In rural areas, the walkable environment was linked to feelings of personal safety and enhanced social capital (i.e., trust, reciprocity, civic engagement, and social networks) (Wood et al., 2008). In urban areas, the poor quality of the built environment, measured as the percentage of problematic housing units and buildings in regions, influenced the depression

level of the population (Galea, 2005). These health impacts remain robust even after controlling the individual characteristics.

Community, social capital, and health. Social and financial institutions function to strengthen social interaction and solidarity among community members (Beard, 2005). For instance, neighborhood associations within the community become channels for improving social capital. These community activities, in turn, facilitate the knowledge and information which benefit health (Sujarwoto & Tampubolon, 2013).

4.1.2. Study design and objectives

Social capital is a distinguishable construct from individual characteristics; therefore, it should be measured at the community level (Lochner et al., 1999). Regarding previous limitations, this study aims to reveal the features of social resources in South Korea and to investigate which types of resources greatly influence HRQoL at the community level. In particular, we focus on broadening the concept of social resources, covering social capital and physical, environmental, cultural, and economic resources in the community.

Detailed research objectives are as follows: (1) we define the typology of social resources to fit and explain the community characteristics. (2) We investigate the effect of social resources on a community's population health regarding HRQoL.

4.2. Methods

4.2.1. Variables

We composed various subset data to cover a broad range of social resources in 250 districts. Social resources were organized into four categories. (1) medical resources (i.e., doctors, essential clinics, hospitals, or unmet medical needs), (2) cultural resources (i.e., sports service establishments, culture infrastructures, or parks), (3) social capital (i.e., social trust, social networks, and social participation), and (4) socioeconomic structure (i.e., characteristics of affluent or deprivation communities – Gross Regional Domestic Product[GRDP], aging index, the proportion of single-member households, or population density, et al.).

Regarding social capital types, trust and religious activities represent the cognitive dimension. Instead, social networks or participations are classified as structural dimension. The external social gatherings corresponded to the bridging (linking) social capital. Detailed definitions of the variables are described in Table.4.1.

4.2.2. Data collection

We used the Community Health Survey (CHS) data in 2019, conducted annually by the Korea Centers for Disease Control and Prevention (KCDC) and the nationwide 255 healthcare centers. This survey aims to collect health

behavior, status, outcomes, and determinants, and the target population is adults aged 19 or older. As study samples were extracted regarding the proportion of the house types in each city, the survey results represent each district's characteristics (Ministry of Health and Welfare & Korea Centers for Disease Control and Prevention, 2020). The CHS data was accessible to all at the official homepage (http://chs.cdc.go.kr). The data in 2019 came from 255 spots (i.e., nationwide health service centers) and 229,099 individuals. As CHS is a survey extracted under complex sampling design, we aggregated the individual responses as regional average values by districts with a concern of sampling structure (5,586 strata; 21,763 clusters) and weights.

In addition, we collected data of the regional characteristics in 2019 through the data library called KOSIS (http://kosis.go.kr) and MDIS (https://mdis.kostat.go.kr). This is the open-source data portal managed by National statistics (South Korea) and provides the summary statistics of several national surveys. It is accessible to all and people can easily download the data file via the portal.

After all, we matched data from several windows described above, aligning to 250 regions. South Korea constitutes 17 metropolitan cities (provinces) and 250 regions (city, county, or district) in an administrative classification – 229 regions in meso-level classification –, and has 255 health service centers in 2019. Since the regional classification varies depending on the data sources, we merged the dataset as 250 districts using the imputation method. Each measure was standardized.

Table 4-1. Definition and data sources of the independent variables

	Variable	Definition	Region Unit	Year	Data sources	Publisher	Data library
Healthcare resources							
	Doctors	No. of doctors (medical / oriental doctors, dentist) per 100,000 residents	250	2019 4/4	National Health Insurance Statistical Yearbook	NHIS, HIRA	KOSIS
	Essential clinics	No. of essential clinics per 100,000 residents	250	2019 4/4	National Health Insurance Statistical Yearbook	NHIS, HIRA	KOSIS
	Tertiary Hospitals	No. of hospitals (tertiary and general hospital) per 100,000 residents	250	2019 4/4	National Health Insurance Statistical Yearbook	NHIS, HIRA	KOSIS
	Nursing hospital	No. of nursing hospitals per 100,000 residents	250	2019 4/4	National Health Insurance Statistical Yearbook	NHIS, HIRA	KOSIS
	Unmet medical needs	% of the survey respondents answered they did not receive the necessary healthcare in the past year	255	2019	Community Health Survey	KDCA	CHS website
Cultural resources							
	Sports service establishments	No. of sports service establishments per area(km2)	250	2019	Census on Establishments	Statistics Korea	MDIS
	Culture infrastructures	No. of culture infrastructures per area(km2)	229	2019	National General Report of Cultural Infrastructure	MCST,MOIS	KOSIS
	Parks	No. of parks per area(km2)	232	2019	Statistics of Urban Plan	LX	KOSIS
Social capital							
	Social trust	% of the survey respondents who answered they believe and trust their neighbors and society	255	2019	Community Health Survey	KDCA	CHS website
	Social network	% of the survey respondents who have contacted their (1) family or (2) friends more than once a week	255	2019	Community Health Survey	KDCA	CHS website

	Social participation	% of the survey respondents who have participated in (1) friendship, (2) leisure, or (3) religious activities more than once a month	255	2019	Community Health Survey	KDCA	CHS website
Socioeconomic status							
	Aging index	Aged-child ratio (65+/ <15 aged)	250	2019	Population Statistics Based on Resident Registration	MOIS	KOSIS
	Single-person households	% of single-person households	229	2019	Population Census	Statistics Korea	KOSIS
	Employment rate	% of the employed among those over the age of 15	154	2019	Local Area Labour Force Survey	Statistics Korea	KOSIS
			75	2019	Economically Active Population Survey	Statistics Korea	KOSIS
	GRDP per capita	Gross Regional Domestic Product(GRDP) per capita at current prices (unit: 1000 USD)	205	2019	Regional Indicators	Statistics Korea	KOSIS
			23	2018	Gyeongsangbuk-do GRDP	Gyeong-sang-buk-do	KOSIS
			1	2019	Regional Income	Statistics Korea	KOSIS
	Urbanization of city	% of the people living in the urban area of the region	229	2019	Statistics of Urban Plan	LX	KOSIS
	Population density	Area(km2)	229	2019	Cadastral Statistics	MOLIT	KOSIS
		No. of residents in the region	250	2019. 12.	Population Statistics Based on Resident Registration	MOIS	KOSIS

***Abbreviation*:** Korean Statistical Information Service (KOSIS), Microdata Integrated Service (MDIS), Community Health Survey (CHS), National Health Insurance Service (NHIS), Health Insurance Review and Assessment Service (HIRA), Korea Disease Control and Prevention Agency (KDCA), Ministry of Culture, Sports and Tourism (MCST), Ministry of the Interior and Safety (MOIS), Korea Land and Geospatial InformatiX Corporation (LX), Minister of Land, Infrastructure and Transport (MOLIT)

4.2.3. Statistical methods

Principal Component Analysis (PCA). We used principal component analysis (PCA) to investigate the distinct nature of social resources in communities and the contribution of variables to the features. This approach is a dimension reduction technique for deriving the low-dimensional set of features from numerous explanatory variables(James et al., 2017). PCA has the advantage of characterizing the multiple variables into their unique exclusive component of each other.

Principal components regression (PCR). Principal components regression (PCR) involves the principal components as regressor to the HRQoL in the linear regression model. Since each PC has the information of every variable, each coefficient of PC (beta Z) in PCR model can be converted to those of original dependent variable (beta x). To enhance the interpretability, we calculated the beta x by multiplying beta Z with eigenvector (matrix V).

Sensitivity analyses. To validate the PCR model fitness, we applied other dimension shrinkage methods, which resulted in variable selection (*see* Appendix). The machine learning algorithms called a lasso, elastic net, and ridge regression were used. Finally, we compared the test error from the models and concluded which model better explains the relation between the social resources and HRQoL.

4.3. Results

4.3.1. Descriptive analysis

The health-related quality of life (HRQoL) index in 2019 was a 0.945 (s.e.=0.0003) score at community averages (Table 4-1). Approximately 6% of people experience unmet medical needs a year.

Across districts of South Korea, per 100,000 residents, there are 278 doctors, 15.6 essential medical clinics, 3.8 hospitals, and 3.7 nursing hospitals. With regard to the cultural facilities per 1km2, there are 3.0 sports service establishments, 0.2 cultural infrastructures, and 1.1 parks.

62.8% of the respondents in the community survey answered that they believe and trust their neighbors. Approximately 50% of people contact their family and friends more than once a week. Regarding social activities, 52.3% have participated in friendship activities more than once a month, 33.6% of people in leisure activities, and 26.5% of people in religious activities.

People over the age of 65 are 2.1 times as many as those under 15. The single-member households in a region reached 31.8%, and the employment rate was 62.5% among those over 15 years. Moreover, 76.7% of residents live in urbanized areas rather than rural.

Table 4-2. Descriptive analysis of the HRQoL and social resources at the community level in 2019

Variables	N	Mean*	S.D. (S.E. of %**)
Health outcome* **			
HRQoL index (Mean, SE)	229,016	0.945	0.0003
Problems with EQ-5D 1 (%)	229,089	10.2	(0.1)
Problems with EQ-5D 2 (%)	229,096	3.5	(0.0)
Problems with EQ-5D 3 (%)	229,096	7.1	(0.1)
Problems with EQ-5D 4 (%)	229,091	27.0	(0.1)
Problems with EQ-5D 5 (%)	229,028	13.5	(0.1)
Healthcare resources			
Doctors (No. of, per 100K)	250	277.6	223.2
Essential clinics (No. of, per 100K)	250	15.6	7.4
Tertiary Hospitals (No. of, per 100K)	250	3.8	2.4
Nursing hospital (No. of, per 100K)	250	3.7	3.0
Unmet medical needs (%)	212,713	6.0	(0.1)
Cultural resources			
Sports service establishments (No. of, per 1km^2)	250	3.0	4.7
Culture infrastructures (No. of, per 1km^2)	250	0.2	0.3
Parks (No. of, per 1km^2)	250	1.1	1.4
Social capital			
Social trust (%)	212,257	62.8	(0.2)
Social network with family (%)	229,019	52.4	(0.2)
Social network with friend (%)	228,859	55.3	(0.2)
Social participation in friendship activities (%)	229,070	52.3	(0.2)
Social participation in leisure activities (%)	229,055	33.6	(0.2)
Social participation in religious activities (%)	229,080	26.5	(0.2)
Socioeconomic status			
Aging index	250	2.1	1.4
Single-member households (%)	250	31.8	4.9
Employment rate (%)	250	62.5	5.3
GRDP per capita (1000 USD)	250	33.3	29.1
Urbanization of city (%)	250	76.7	26.5
Population density (No. of residents, per 1km^2)	250	3921.3	5911.6

Notes: * For CHS data (N=229,099), mean percentage was calculated, taking account into survey weights and sampling design information - Number of Strata 5,586; Number of Clusters 21,763; Number of Observations 229,099; Sum of Weights 4,3038,864.

** Standard error of percent.

***Percentage indicates the proportion of the person who answered having “some problems” or “severe problems”, rather “no problem”.

4.3.2. Principal Component Analysis (PCA)

We summarized the resource type into principal components (PC) which is drawn by a dimension shrinkage method. As a result of principal component analysis (PCA), the orthogonal 20 principal components (PCs) were drawn by using 20 social resource variables. The first dimension of the principal components embraces much information regarding the 20 variables. The PC of which eigenvalue exceeds one is considered meaningful.

Table 4-3 contains the eigenvalue for each PC, and the percentage of variance explained. According to the principal of PC analysis, the first PC accounted for 34.6% of the overall variance of data and second PC explain 12.5% of variance in data. The first to sixth dimensions exceeded 1 of the eigenvalue and explained 73.6% of the total variance when calculating the proportion.

Table 4-3. Percentage of variance explained for each principal component

	Standard deviation	**Eigenvalue (Var(PCs))**	**Proportion of Variance**	**Cumulative Proportion of variance**
PC1	2.629	**6.910**	34.6%	34.6%
PC2	1.579	**2.494**	12.5%	47.0%
PC3	1.249	**1.559**	7.8%	54.8%
PC4	1.140	**1.301**	6.5%	61.3%
PC5	1.114	**1.240**	6.2%	67.5%
PC6	1.106	**1.224**	6.1%	73.6%
PC7	0.996	0.993	5.0%	78.6%
PC8	0.828	0.686	3.4%	82.0%
PC9	0.800	0.641	3.2%	85.2%
PC10	0.726	0.527	2.6%	87.9%
PC11	0.635	0.403	2.0%	89.9%
PC12	0.623	0.388	1.9%	91.8%
PC13	0.619	0.383	1.9%	93.7%
PC14	0.602	0.363	1.8%	95.6%
PC15	0.496	0.246	1.2%	96.8%
PC16	0.469	0.220	1.1%	97.9%
PC17	0.394	0.155	0.8%	98.7%
PC18	0.360	0.129	0.6%	99.3%
PC19	0.288	0.083	0.4%	99.7%
PC20	0.237	0.056	0.3%	100.0%

Figure 4-3 demonstrates the variable's contributions to each PC dimension. When a variable contribution exceeds the benchmark for a component, the variable is considered a valid factor in composing a given component.

The first dimension (PC1) indicates the **'physical environments'** represented by physical facilities - such as clinics, sports service establishments, cultural infrastructures, and parks - and **'city urbanization'** with population density and employment rate. Additionally, social trust and networks with family were captured as the first principal component.

The second dimension (PC2) corresponded to the feature of 'demographic factor' and abundance of 'medical resources.' Those consequently reflect the '**supply and demand of medical resources'**. The number of doctors and the number of high-skilled tertiary hospitals per 100,000 residents represent the supply aspect, and the population aging index does the demand aspect, respectively. In the seventh dimension (PC7), the '**unmet medical needs'** exclusively explain the dimension near 80%.

The third (PC3), fourth (PC4), and sixth (PC6) dimensions were highly contributed by each social capital type. PC3 reflects kinds of **'linking social capital'** encompassing social participation in friendship and leisure activities. PC4 reflects both **'cognitive** (i.e., religious involvement and trust) and **structural** (i.e., social participation and networks) **social capital**.'

Lastly, the fifth dimension is primarily characterized by the regional GDP (GRDP), which is correlated with the degree of financial independence and the **'economic affluence'** of the region.

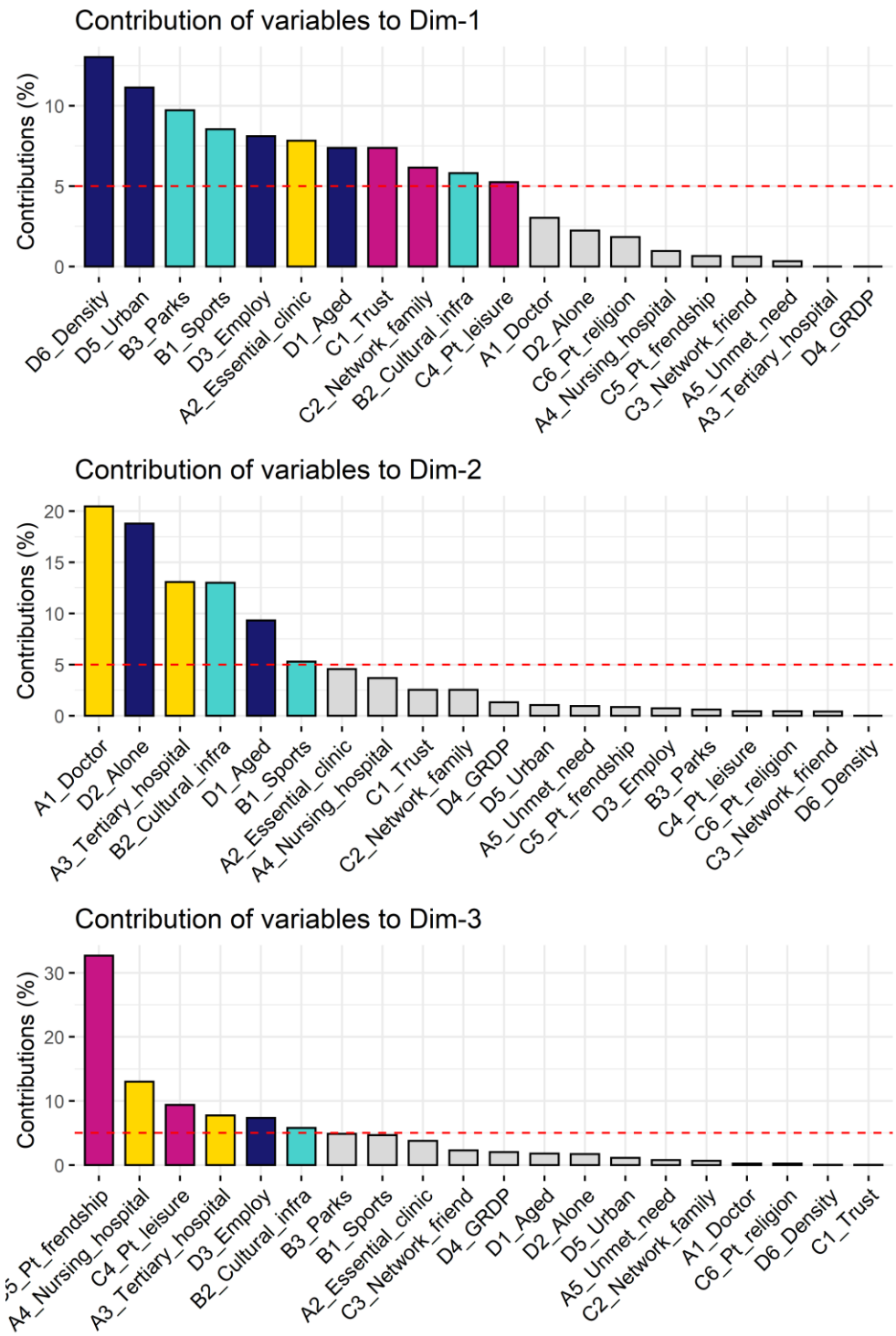


Figure 4-1. Variable contribution to each principal component

Note: The red dashed line indicates the expected average contribution.

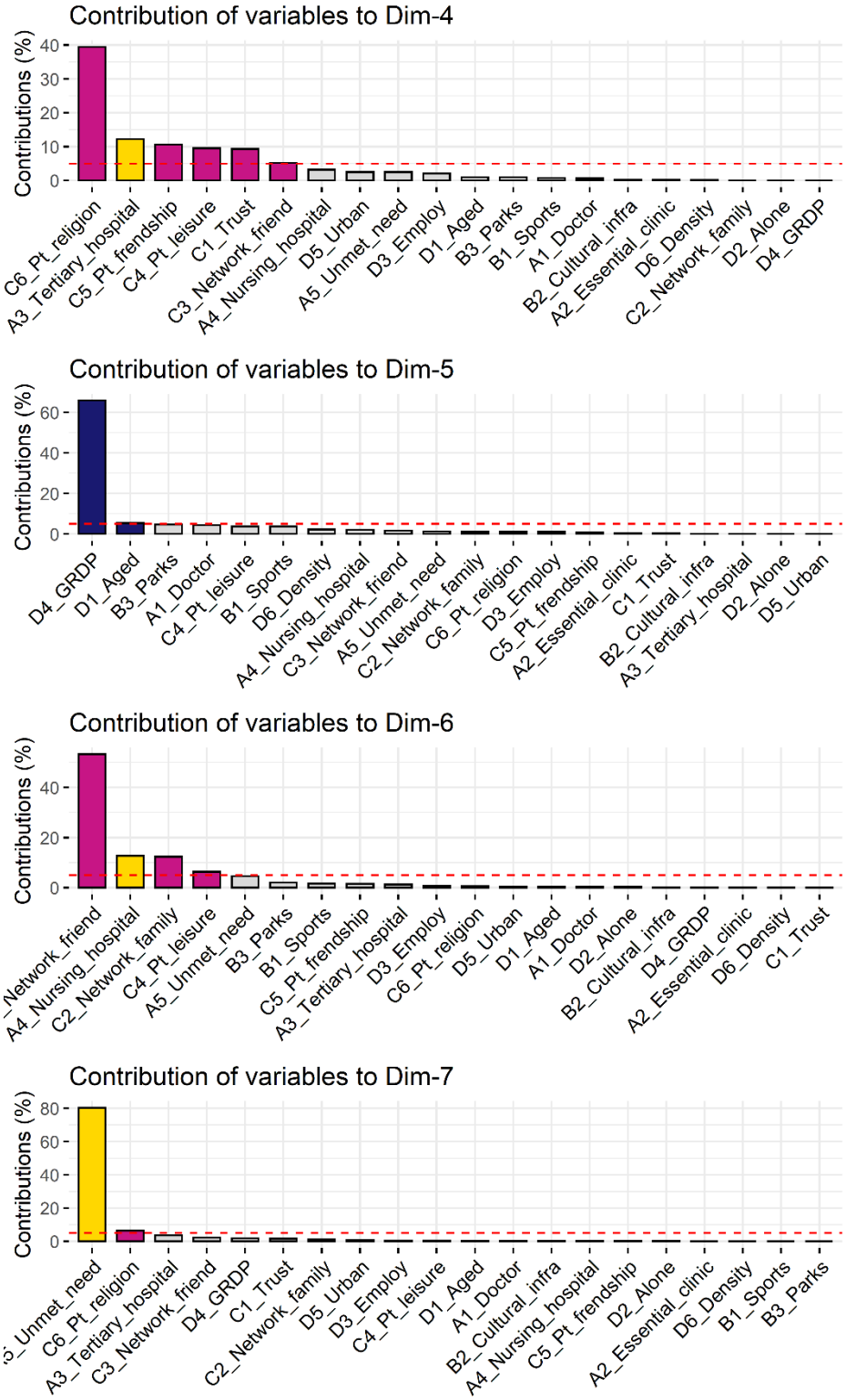


Figure 4-1. Variable contribution to each principal component (Cont'd)

4.3.3. Principal Components Regression (PCR)

We set a Principal component regression (PCR) model to explore the relation to the dependent variable ('HRQoL') and principal components. Before fitting the PCR model, we selected the optimal number of PCs to be included among overall 20 PCs. Applying the 10-fold cross-validation approach, the result of RMSEP indicates that containing the first to seventh PCs is optimal with the lowest model error (Appendix B Figure S2).

Table 4-4. Principal component regression to HRQoL in 2019

	Estimate	Standard Error	t-value	Pr(>|t|)	
PC1	-0.218	0.018	-12.181	<0.001	***
PC2	-0.152	0.030	-5.096	<0.001	***
PC3	-0.101	0.038	-2.692	0.008	**
PC4	0.093	0.041	2.245	0.026	*
PC5	-0.109	0.042	-2.590	0.010	*
PC6	-0.035	0.043	-0.815	0.416	
PC7	0.187	0.047	3.959	<0.001	***
(Intercept)	0.000	0.047	0.000	1.000	
Residual standard error		0.7425 on 242 degrees of freedom			
Multiple R-squared		0.4642			
Adjusted R-squared		0.4487			
F-statistic		29.95 on 7 and 242 DF			
p-value		< 2.2e-16			

***Note*: *** <0.001, ** <0.01, * <0.05, . <0.1**

Table 4-3 indicates the results of the fitted PCR model using 7 PCs. Each PC except the sixth PC was statistically significant to the HRQoL. The 78.6% of independent data variance (X-dimension) and 46.4% of the dependent data variance (Y-dimension) were explained in the fitted PCR model (Appendix B Table S2).

To confirm each variable's effect, we converted the coefficient of PCs (beta Z) to those of the original variables (beta x). Table 4-4 and Figure 4-4 present the result of converted beta x. Several variables have a high coefficient (above 0.05) both in each PC and the sum of 7 PCs – (1) the number of essential clinics, (2) unmet medical needs, (3) Trust, (4) Participation in leisure activities, (5) Participation in religious activities, (6) Aging index, (7) Single-member household, (8) Employment rate, (9) GRDP per capita, (10) Urbanization of city, and (11) Population density.

Table 4-5. Coefficients derived by the results of PCR

		PC1	PC2	PC3	PC4	PC5	PC6	PC7	Total Sum
1	Doctors	0.038	**-0.069**	0.005	0.007	0.023	-0.002	-0.010	-0.008
2	**Essential clinics**	**0.061**	-0.032	0.020	0.004	0.007	-0.002	0.004	**0.061**
3	Tertiary Hospitals	0.001	**-0.055**	0.028	0.032	-0.002	-0.004	-0.035	-0.034
4	Nursing hospital	-0.021	-0.029	0.037	0.016	-0.016	-0.012	-0.009	-0.035
5	Unmet needs	-0.012	0.015	-0.009	0.014	0.013	0.007	**-0.167**	**-0.139**
6	Sports infra.	**0.064**	-0.035	-0.022	-0.008	-0.021	0.004	-0.003	-0.021
7	Culture infra.	**0.053**	**-0.055**	-0.024	-0.004	0.005	0.002	0.009	-0.014
8	Parks	**0.068**	-0.012	-0.022	-0.009	-0.024	0.005	-0.001	0.005
9	Trust	**-0.059**	-0.024	0.001	-0.028	-0.006	0.001	0.024	**-0.091**
10	Family network	**-0.054**	-0.024	0.008	0.002	-0.011	0.012	0.018	-0.049
11	Friends network	-0.017	-0.010	0.015	0.021	-0.014	0.025	0.028	0.049
12	Leisure activities	**0.050**	0.010	0.031	-0.029	0.021	0.009	-0.012	**0.080**
13	Friendship activities	-0.018	-0.014	**0.058**	-0.030	0.009	0.004	-0.008	0.002
14	Religious activities	0.029	-0.010	0.005	**-0.058**	-0.011	-0.003	-0.048	**-0.096**
15	Aging index	**-0.059**	-0.046	-0.013	-0.009	-0.025	-0.002	-0.011	**-0.167**
16	Single-person households	-0.033	**-0.066**	-0.013	-0.002	-0.001	0.002	-0.007	**-0.119**
17	Employment	**-0.062**	-0.013	-0.027	-0.013	0.011	0.003	-0.012	**-0.114**
18	GRDP	0.000	-0.017	-0.014	-0.001	**0.089**	0.002	0.026	**0.084**
19	Urbanization	**0.073**	0.016	0.011	0.015	-0.001	0.003	0.015	**0.131**
20	Population density	**0.079**	-0.001	-0.002	0.003	-0.017	0.001	-0.004	**0.060**

Note: The number of variables corresponds with the one described in Figure 4-2.

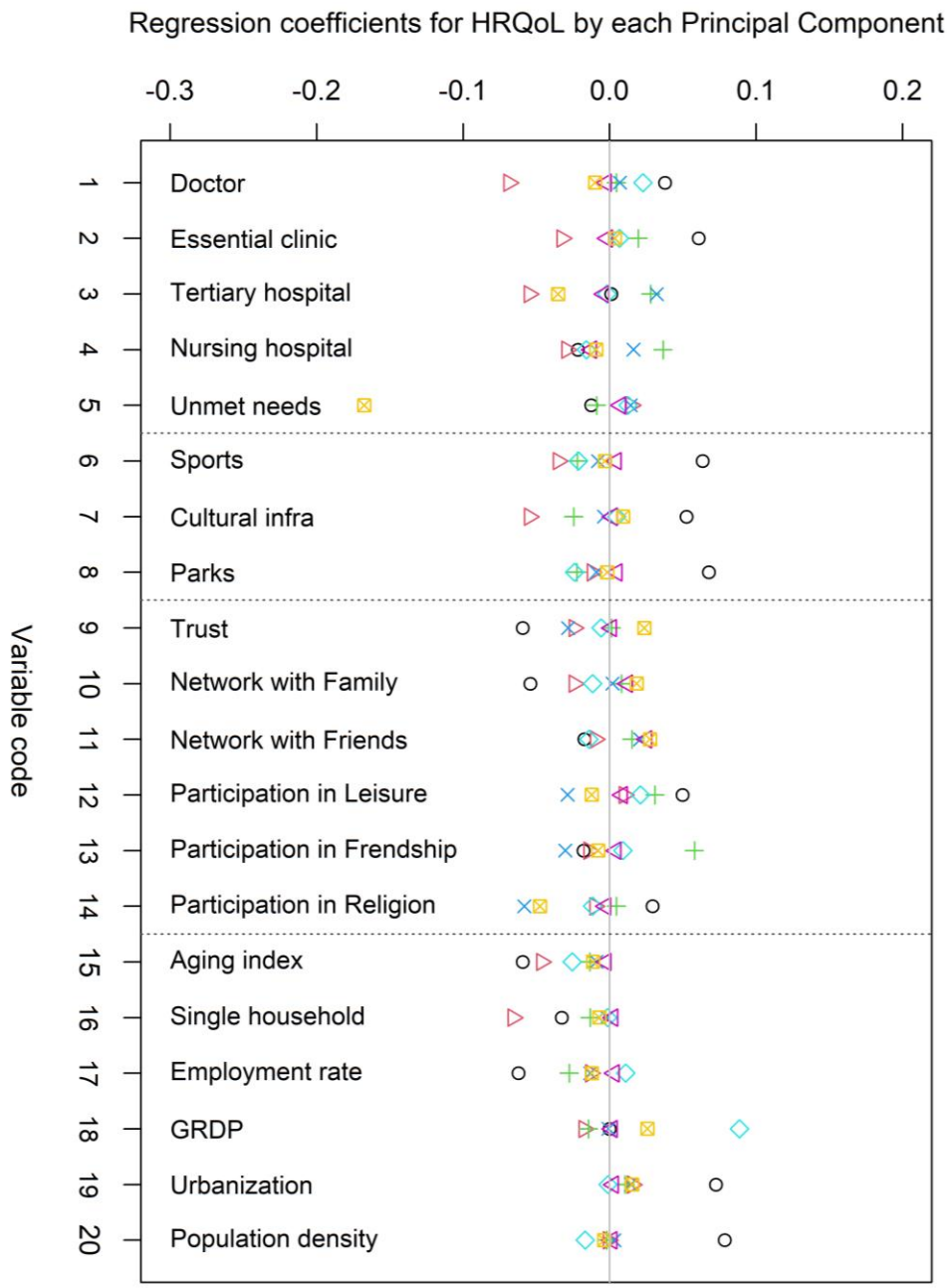


Figure 4-2. Coefficient distribution by each principal component

4.4. Discussion

The social resources inherent in the communities were characterized by five typologies in this study. (1) The urban environment covering physical facilities, (2) the demand and supply environment for healthcare, and (3) bridging, bonding, and cognitive social capital, and (4) economic affluence are community resources that specify Korean society.

4.4.1. Aggregate of built environment and neighborhood effect

We need to understand the impact of the built environment, such as public transportation, green space, and pedestrian facilities, on health and build societies in direction of upgrading these. In addition to specific roles applied to sanitation or fire code, the built environment can address and solve a more broad range of physical and mental health issues (Jackson, 2003).

Based on the results, the social resources exert population health through the community features represented by the urban environment (i.e., single-member households, employment rate, population density, and urbanization of city), demand and supply of healthcare resources (i.e., aging index, essential clinics, and unmet medical needs), and social capital (i.e., social trust, social participation in leisure or religious activities).

Overall findings in this study strongly support the neighborhood effect on population health.

4.4.2. Structural and cognitive resources in community

The results of PCs demonstrate the intensive and peculiar characteristics of resource types in the community. These results support previous discourses that resources can be identified as diverse domains that range from structural, cultural, or even cognitive realms. Further, we need to consider the neighborhood context. Whether it has mutual trust and solidarity, collective efficacy is exerted, allowing residents to be willing to intervene for the public good. In other words, socially cohesive neighborhoods benefit from informal social control (Sampson et al., 1997).

Significance of social resources in community context. Social capital as a capital. Social capital is free, invisible, and does not require labor or investment funds, but it does exist and works on the community's wealth and quality of life (Wilson, 1997). Narayan and Pritchett (1999) also state that social capital is capital, given that it provides a beneficial mechanism that earns more income. People in communities affluent in social capital, for example, can enjoy better public services or can join in diverse community activities, which induce higher income. In particular, social capital help to improve household welfare and household income. These impacts are based on local, community, and social contexts, operating at the community level (Narayan & Pritchett, 1999).

Social capital as resources for resilience. Apart from one's familial or individual characteristics, people living in more affluent neighborhoods are more likely to know and trust neighbors who can be helpful when

encountering troubles or dangers. (Putnam, 2016) p.219. People can recover their difficulties incurred by financial, disease, or natural crises by utilizing various resources from social life. This **resilience** can operate at the community level as well as individual level. Community resilience means the collective capacity to handle stressors and restore the rhythm of daily life through neighborhood and community cooperation in response to a social, physical, or ecological catastrophe (Aldrichi et al., 2018)

4.4.3. Strengths and limitations

This study has certain strengths. Compared to the OLS model (Appendix A Table S1), the PCR is free from VIF issues that are problematic for OLS due to the correlation between variables. It implies that the PCR model shows good prediction performance and better explains the variance of the community characteristics.

Compositional Or Contextual effect? Several studies support that the social capital effect works at a contextual level apart from the resident's compositional effect. Collective efficacy is reliably measured as an important construct in neighborhood phenomena rather than individual traits (Sampson et al., 2002; Sampson et al., 1997). Even after adjusting for the individual differences in neighborhood composition, the effect of aggregated social cohesion and trust at the community level remains robust (Sampson et al., 1997).

Furthermore, our model covers the demographic information of

residents—e.g., aging index, employment rate, rate of single-member households, or regional GDP—to control confounding. Therefore, the results may indicate the original contextual effect of community resources, not induced by residents' compositions.

However, these interpretations have a limit that overlooks the geographical information on the communities. Even though principal components encompass multiple contexts within each dimension, this approach cannot cover the geographical distance. As observations spatially closer are more related than those farther away (Tobler, 1970), spatial non-stationarity may result in spatial modification between social resources and health outcomes. Therefore, further research is needed to address this spatial dimension.

4.5. Supplementary data

Appendix A. Correlation of variables and OLS model

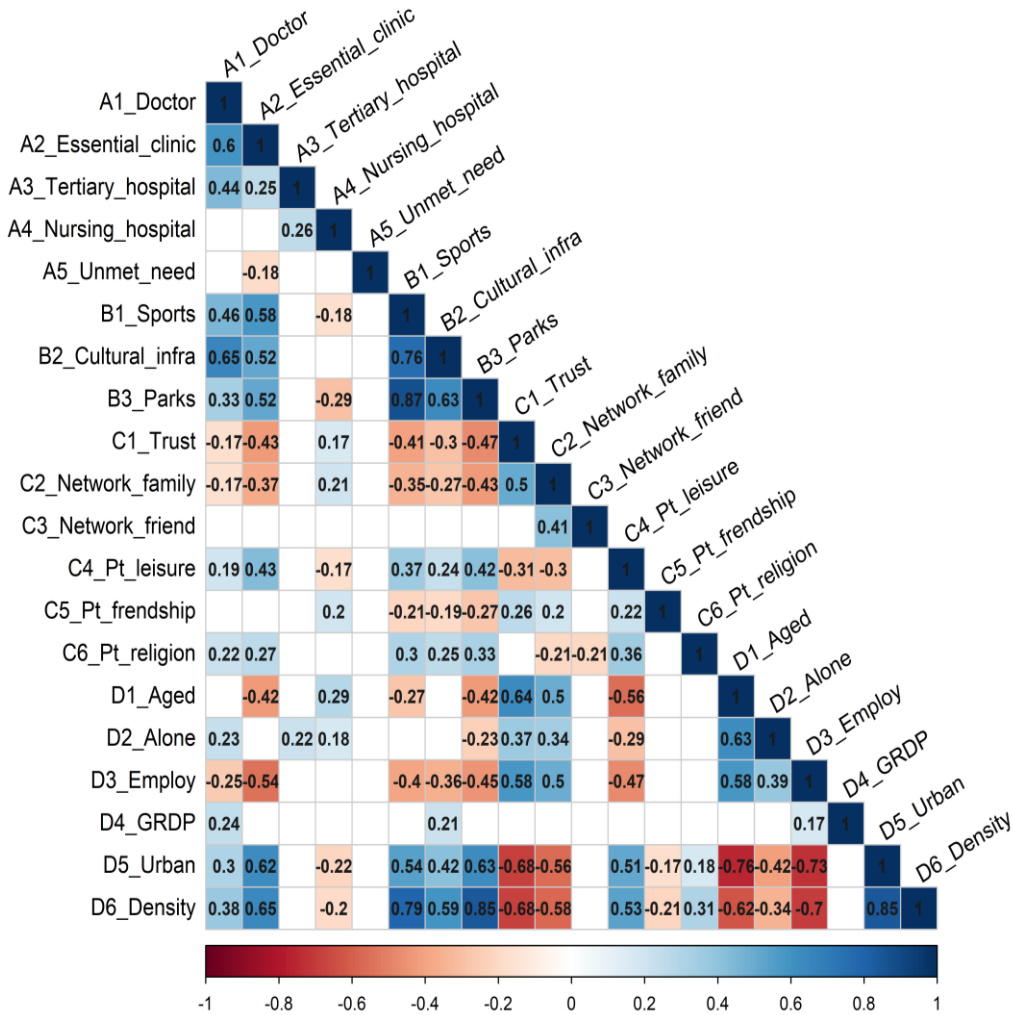


Figure S4-1. Correlation matrix of the explanatory variables

Table S4-1. Ordinary least squares (OLS) model

	Estimate	Std.Error	t-value	Pr(>|t|)		VIF
Doctors	0.095	0.076	1.251	0.212		3.00
Essential clinics	-0.116	0.074	-1.568	0.118		2.83
Tertiary Hospitals	0.035	0.054	0.647	0.519		1.53
Nursing hospital	-0.015	0.051	-0.304	0.761		1.34
Unmet medical needs	-0.116	0.047	-2.475	0.014	*	1.13
Sports service establishments	-0.126	0.122	-1.037	0.301		7.66
Culture infrastructures	-0.036	0.092	-0.391	0.696		4.41
Parks	0.133	0.118	1.128	0.261		7.21
Trust	0.174	0.071	2.430	0.016	*	2.63
Network with family	0.012	0.063	0.191	0.849		2.08
Network with friends	-0.003	0.052	-0.064	0.949		1.40
Leisure activities	-0.103	0.067	-1.539	0.125		2.33
Friendship activities	0.102	0.054	1.887	0.060	.	1.51
Religious activities	-0.128	0.053	-2.423	0.016	*	1.44
Aging index	-0.566	0.097	-5.837	0.000	***	4.85
Single households	-0.078	0.065	-1.208	0.228		2.15
Employment rate	-0.039	0.077	-0.507	0.613		3.10
GRDP per capita	0.076	0.058	1.311	0.191		1.72
Urbanization of city	-0.021	0.111	-0.186	0.853		6.40
Population density	0.441	0.164	2.688	0.008	**	13.89
(Intercept)	0.000	0.044	0.000	1.000		

Residual standard error	0.695 on 229 degrees of freedom
Adjusted R-squared	0.518
F-statistic	14.36 on 20 and 229 DF
p-value	< 0.001
AIC	549.266

Note: *** <0.001, ** <0.01, * <0.05, . <0.1

Appendix B. Detailed information on PCA and PCR results

Principal component analysis (PCA). Figure S2 shows the representation quality of each variable to the PCs. The darker color indicates that PC's dimension explains the variable's variance more clearly.

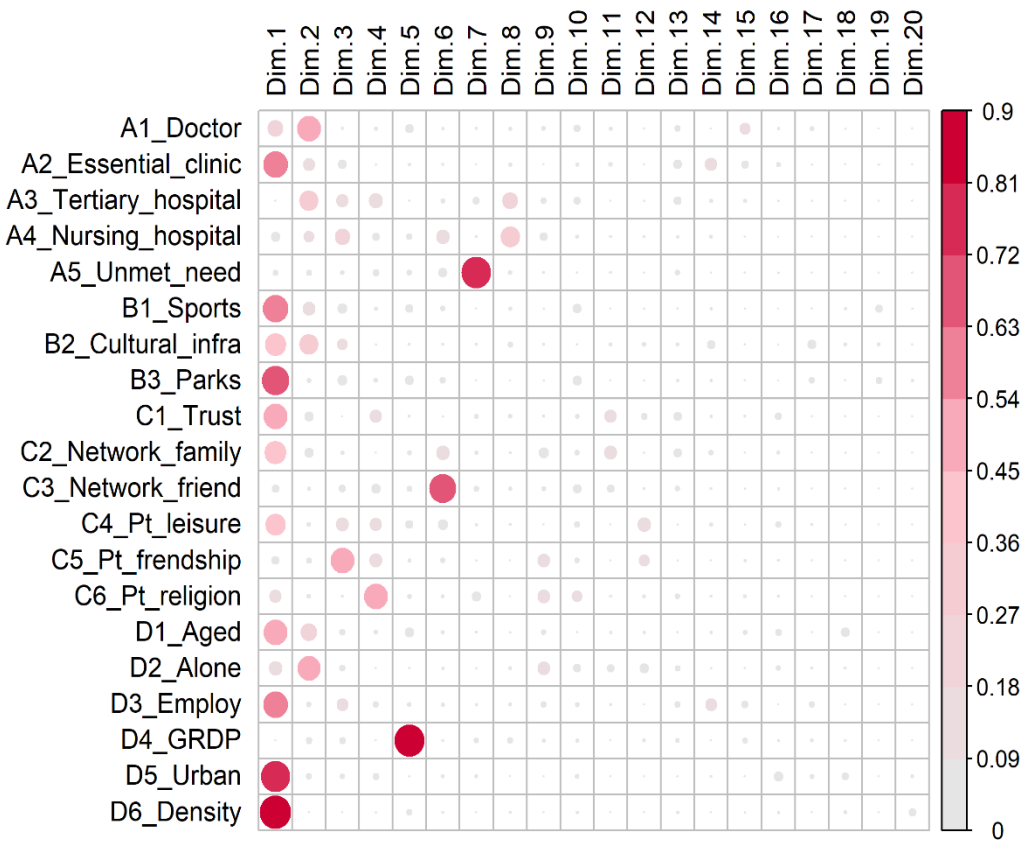


Figure S4-2. Quality of representation of variables to each principal component

Principal component regression (PCR). Figure S3 illustrates the determining process for the optimal number of PCs on the principal component regression (PCR) model.

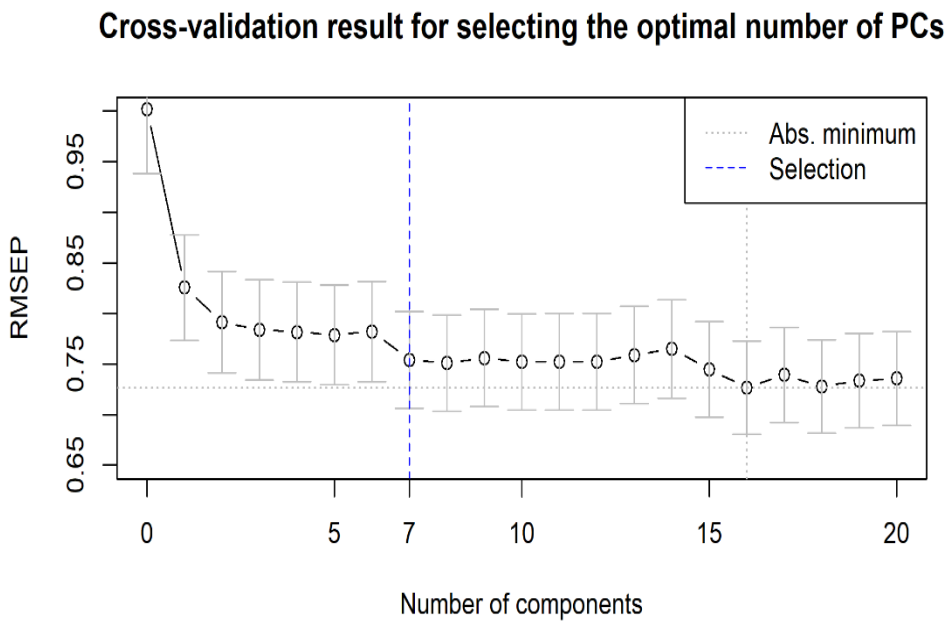


Figure S4-3. Cross-validation result for determining the optimal number of PCs on PCR model

Figure S4-4. Percentage of variance explained in the fitted PCR model

(Unit: %)

	X-dimension	**HRQoL**
1 principal component	34.6	32.9
2 principal component	47.0	38.6
3 principal component	54.8	40.2
4 principal component	61.3	41.3
5 principal component	67.5	42.8
6 principal component	73.6	43.0
7 principal component	**78.6**	**46.4**
8 principal component	82.0	46.8
9 principal component	85.2	47.1
10 principal component	87.9	48.2
11 principal component	89.9	48.5
12 principal component	91.8	48.5
13 principal component	93.7	48.5
14 principal component	95.6	48.6
15 principal component	96.8	50.2
16 principal component	97.9	53.2
17 principal component	98.7	53.7
18 principal component	99.3	54.5
19 principal component	99.7	54.7
20 principal component	100.0	55.6

Appendix C. Sensitivity analyses: Comparison to other dimension reduction methods.

We compared the coefficients and test error of the PCR model to other dimension reduction models based on machine learning algorithms- called Lasso, elastic net, and ridge regression.

Compared to the OLS, which has a high probability of multi-collinearity problems, PCR coefficients had valid degrees and directions consistent with the existing literature. In general, the PCR coefficients were similar tendency corresponded with the results from the machine learning algorithm such that unmet medical needs, religious activities, aging index, the proportion of single-person households, and urbanization of the region were significant factors. On the other hand, the number of essential clinics and the degree of social trust in communities showed different tendencies in the PCR model compared to the other models.

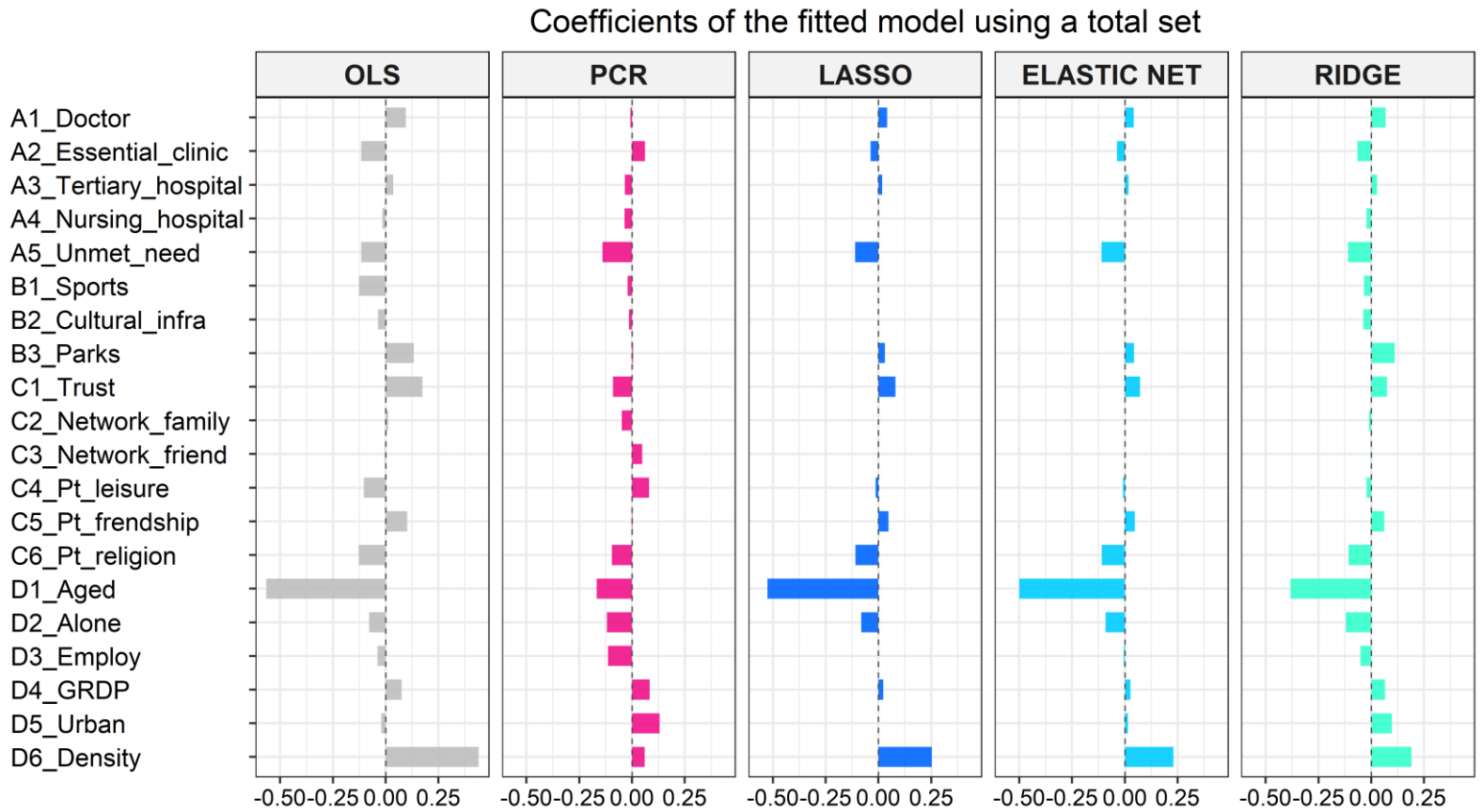


Figure S4-5. Comparison between OLS, PCR, and machine learning algorithm

Chapter 5.
Spatial dependences of social resources on health-related quality of life

Chapter 5.
Spatial dependences of social resources on health-related quality of life

5.1. Introduction

According to Tobler's first law of geography, "everything is related to everything else, but near things are more related than distant things (Tobler, 1970)". This insight still holds up in the discourse of the health domain. Aside from the geographical principle, some sociological and historical reasons evoke spatial patterns in social determinants of health.

5.1.1. Study backgrounds

Ecological differentiation, which partially stems from a community's social-structural characteristics, is very much a **spatial affair** (Sampson et al., 1999; Sampson et al., 2002; Sampson et al., 1997; Wilson, 2012).

The macroeconomic system, demographical changes, and governmental policies have incited the disproportionate *concentration of poverty or affluence* in specific regions, resulting in neighborhood differentiation. This *social stratification by place*, in turn, intensifies the social isolation of the deprived families from supportive networks and collective efficacy, which can bring opportunities for social life and be a vital resource (Sampson et al., 1997; Wilson, 2012)

In addition, social capital effects on health have heterogeneity depending on the urban context and population subgroup (Kim & Kawachi, 2006). residential instability regarding residential tenure or homeownership weakens the social network system and disrupts institutional relationships and community context (Sampson et al., 1999; Sampson et al., 1997)

Furthermore, it is worth noting that benefits from the neighborhood effect can be created, operated, and diffused only if the availability of institutional resources is insured. Leventhal and Brooks-Gunn (2000) delineated the essential prerequisites regarding neighborhood residences for population well-being and adolescent development. The community resources and traits shall include access to public resources that produce activities and provide welfare, access to medical services, and opportunities for employment in the community. Furthermore, they emphasized not only the presence of institutional resources but also their actual accessibility, affordability, and quality of services. (Leventhal & Brooks-Gunn, 2000).

Taken together, the accessibility or acceptability of the resources (facilities) can differ depending on the nature of the community. Furthermore, it is a critical concern whether healthcare resources are sufficient to meet the community's needs. In addition, it is not just the overall amount of medical resources that determine the quality of population health, but the even distribution between communities. These entangled characteristics of communities vastly– but even unconsciously – affect health.

As a result of Chapter 4, it was revealed which resource types affect HRQoL at the community level. However, there was no answer as to how they worked from a geographical perspective or to what extent social resources interacted with each other.

5.1.2. Study design and objectives

It is valid to suppose that each region has different effectiveness and significance on the health effect of social capital because the health impact of social capital is affected by regional and spatial characteristics.

Therefore, the primary issue of this study is to assess the effect of social capital on health-related quality of life (i.e., HRQoL) by districts. In particular, we investigate which social capital type has a significant contextual effect (regional sensitivity) on health. Detailed research hypotheses are as follows.

(1) HRQoL is spatially clustered, indicating global and local spatial autocorrelation.

(2) Effect of social resources on HRQoL is better explained when considering geographical structure and spatial correlation.

(3) The effectiveness and its statistical significance of social resources on HRQoL vary across districts.

5.2. Methods

5.2.1. Data collection and variables

Because this chapter is designed to be linked to Chapter 4, I reused the dataset in Chapter 4 and applied the same variable definitions. Detailed information of variables are described in Table 4-1 (in Chapter 4).

At first, I the selected eleven variables that were highly influence HRQoL in Chapter 4—(1) the number of essential clinics, (2) unmet medical needs, (3) Trust, (4) Participation in leisure activities, (5) Participation in religious activities, (6) Aging index, (7) Single-member household, (8) Employment rate, (9) GRDP per capita, (10) Urbanization of city, and (11) Population density. Secondly, since the spatial analysis method applied in this study is vulnerable to the multi-collinearity issue, it went through the variable selection process once again, as described in Appendix). Finally, among these eleven variables, eight variables were selected in final model (Table 5-1). To adjust the scale of variables in the analysis, variables were standardized.

In sum, ***Health-related Quality of life (EQ-5D index)*** *were* summarized and scored the EQ-5D indicators as an index using sampling weights from a South Korean study described elsewhere (Lee et al., 2009). ***Social capital*** was identified with two components: social trust and social participation with religious activities. The unmet medical needs was combined in the analysis, as a representative of ***Healthcare Resources***

availability. Regarding ***Regional characteristics,*** physical, environmental, economic, and demographic factors of the community were collected to cover regional traits.

A map for geographical distributions was obtained via a location-based open service platform of South Korea (https://sgis.kostat.go.kr). The Coordinate Reference Systems (CRS) was set of 'WGS84'.

Table 5-1. Selected independent variables in 2011, 2015, and 2019

Variable	**Definition**	**Publisher**
Essential clinics	No. of essential clinics per 100,000 residents	NHIS, HIRA
Unmet medical needs	% of the survey respondents answered they did not receive the necessary healthcare in the past year	KDCA
Social trust	% of the survey respondents who answered they believe and trust their neighbors and society	KDCA
Participation in religious activities	% of the survey respondents who have participated in religious activities more than once a month	KDCA
Aging index	Aged-child ratio (65+/ <15 aged)	MOIS
Single-member households	% of single-person households	Statistics Korea
Employment rate	% of the employed among those over the age of 15	Statistics Korea
Urbanization of city	% of the people living in the urban area of the region	LX

Notes: 2011 year -253 spots - 229,226 people; 2015 year -254 spots - 228,558 people; 2019 year - 255 spots - 229,099 people

5.2.2. Statistical Analyses

This study conduct spatial analysis with the concern of different time period in 2011, 2015, and 2019.

Spatial autocorrelation. A spatial weight matrix for 250 districts of South Korea was set using the k-nearest neighbors (KNN) algorithm. The optimal k was designated as six. To test whether spatial clustering is globally significant, we examined statistics and z-scores of Global Moran's I index. We then calculated Local Moran's I and depicted the corresponding regions of statistical significance to detect the spatial correlations (i.e., specific hot spot and cold spot).

Geographically Weighted Regression (GWR). To assess the spatial heterogeneity of social capital on HRQoL, we used Geographical Weighted Regression (GWR) analysis. It explores spatial non-stationarity (Brunsdon et al., 1998) and a method of nonparametric regression analysis that determines and applies spatial weights using nonlinear kernel functions. GWR can account for both "heterogeneity of interregional regression relations" and "spatial dependence." (Fotheringham et al., 2003). As the GWR model is sensitive to multicollinearity, we confirmed whether each variable are under five score of variance inflation factor (VIF) in OLS or not, in turn, then conducted GWR model. The bandwidth of the kernel in GWR model was calculated based on cross-validation (CV) and Akaike Information Criteria (AIC), respectively. Then, a final model was selected by comparing model fit statistics among models with two bandwidths (Gollini et al., 2014).

K-means clustering of the GWR coefficients. GWR results provide an individual set of coefficients for each region. It is advantageous for localized calibrations with a better description, reducing spatial autocorrelation in the model. On the other hand, these heterogeneities with numerous coefficients are challenging to interpret (Fahy et al., 2019). Therefore, the spatial grouping of the GWR results is valid for identifying and delineating distinct spatial settings (Wimberly et al., 2008).

In this regard, we applied K-means clustering to cluster homogeneous features of the GWR results (i.e., coefficients). To determine the optimal number of clusters, we analyzed the gap statistic method. We then calculated the t-values by cluster to enhance the interpretability and characterize each cluster group.

To calculate basic statistics considering survey sampling weights, we used PROC SURVEYMEANS statement of SAS software 9.4. version. We used R, QGIS, and GeoDa software to conduct spatial analyses.

Table 5-2. Descriptive statistics of HRQoL and social resources in 2011, 2015, and 2019

Variable	2011 (N = 229,226)			2015 (N = 228,558)			2019 (N = 229,099)		
	N	Mean*	S.D. (S.E. of %**)	N	Mean*	S.D. (S.E. of %**)	N	Mean*	S.D. (S.E. of %**)
Health outcome* **									
HRQoL index (Mean, SE)	228,984	0.946	0.000	228,493	0.947	0.000	229,016	0.945	0.0003
Problems with EQ-5D 1 (%)	229,189	10.7	(0.1)	228,552	10.8	(0.1)	229,089	10.2	(0.1)
Problems with EQ-5D 2 (%)	229,196	3.5	(0.0)	228,556	3.6	(0.0)	229,096	3.5	(0.0)
Problems with EQ-5D 3 (%)	229,198	8.2	(0.1)	228,553	7.9	(0.1)	229,096	7.1	(0.1)
Problems with EQ-5D 4 (%)	229,190	23.0	(0.1)	228,551	23.8	(0.1)	229,091	27.0	(0.1)
Problems with EQ-5D 5 (%)	229,017	14.4	(0.1)	228,502	13.0	(0.1)	229,028	13.5	(0.1)
Healthcare resources									
Essential clinics (No. of, per 100K)	251	14.5	6.6	252	14.7	6.7	250	15.6	7.4
Unmet medical needs (%)	229,172	13.8	(0.1)	228,546	11.7	(0.1)	212,713	6.0	(0.1)
Social capital									
Social trust (%)	193,462	64.5	(0.2)	213,794	61.3	(0.2)	212,257	62.8	(0.2)
Social participation in religious activities (%)	229,061	29.4	(0.2)	228,547	27.3	(0.2)	229,080	26.5	(0.2)
Socioeconomic status									
Aging index	251	1.2	0.9	252	1.6	1.1	250	2.1	1.4
Single-member households (%)	251	26.0	5.6	252	29.1	5.2	250	31.8	4.9
Employment rate (%)	251	58.6	5.2	252	61.9	5.6	250	62.5	5.3
Urbanization of city (%)	251	75.3	27.5	252	76.3	26.7	250	76.7	26.5

Note: * For CHS data; Survey weights and sampling design information are considered for each year. ** Standard error of percent.

***Percentage indicates the proportion of the person who answered having “some problems” or “severe problems”, rather “no problem”.

5.3. Results

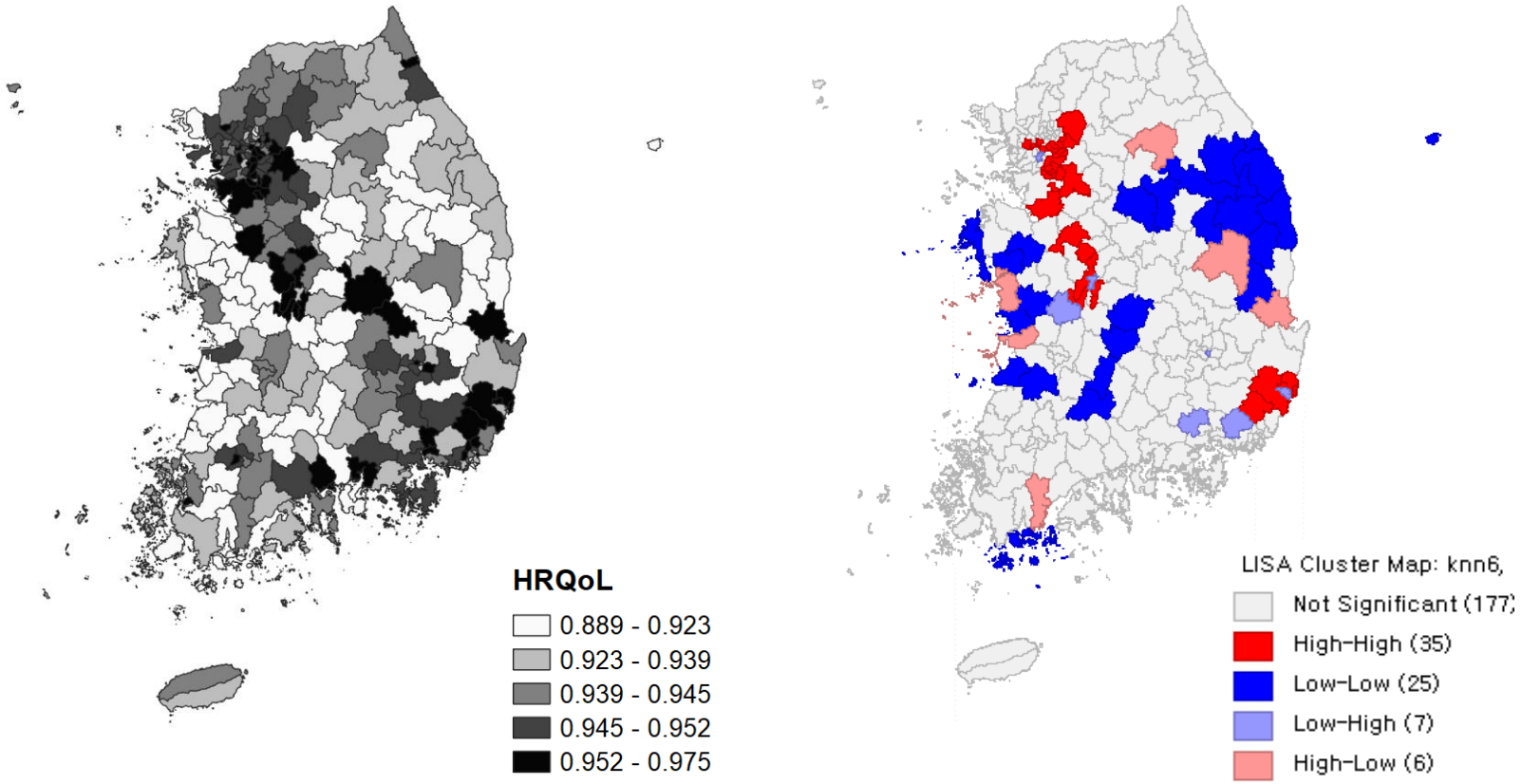
5.3.1. Geographical distribution and spatial correlation

Figure 5-1 describes the geographical distribution of HRQoL and its spatial autocorrelation aspects. Seoul - a metropolitan city - and near central regions showed significant clustering high-scores of HRQoL, indicating the 'hotspot.' Instead, the east and west side near the sea showed significant clustering of negative scores, called 'cold spots.'

Table 5-3 shows that the global index for spatial autocorrelation (Global Moran's I = 0.286) was statistically significant. These results imply that spatial analysis needs to be considered.

Table 5-3. Global Moran’s I of HRQoL

HRQoL	index	z-score	p-value
Global Moran's I	0.286	8.7618	0.001



(A) Distributions of HRQoL

(B) Hot spot of HRQoL (LISA)

Figure 5-1. Geographical distribution (A) and spatial autocorrelation (B) of HRQoL in 2019

5.3.2. Geographical weighted regression (GWR)

The GWR coefficient estimates vary across districts, and the number of regions with significant coefficients also varies by each indicator (Table 5-4). Social trust is likely to increase HRQoL, and the relationship was statistically significant in 119 regions among 250 districts (47.6%). Instead, people who highly participate in religious activities tend to have lower HRQoL in 44.8% of regions. The aging society was strongly associated with lower HRQoL across regions. The high degree of urbanization and low degree of unmet medical needs correlated with higher HRQoL.

In the Appendix B, we showed the results of OLS and spatial autocorrelation in each model's residual. The results showed GWR performs better compared to OLS.

Table 5- 4. Summary of GWR coefficient estimates (2019)

	Distribution of the GWR Coefficients					**Global**	**# of sig. region (N=250)**
	Min.	**Q1**	**Median**	**Q3**	**Max**		
Essential clinics	-0.223	-0.034	0.021	0.053	0.212	0.000	0
Unmet medical needs	-0.227	-0.176	-0.140	-0.104	0.112	-0.126	128
Trust	-0.241	0.099	0.144	0.218	0.243	0.093	119
Religious activities	-0.244	-0.176	-0.098	-0.063	0.109	-0.085	112
Aging index	-0.995	-0.693	-0.550	-0.473	0.233	-0.523	226
Single-member household	-0.469	-0.124	-0.074	-0.028	0.093	-0.066	42
Employment rate	-0.192	-0.108	-0.091	-0.064	0.126	-0.056	4
Urbanization	-0.013	0.175	0.237	0.288	0.594	0.192	120
Intercept.	-0.144	-0.042	-0.033	0.009	0.201	0.000	
Kernel function			Gaussian				
Fixed bandwidth			92.3				
Number of data points			250				
AICc			544.7				
AIC			504.2				
Residual sum of squares			97.7				
Quasi-global R2			0.608				

5.3.3. GWR significant coefficients in 2019

Figure 5.6 indicates the significant GWR coefficients of each social resource on HRQoL. The white shading on the map indicate the region of non-significance effect on HRQoL.

The positive effectiveness of social trust (i.e., GWR coefficients) were regionally clustered around Seoul and Gyeonggi-do, and the value of coefficients decreased farther away from Seoul. Negative associations between religious involvement (social participation in religious activities) and HRQoL were clustered around Busan, Ulsan, and Gyeongsangnam-do areas.

Unmet medical needs indicated a more substantial negative effect among the eastern regions, including inland areas. The negative impact of aging on HRQoL spread globally. Urbanization showed a negative association with health in the western region

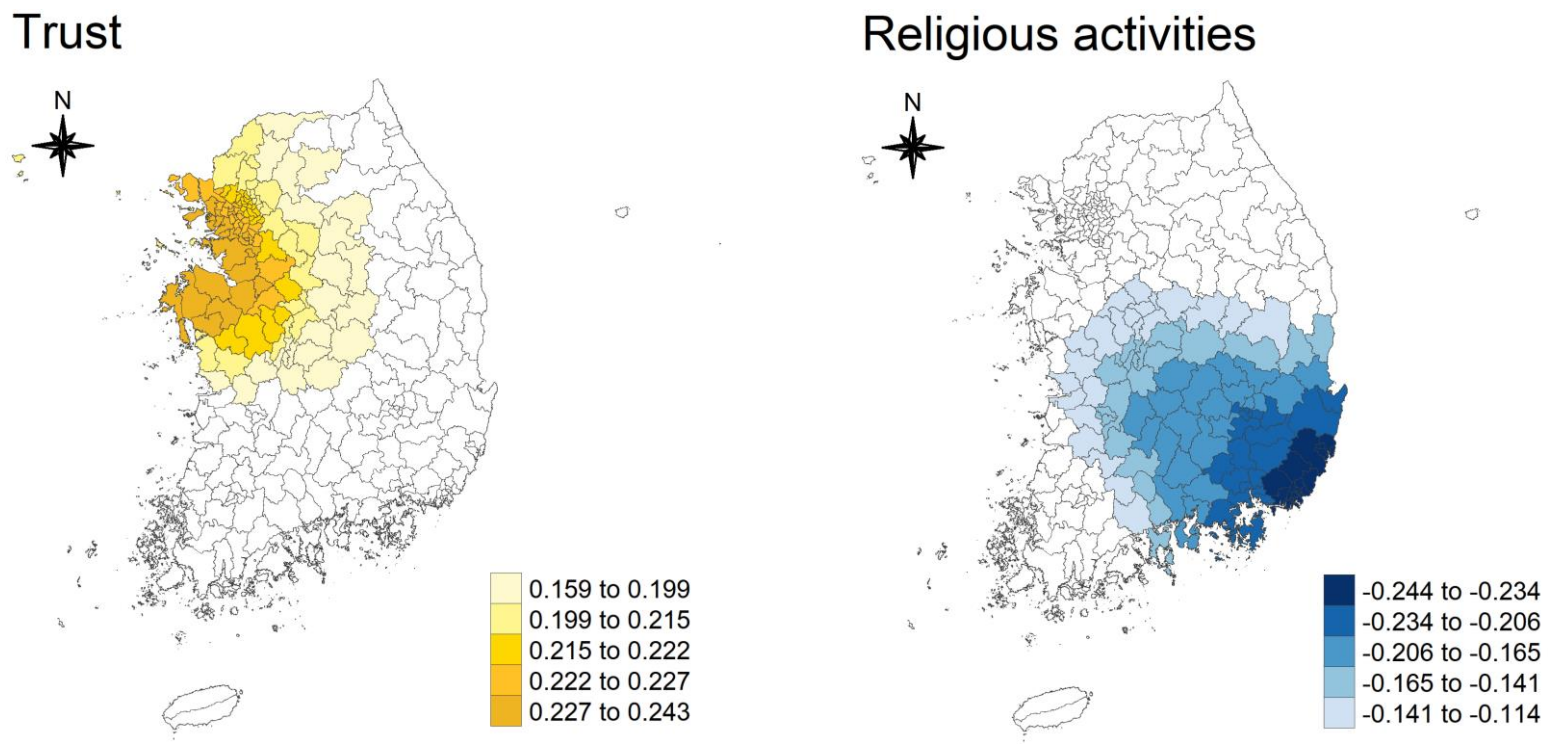


Figure 5-2. Spatial heterogeneity in GWR coefficients with statistical significance for each variable

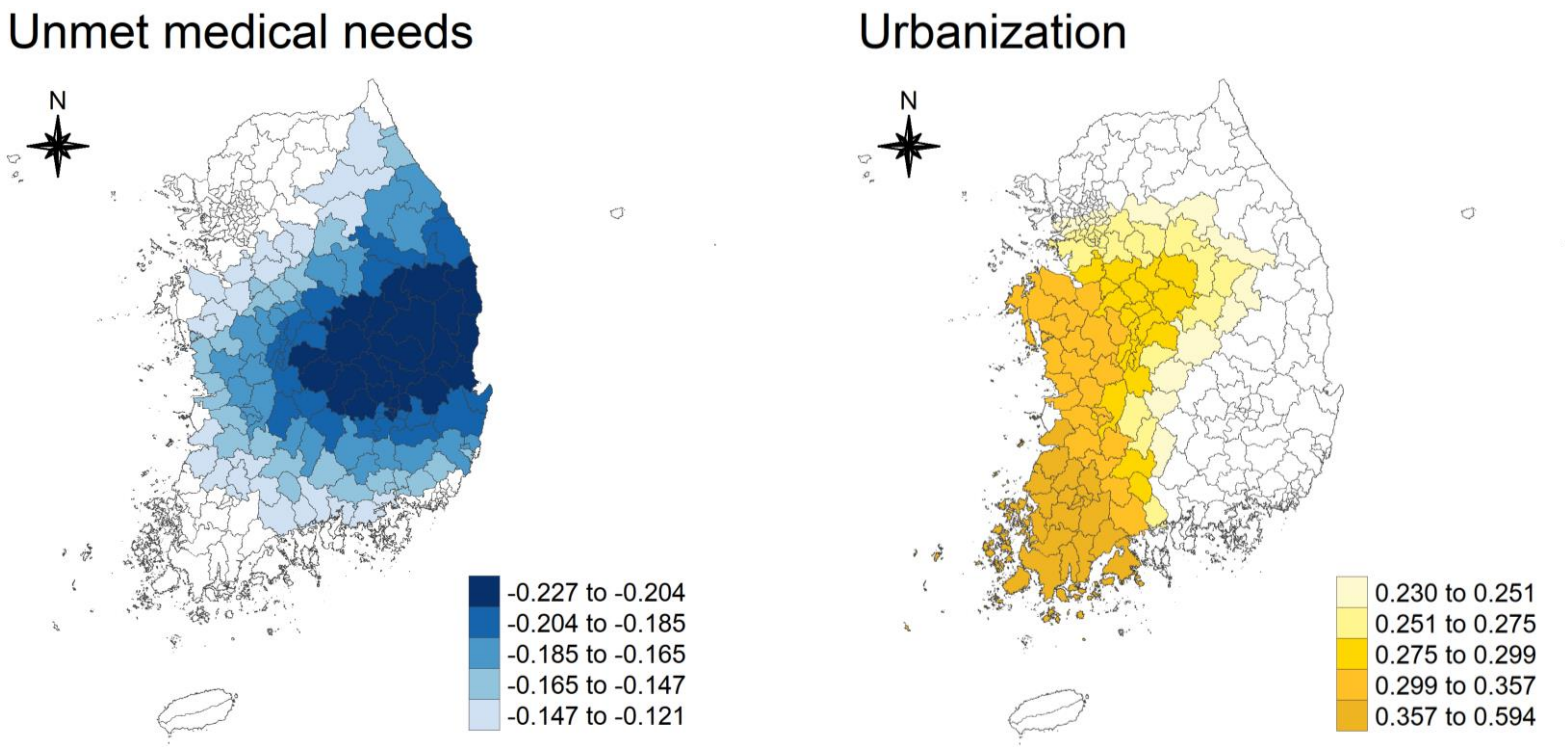


Figure 5-2. Spatial heterogeneity in GWR coefficients with statistical significance for each variable (Cont'd)

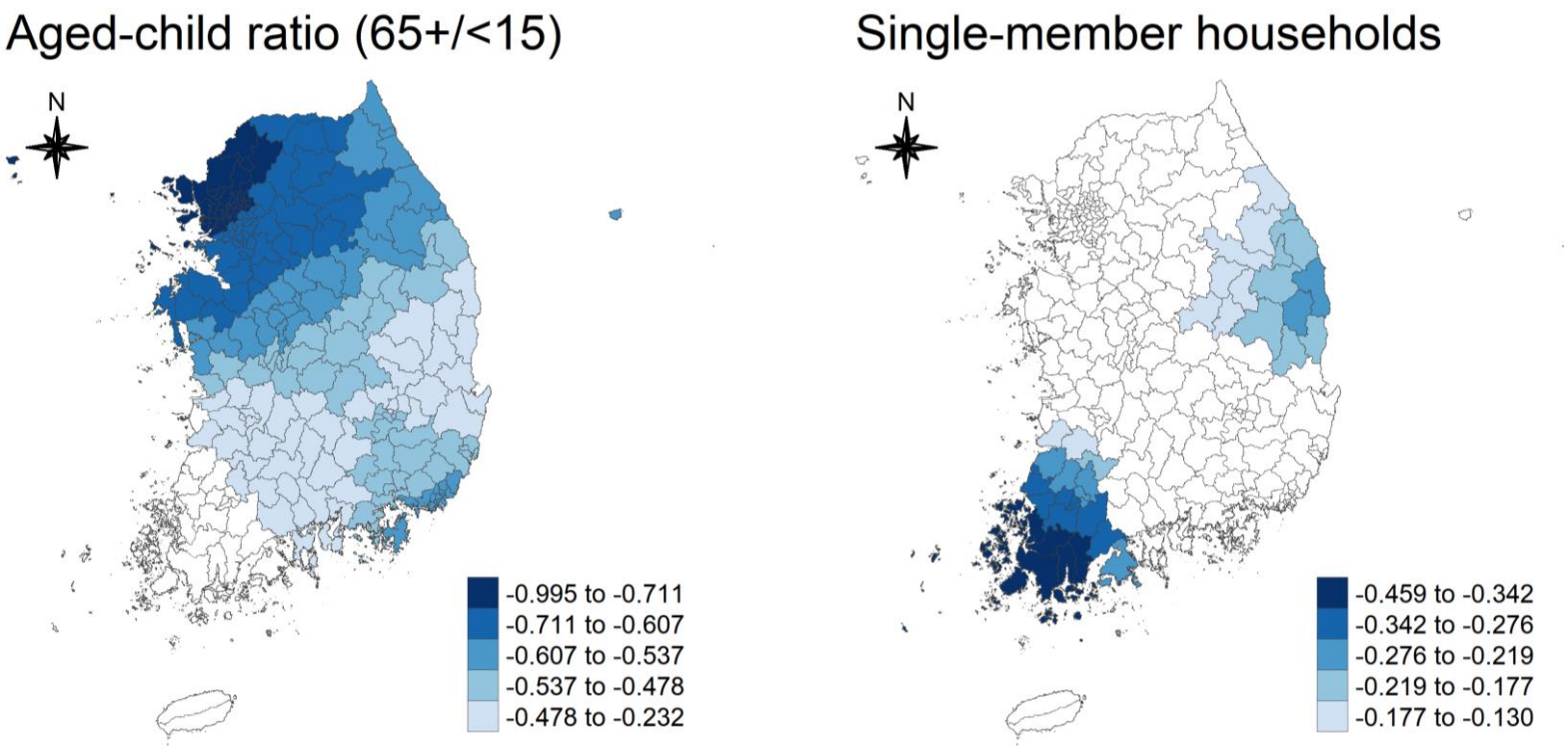


Figure 5-2. Spatial heterogeneity in GWR coefficients with statistical significance for each variable (Cont'd)

5.3.3. GWR coefficients clustering in 2019

K-means clustering was conducted to obtain the distinct zone which share similar GWR coefficients features on variables. The geographical mapping illustrated the five clusters (Figure 5-3). The mean of GWR t-values by clusters were described in Figure 5-4.

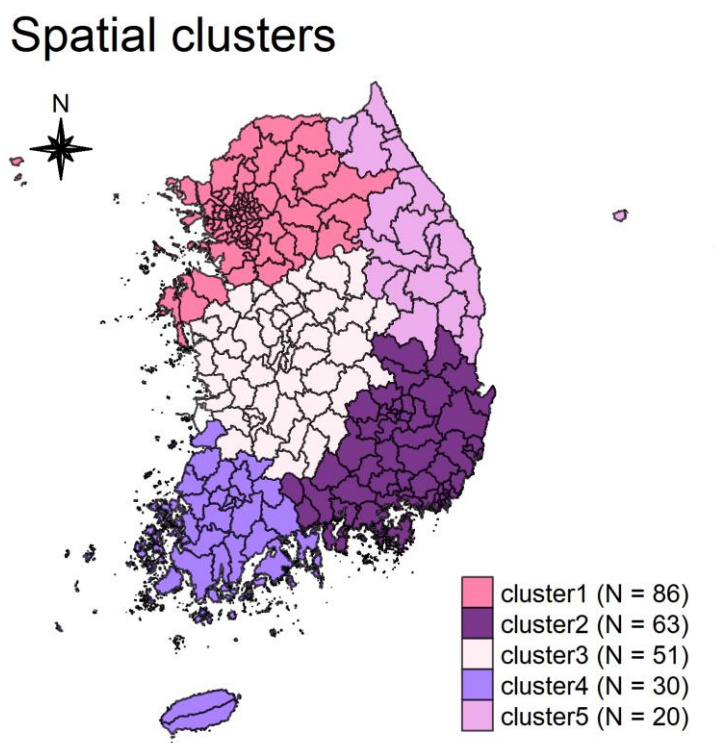


Figure 5-3. Spatial clusters of GWR coefficients in 2019

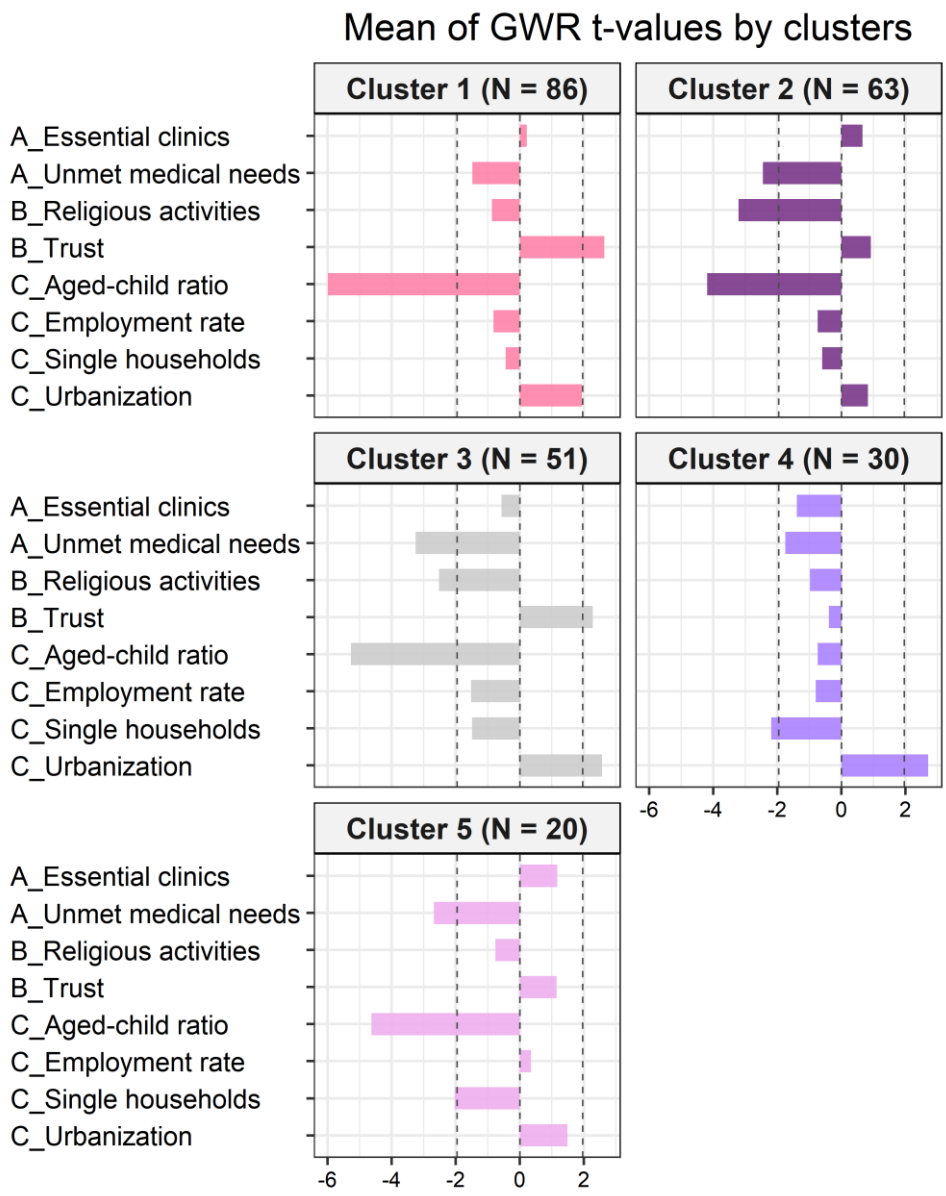


Figure 5-4. Mean t-value of each GWR coefficients by clusters

Cluster 1 indicates the positive effect of social trust on health but was primarily affected by the age structure. Cluster2 and 3 showed a similar tendency; they negatively correlated religious activities, unmet medical needs, aging index, and health, respectively. Cluster 4 is the area with a slight health impact depending on urbanization. Lastly, cluster 5 is the region affected by "structural resources" to health, including the community's age structure, single-member households, and unmet medical needs. The descriptive statistics of each variables were described in Table 5-4.

5.3.4. GWR Clusters in 2011 and 2015

To validate the consistency of the clusters derived in 2019, the GWR modeling and k-means clustering in 2011 and 2015 were repeatedly applied using same set of variables in 2019. Clusters centered on Seoul and Busan showed consistent tendencies for about 10 years (2011-2019), implying strong 'Regionality'.

Table 5-5. Descriptive statistics of GWR clusters

	Cluster 1 (N = 86)		**Cluster 2 (N = 63)**		**Cluster 3 (N = 51)**		**Cluster 4 (N = 30)**		**Cluster 5 (N = 20)**	
	M	**(SD)**	**M**	**(SD)**	**M**	**(SD)**	**M**	**(SD)**	**M**	**(SD)**
HRQoL	0.945	(0.012)	0.941	(0.017)	0.934	(0.019)	0.931	(0.018)	0.924	(0.019)
Essential clinics	17.3	(6.2)	16.0	(9.5)	16.5	(5.0)	12.4	(6.3)	9.3	(7.8)
Unmet medical needs (%)	5.9	(2.8)	5.8	(2.7)	6.8	(3.4)	7.2	(4.0)	6.0	(2.9)
Trust (%)	62.3	(10.0)	67.6	(10.8)	71.0	(11.2)	76.4	(10.6)	78.3	(5.8)
Religious activities (%)	28.9	(5.0)	20.0	(5.8)	26.8	(7.3)	25.4	(4.7)	21.5	(5.1)
Aging index	1.4	(0.7)	2.4	(1.7)	2.2	(1.3)	2.8	(1.5)	3.0	(1.1)
Single-member household (%)	29.6	(5.7)	31.8	(5.1)	33.0	(2.7)	33.9	(3.7)	34.8	(2.8)
Employment rate (%)	60.8	(4.1)	61.0	(5.5)	63.7	(4.8)	66.4	(5.2)	65.7	(6.4)
Urbanization of city (%)	89.5	(20.8)	78.4	(27.1)	67.4	(24.6)	61.9	(27.2)	62.3	(24.8)

Abbreviations: Mean (M), Standard Deviation (SD)

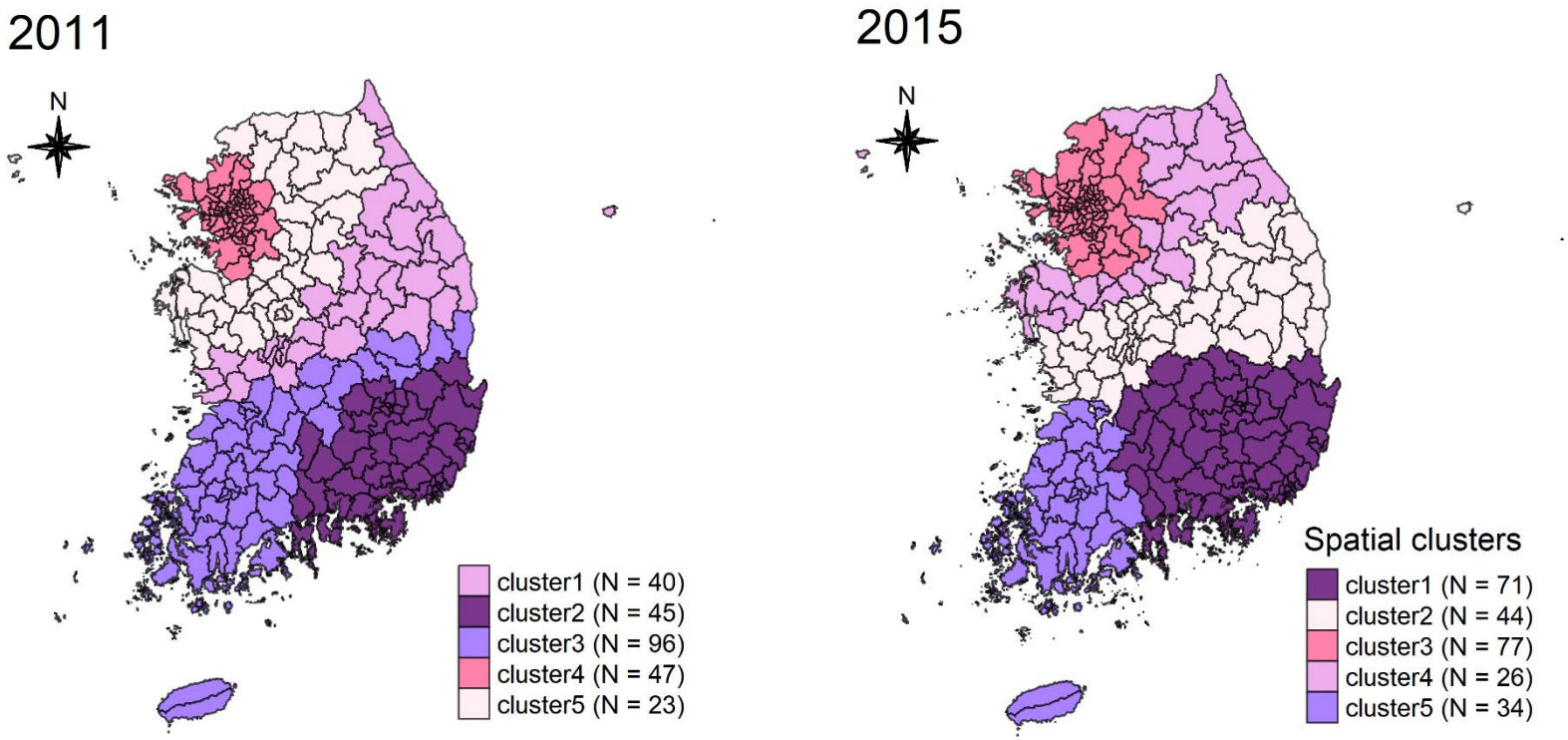


Figure 5-5. Spatial clusters based on GWR in 2011 and 2015

Notes: We applied GWR and K-means clustering with the same set of explanatory variables described in Table 5.1.

5.4. Discussion

This study assessed the health impact of diverse social resources across regions. We found that the HRQoL was geographically clustering. Spatial analysis, therefore, is more suitable to assess the determinants of HRQoL than the typical regression model. The effect of social capital on health varies by regions, but at the same time, it shares the effectiveness within a specific area range.

5.4.1. Different effectiveness across regions

The most exciting result of this spatial analysis is that the resources effectiveness on health differs across regions. For instance, social trust serves as a crucial social resource around Seoul and Gyeonggi-do areas but has not affected health in the other regions. People with lower HRQoL were more likely to participate in religious activities around the Gyeongsangnam-do area. Residents of single-member households living in rural areas around Gwangju are at high risk of decreasing HRQoL. However, those with similar conditions near Busan relatively do not affect HRQoL. Meanwhile, regional population structure (aged-child index) and the degree of unmet medical needs determined the HRQoL level across regions.

These findings tell us; social resource effects on health varies across regions and it seems to be a neighborhood effect as a moderator. Depending on the community context, the community acts as a buffer or catalyst for the

relationship between personal risk factors and mental health (Cutrona et al., 2000).

5.4.2. Social trust

Social trust contributes to effective and smooth social functioning and social relationship. In particular, countries with greater income inequality have lower level of social trust (Wilkinson & Pickett, 2011) In democratic society, trust allow people to cooperate with each other (Fukuyama, 1996).

Meanwhile, trust is high in areas with a high level of homogeneity between neighbors (Portes & Vickstrom, 2015). Therefore, trust is considered an indicator of social cohesion (Jen et al., 2010). As a cognitive dimension, trust favors a strong tie and plays a critical role in shaping values and sharing vision among network members (Parra-Requena et al., 2010).

Interestingly, Seoul and Gyeonggi-do areas are less likely to be homogeneous as they are metropolitan. Nevertheless, our results of high significance in those regions indicate that social capital is a more valuable resource in Korean society.

5.4.3. Religious social capital.

Traditionally, religious institution is correlated with social support that enhance health. Putnam (2016) states the capacity and importance of religious institutions to support families at socially and economically risks. Religious involvement is a less class-biased social activity than the others. On the other

hand, its effect is much more prominent in the poor than in the rich, because the rich can be more exposed to other positive resources that the poor cannot. When resources or capacities of families are not abundant to protect children and cope with problems, the religious institutions can provide safeguards (Putnam, 2016) p.224.

However, in this study, religious social capital was negatively associated with HRQoL near Busan area, suggesting that religious social capital contains a distinct regionality. This negative association can be interpreted as the deprived are more likely to lean on religion. Maselko et al. (2011) claim that levels of religious social capital were correlated with high levels of urban stressors (i.e., the stress sources in urban life such as money, finances, crime, violence, transportation). People who regularly attend religious services reported a higher level of urban stress (Maselko et al., 2011). This kind of latent nature of urban life in Busan and Gyeongsangnam-do could affect the association.

Furthermore, a deprivation-compensation theory also support this negative association. Individuals near the bottom of the stratification system tend to rely on religion to compensate for their lack of secular resources (Norris and Inglehart 2004; Kim, 2022).

5.4.4. Change pattern of GWR clusters over time

For an in-depth understanding of neighborhood effects, Sampson (2002) claimed that future research should consider spatial and temporal dynamics

in neighborhood social processes (Sampson et al., 2002). In this regard, I repeatedly conducted GWR in 2011, 2015, and 2019.

There are conspicuous changing patterns regarding the shape and centroid of GWR clusters in each year. In particular, an inland area of the Chungchung-do cluster, a composite of Sejong, Deajeon, and Chungchung-do, turned into a circle shape with a centripetal point over time. There can be two interpretations of the changes in the cluster shape.

Firstly, Korean administrative areas were renewed in 2012 such that Sejong City has become the administrative capital. Many administrative agencies and government research institutes moved into Sejong city. As the commercial district grew, Sejong also influenced the adjacent Daejeon and Chungcheong-do areas, and various resources gathered and activated in the Chungcheong-do area.

Secondly, these variations may result from the model fitness. We applied the same variable set to 2011, 2015, and 2019 GWR models to ensure comparability. As the variables were selected for best fitting to 2019 through chapter 4, the 2011 and 2015 GWR models' fitness was not as good as the 2019 model.

5.4.5. Limitations

This study did not measure collective efficacy directly. Instead, it indirectly interpreted the aggregated social capital as collective efficacy. Furthermore, the study design was not organized in multilevel research, which usually

composed the individual and community level and analyzed each variance to the outcome.

There are another inevitable limitation in this study as a spatial analysis. When defining the community, the modifiable areal unit problem (i.e., MAUP) evoked (Pfeiffer et al., 2008). There were several researches that defined and measured a community as a cluster based on geographical proximity and similar socioeconomic status. However, due to the limitations on dataset, we used administrative boundaries as proxies of neighborhoods.

Lastly, we cannot confirm the causal inferences between social capital and health because of the cross-sectional survey design. Due to the inevitable limitation of cross-sectional data, a causal association cannot be guaranteed.

Notwithstanding the limitations, this research improves the understanding of the impact of each social capital type on health through a geographical approach.

5.5. Supplementary data

Appendix A. Spatial distributions of HRQoL in 2011, 2015, and 2019

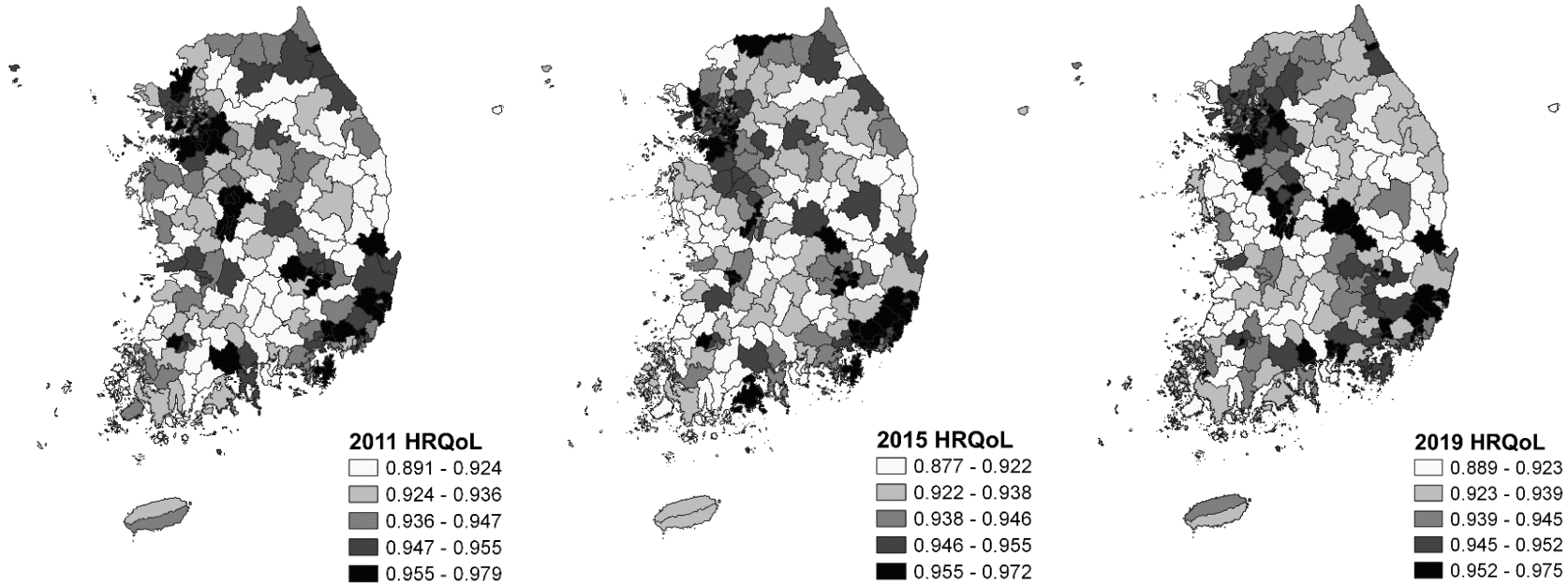


Figure S5-1. Spatial distribution of health-related quality of life in (A) 2011, (B) 2015, and (C) 2019

Note: Divided by quantiles

Appendix B. Detailed information on the 2019 GWR modeling

Model selection. We involved the valid sets of 10 variables which were selected in Chapter 4 (PCR results) at first stage. The combination of the selected 8 variables which excluded 'population density' and 'participation in leisure activities' variables from primary set, indicated the lowest AIC. We, therefore, used the selected variables in this GWR modeling chapter.

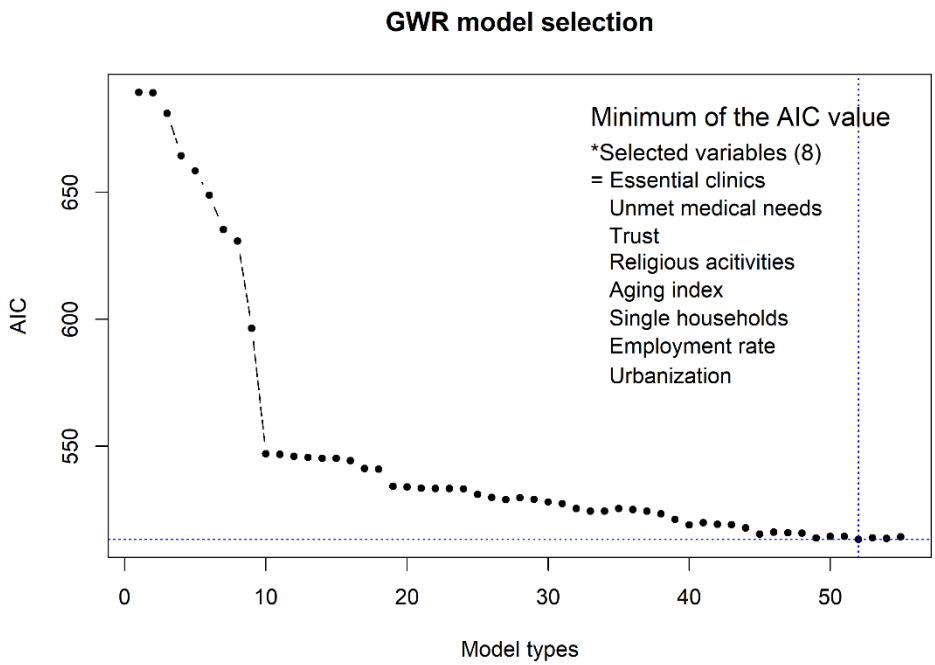


Figure S5-2. AIC criteria for the GWR model selection

Model fitness of the 2019 GWR model across regions. Figure S.5.3. showed the spatial distribution of local R2 from the fitted GWR model in 2019. The quasi-global R2 value of the GWR model was 0.638 (Table 5.1.). The high score of the R2 value corresponds that the GWR model improves the fitness of the regression model. When GWR considers local features as weights, the local R2 range from 0.418 to 0.752, implying different degrees of fit across regions. The GWR model fitness for the region increases moving towards inland area.

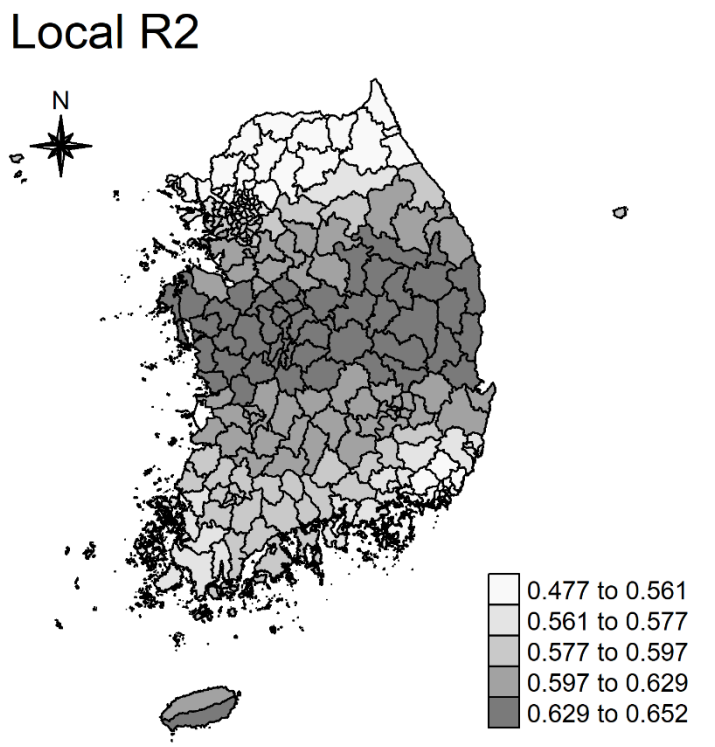


Figure S5-3. Spatial distributions of the Local R2 for GWR model

Mean t-value of coefficients by 2019 spatial clusters.

Table S5-1. Mean t-value of each GWR coefficients by clusters

	Cluster 1 (N = 86)	**Cluster 2 (N = 63)**	**Cluster 3 (N = 51)**	**Cluster 4 (N = 30)**	**Cluster 5 (N = 20)**
Essential clinics	0.22	0.66	-0.57	-1.39	1.17
Unmet medical needs	-1.49	-2.45	-3.26	-1.75	-2.68
Trust	2.63	0.92	2.28	-0.39	1.15
Religious activities	-0.88	-3.21	-2.52	-0.98	-0.76
Aging index	-6.00	-4.19	-5.27	-0.74	-4.63
Single-member household	-0.44	-0.60	-1.50	-2.19	-2.03
Employment rate	-0.82	-0.74	-1.52	-0.80	0.35
Urbanization of city	1.93	0.83	2.57	2.71	1.49

Comparison between GWR and OLS in 2019. Compared to OLS, GWR performs better with the lower AIC and higher adjusted R-square values (Table S5-1). Moreover, the spatial autocorrelation in the residual derived from GWR disappeared, while residual of OLS remained. It indicates the issue of spatial autocorrelation still unresolved in OLS model.

Table S5-2. Model comparison: OLS and GWR model on HRQoL (2019)

	OLS			**GWR**	
	β	**Pr(>|t|)**	**VIF**	**Global β**	**# of significant regions**
Essential clinics	0.000	0.997	1.91	0.000	0
Unmet medical needs	-0.126	0.008 **	1.09	-0.126	128
Trust	0.093	0.162	2.15	0.093	119
Religious activities	-0.085	0.072 .	1.09	-0.085	112
Aging index	-0.523	0.000 ***	3.40	-0.523	226
Single-member Households	-0.066	0.277	1.81	-0.066	42
Employment rate	-0.056	0.418	2.34	-0.056	4
Urbanization of city	0.192	0.038 *	4.15	0.192	120
(Intercept)	0.000	1.000		0.000	
Adjusted R^2	0.4913			0.608	
AIC	551.3			504.2	

Note: For all variables in each model, the VIF was less than 5 points. Every variable was standardized.

Appendix C. Sensitivity analyses: Validation of the ‘religious activities’ coefficient

We measured whether confoundings cause the geographical effect of religious activities or not. In Appendix C described in Chapter 4, the correlation matrix showed that ‘religious activities’ are positively correlated with frequent leisure activities of residents, the number of parks in the region, and population density. However, the people engaged in more religious activities are less likely to network with their family or friends.

Therefore, we involved the above relating factors stepped by step into the GWR modeling and evaluated the changes in the coefficient of religious activities.

Table S5- 3. Global GWR coefficients for model correlated with the Religious activities in 2019

	GWR Model 1	**GWR Model 2**	**GWR Model 3**	**GWR Model 4**	**GWR Model 5**	**GWR Model 6**
Religious activities	**0.034**	**-0.117**	**-0.070**	**-0.140**	**-0.141**	**-0.142**
Leisure activities		0.420	0.275	0.095	0.096	0.097
Parks			0.384	0.292	0.289	0.289
Population density				0.443	0.436	0.436
Network with family					-0.015	-0.012
Network with friends						-0.004
Bandwidth selection method	AIC	CV	CV	CV	CV	CV
Fixed bandwidth	91.3	33.3	63.5	74.5	91.3	88.8
AICc	692.8	654.4	615.3	577.8	579.4	581.0
AIC	682.7	584.5	583.8	548.1	552.6	548.1
Residual sum of squares	218.1	126.3	137.5	119.8	122.9	118.7
Quasi-global R2	0.124	0.493	0.448	0.519	0.506	0.523

Abbreviation*:* Cross-validation (CV), Akaike information criterion (AIC)

Notes*:* Kernel function = Gaussian; Number of data = 250

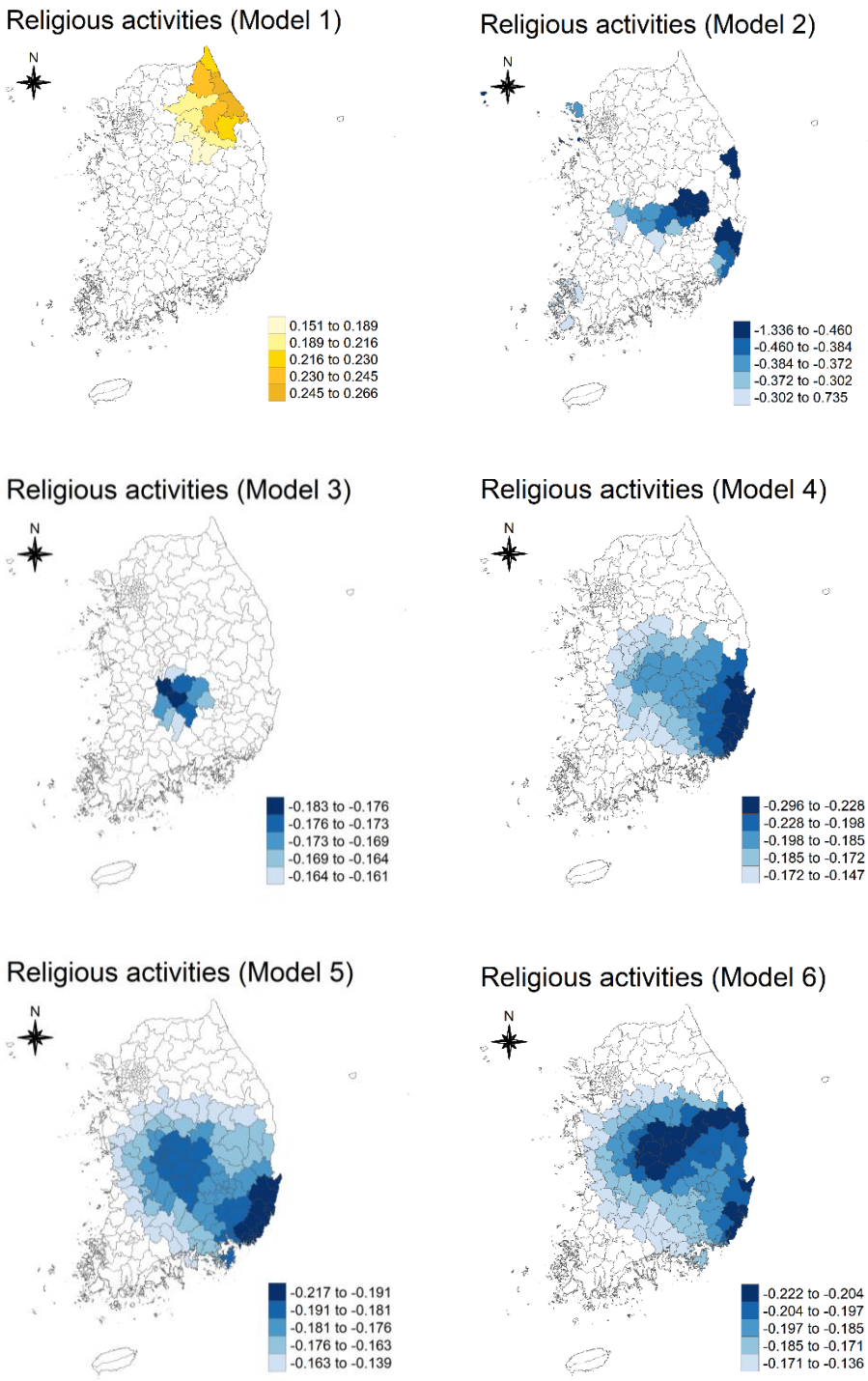


Figure S5-4. Validation for confounding effect of the religious activities in GWR models

Chapter 6.

Overall discussion

Chapter 6.
Overall discussion

6.1. Summary of the studies (Chapter 2-Chapter5)

Chapter 2 shows that household members have different perceptions of their household social status, although they share material resources within the same living space. The reliability of SSS among household members was moderate to good but decreased when there were underage children. Household wealth and housing conditions were strong determinants of household SSS. Responsibilities related to family roles can drive people to estimate a low SSS relative to objective status. Social policies that support the socioeconomic stability of households may play a vital role in buffering social inequality.

Chapter 3 demonstrates that objective and subjective social status interact, forming a distinct trajectory in the life course. And changes in health-related quality of life are strongly influenced by these changes in the combined patterns of objective and subjective social status. As a result, we can conclude that the benefits from economic growth are concentrated on the advantaged while low-income groups are left behind. Income inequalities result in a lack of social mobility, both objectively and subjectively, and widen health disparities over time. A fast-growing and affluent society is at risk of inequitable health and unequal access to economic resources, which

condemns low-income households to a cycle of being disadvantaged and having a declining health status.

Chapters 4 and 5 illustrate how social resources in the community, such as social capital, neighborhood context, and built environment, are correlated with population health. Chapter 4 showed that the social resources that originate from communities are characterized by (1) structural environments (physical facilities), (2) supply and demand for healthcare, (3) bridging, bonding, and cognitive social capital, and (4) economic affluence. The actual availability of resources (e.g., unmet medical needs) matters for population health, not the number of facilities (e.g., number of tertiary hospitals). Unexpectedly, cognitive social capital, such as trust and religious activities, showed a reverse association with health. Nonetheless, significant neighborhood effects were observed.

Chapter 5 demonstrates the spatial heterogeneity of social resource effects on health. In particular, the positive effect of social resources on health has been limited to a specific region. It was confirmed that spatial heterogeneities among regions exist considering the effects of social resources. These spatial clusters, which are derived from the spatial analysis regarding resource effectiveness, prominently resemble the conventional administrative areas. These findings increase the significance of social capital as a policy target to decrease inequality and improve the health status of residents. In this regard, it highlights the importance of establishing tailored

community plans corresponding to regional resource distribution and effectiveness.

6.2. Framework of Multilevel Resource Distribution

This study considered a broad spectrum of resource types and their distribution across time and space to address health disparities. Despite the increase of individualism in society, results support the notion that the family context, social context, social capital, neighborhood effect, and built environment affect the population health.

Previous research has explained some of the diverse relationships between resources and their impact on (1) the social determinants of the health framework (*Y-axis*) and (2) the "Availability, Accessibility, Acceptability, and Quality" framework for the healthcare domain (*X-axis*). Here, Figure 6-1 indicates the consolidation and extension of these concepts into a comprehensive conceptual framework. The Y-axis is similar to multilevel approaches to SDH (World-Health-Organization, 2010). The front section of the figure illustrates the structure between the social class of the family, social relationships, the community environment, and society. These associations and nested structures have also been proposed in studies regarding SDH with multilevel perspectives.

When defining equity in healthcare, it is established based on the "equal access to available care for equal needs," "equal utilization for equal

needs," and "equal quality of care for everyone that assure equal opportunity and acceptability." (Whitehead, 1991). Health equity approaches provide insight into the importance of fairness and provide criteria to be met. Therefore, the *X-axis* of this framework borrows these concepts to show how SDH works and to provide the right basis for investigating the operation of SDH.

The *Distribution* section in this figure is interrupted between Volume and Effectiveness. Similarly, Whitehead (1991) emphasized evenly distributed resources and facilities around geographical areas and across populations. (Whitehead, 1991). Based on the study results, three primary distribution patterns can be classified as follows: Chapter 2 explains the variations in SSS between household members as indicators of unequal resource allocation by *family resource-sharing dynamics*. In Chapter 3, the results imply that South Korea may encounter growing income inequality and become a rigid society. Income inequality restricts social mobility and pins down one's perceptions of their social position, *strengthening social stratification*. This rigid social structure widens the HRQoL disparities over time. In Chapters 4 and 5, the various community resources were differently clustered and distributed across the region and associated with population health, which indicates *firm regionality and neighborhood effect*.

Previous health research has focused primarily on the fundamental section—e.g., the disproportionation of resources to target populations or regions. Previous studies have evaluated the social structure created by the

social context and whether social classes are accessible based on the volume of resources. However, this study is significant, as it emphasizes whether resources were adequately distributed and fully available to individuals.

This study has the limitation of not empirically addressing the acceptability, or mechanisms by which, resources indicate practical effects. Nevertheless, this framework provides a novel view of SDH and possible hypotheses for further research.

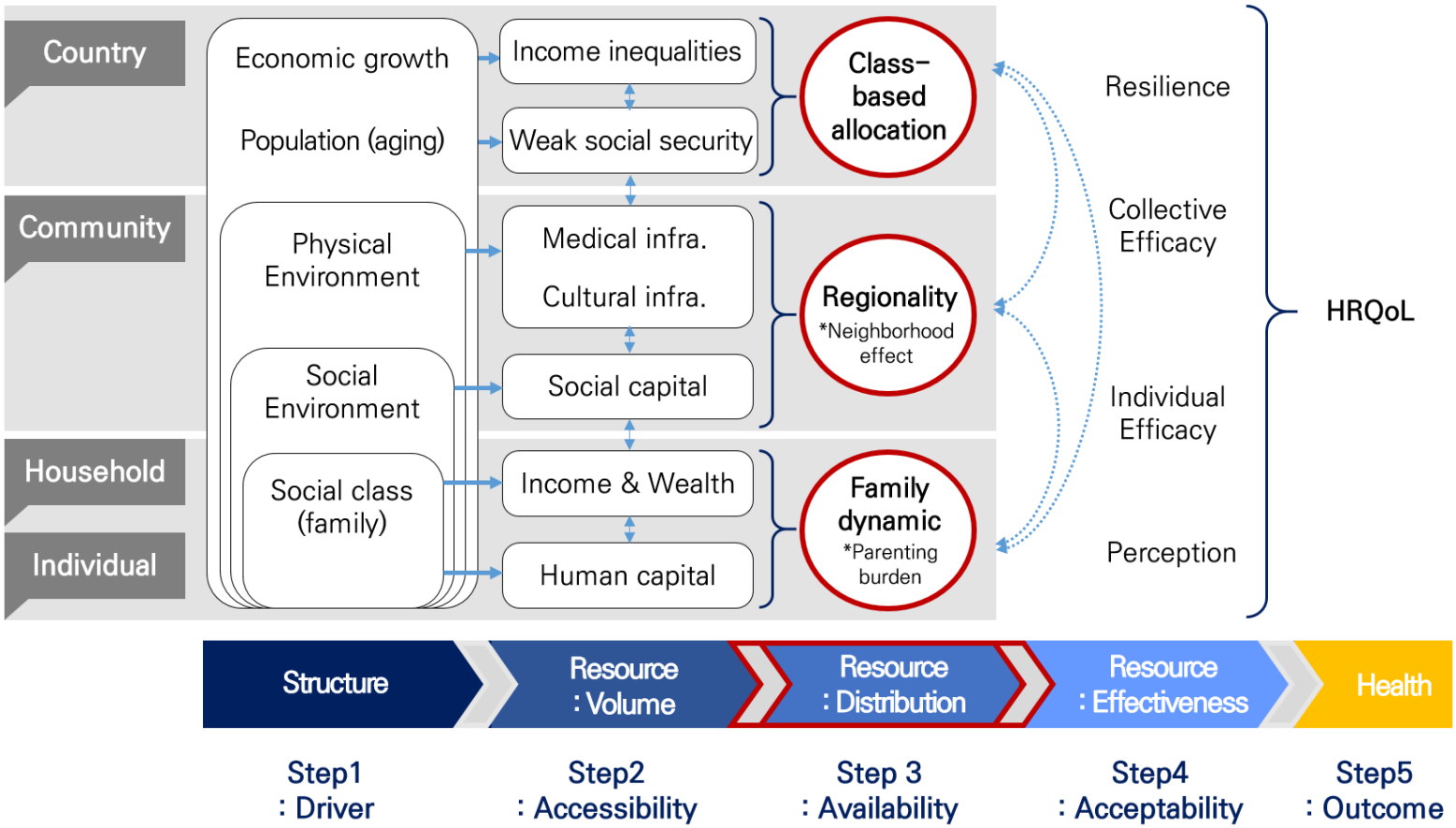


Figure 6-1. Conceptual framework of multilevel resource distribution and health-related quality of life

6.2.1. Class-based allocation: growing inequality in a rigid society

Social prestige produced by social conditioning contributes to sustaining existing structures and class-based inequalities (Bourdieu, 1998; Doob, 2019). However, the results of this study illustrate a bleak future. Socioeconomic trajectories showed the economic inequalities is widening and Korean society is going to a rigid society where social mobility is restricted (Chapter 3). Indeed, household wealth was more important to SSS than to individual socioeconomic ability (Chapter 2). Furthermore, this stratification worsen health disparities as increasing the risk of being low and declining HRQoL trajectory (Chapter 3). Communities were clustered healthy ones with a similar one and health-deprived ones with a similar one (Chapter 5). Furthermore, the characteristics of environment and social resources can aggravate the regional disparities on health (Chapters 4 and 5).

In this context, the best way to improve all populations' quality of life and well-being is to reduce inequalities (Wilkinson & Pickett, 2009). In a discourse on health inequalities, it is essential to consider the distribution of or relative income within a country, instead of the average or absolute income (Pickett & Wilkinson, 2015). It is particularly true for rich countries. When a country reaches a threshold for adequate material living standards, relative deprivation, as opposed to absolute poverty, better explains health disparities (Marmot, 2004; Wilkinson & Pickett, 2009). Furthermore, we need a broader understanding of social functioning or diverse human needs, reaching beyond

material or physical conditions to a person's capabilities, psychosocial needs, or spiritual resources (Marmot, 2005).

6.2.2. Family dynamics: Disparities between family members

The family-based social class creates resources, sustains a long-term environment surrounding individuals, and bequeaths material and intangible heritage across generations. Moreover, every family has its own 'family dynamics' regarding the ways that roles, power, authority, and responsibility are assigned.

Chapter 2 illustrates that; even though family members share common assets, economic budget, and living spaces, they reported different levels of SSS according to their family roles. These discrepancies may primarily result from the resource-sharing dynamics between provider and receiver of resources within a household according to the identity of family roles or parenting burdens.

Indeed, in households with dependents, subjective status was more likely to be lower than objective status, as measured by income level. The members from two or three generation households were at risk of lower SSS than objective status. Two generation families without spouses encounter great risk of downward shift of SSS. These suggest that strains such as parenting burden or family role obligation may act as risk factors.

These household environments are more significant by considering time effect. In addition, given that inequalities of resource allocation arise

both inside and outside of the household, it is time to take urgent action against the burden of child rearing and elder dependents with sparse resources.

6.2.3. Spatially shaped social process

The results from Chapters 4 and 5 can be interpreted as spillover effect and spatial dynamics in collective efficacy, supporting empirical evidence of neighborhood effect. Social capital or collective efficacy, which are the benefits derived from neighborhoods, spills over to the adjacent neighboring area, forming "*spatial externalities*" as opposed to internal residents' characteristics. In other words, the social processes generating collective efficacy depend partly on geographical position apart from structural (socioeconomic) differentiation in local communities. These *spatial dynamics* in generating collective efficacy were described in a previous study by Sampson and colleagues (1999). They applied a spatial analysis and derived geographical cluster patterns of collective efficacy in Chicago. Regarding the spillover aspects of collective efficacy, fully efficacious communities were distributed mainly on the far northwest and southwest sides of the city. In contrast, socially vulnerable ones were likely to be situated in the interior (Sampson et al., 1999).

Sampson (2012) used the term *"spatially shaped social process"* when explaining the diverse effects of immigration across cities in America. Beyond a matter of geographical proximity, spatial location has meaning as the construct that strengthens or countervails the effect of social events

(Sampson, 2012), pp.254-255. Moreover, variation in collective efficacy across cities is an original social property nested in place. The collective efficacy exerts its influence even after adjusting for the interpersonal ties with others or the aggregated composition of individual properties(Sampson, 2012), p.369.

Collective efficacy is linked to population well-being in a wide range, such as social safety, crime rate, public health, and even life expectancy (Sampson, 2012), p.178. These mechanisms may increase social inequalities in that benefits from collective efficacy and trust are concentrated in rich villages providing positive outcomes such as community health and child development (Putnam, 2016), p.219.

6.3. Overall discussion

6.3.1. Complementary resources in family, community, and society

Resources can be generated, expanded, and enjoyed at home and to the extent of community or social relations. In this regard, income alone has a limited effect on health. For instance, household income cannot explain the stable SSS pattern over time, and there is an upper limit of household income to enhance health trajectories in upper-middle or privileged (Chapter 3). These findings drive an important assumption that the social resources beyond household determine one's health. Furthermore, the distinctive perception among household members of their social position (in Chapter 2) may imply that the resources beyond the household—social resources—influence the social status.

Even if one's objective resources are scarce (e.g., low income, poor education, and unemployed status), people can maintain better health and quality of life as long as they have adequate social support and norms that assure resilience (Gallo et al., 2009). It is partly because psychosocial and cultural factors protect health against adverse environments and provide another route for accessing the needed resources; in that case, income may become less potent for health (Braveman & Gottlieb, 2014).

Family conditions intensify these mechanisms of resource accessibility intrinsic to social capital. For instance, more educated and

affluent families (parents) tend to link deeper and broader social networks with acquaintances in disparate social niches (i.e., psychotherapists, doctors, professors, lawyers, or business leaders, et al.). These supportive relationships outside of the family can help deal with family tensions, give children a sense of self-worth, help them achieve educational and economic advancement, and, in turn, help them move up in society (Putnam, 2016) pp.207-8.

Indeed, Putnam (2016) mentioned that apart from financial or institutional resources, the social network and safe neighborhood environment can play a role in "airbags" to minimize negative consequences when families – particularly children – confront family troubles or risk of delinquency (Putnam, 2016) p.198. Similarly, social capital arising within neighborhoods, instead of family, was more beneficial to youth mental health in South Africa. While the household income did not enhance the mental health of young adults (ages 15–24), the neighborhood's characteristics protected youth from developing depression (Somefun & Simo Fotso, 2020). It is also essential for parents who care for underage children to have supportive networks outside the home. These social ties can be of actual help in material aspects and can help diminish parenting burdens in psychological aspects. In particular, low-income single mothers cope with stress and empower themselves through social support and interactions (Broussard et al., 2012).

Hopefully, the bad situation South Korea is in, shown in this study, can be fixed by the moderating effect of social capital (trust). Social capital plays a vital role in health within a stratified and unequal society (Mcleod, 2013a). Income inequality is correlated with the lack of social trust and cohesion, and these low levels of social capital increase the risk of mortality (Kawachi et al., 1997). Bonding, bridging, and linking social capital were correlated with socioeconomic inequalities in health, respectively. Furthermore, they buffered the adverse health effects derived from low SES, protecting people with low socioeconomic conditions (Uphoff et al., 2013).

Social capital operates in much the same way as social class works in access to resources. Social networks regulate or facilitate the accessibility of life opportunities by the extent to which they connect ties to other ties (Berkman et al., 2000). In particular, weak ties can convey the diffusion of influence and information between groups, instead of stagnating, and consequently provide opportunities for mobility (Granovetter, 1973).

This evidence suggests that social capital can be a key to breaking the link between growing income inequality and health problems.

6.3.2. Implication for public health policies: toward contextual variations

This thesis investigated multidimensional SDH at diverse level and its health impact, considering time and place. The results of this study emphasize the importance of housing policies and the need to reduce the burden of parenting.

In addition, it evokes the importance of the outdoor resources, such as social capital and neighborhood context. Furthermore, since the HRQoL trajectories did not show a longitudinally increasing pattern, it is crucial to prevent and protect the deterioration of HRQoL in ahead. It is only possible if the accessibility and availability of diverse social resources are ensured.

These agendas are, to some degree, in line with the arguments suggested by Berkman (2000). Individuals exist within the social system or structural context. Policies and interventions for health promotion should focus on enhancing the *family- and community- capacity* to take care of vulnerable groups based on social support and social cohesion (Berkman, 2000).

Regarding ***family issue***, our findings may be helpful to policymakers interested in the factors that divide society and make some individuals more vulnerable. Inter- and intra-social class conflicts may be diminished by countermeasures that address residential stability and strain related to family roles.

Social capital strategies. Chapter 5 results represent the empirical evidence of the segmentation phenomenon in terms of moderating effects of social capital across regions—which Villalonga-Olives and colleagues (2018) pointed out that previous consideration is insufficient so far.

Traditionally, interventions have focused on directly strengthening social capital at the community level instead of the individual level. These interventions are intuitive and effectively promote positive outcomes with

relatively few resources. On the other hand, it is notable that social capital can intervene in health as an indirect channel or mediator, as well as a moderator by involving segmentation strategy for specific subgroups. To increase the impact of interventions, adopting strategies toward the *indirect role of social capital with multilevel mechanisms* is crucial (Villalonga-Olives et al., 2018; Wind & Villalonga-Olives, 2019). Further public health interventions need to reflect these findings to operate.

In addition, Aldrich and Meyer (2015) state that public policies and program need to cover a goal of *increasing trust and social networks*, given that social capital is a crucial resource in determining community resilience. They suggest valid community interventions, such as holding focus group meetings and social events and redesigning physical and architectural structures. Particularly, concerning the spatial layout of communities, city planning should provide third places (not residential or workplaces) for social capital where residents can meet, spend time, and socialize (i.e., libraries or public squares). In addition, areas around home or streets should be structured such that residents feel connected with each other, building up connections across groups in communities (Aldrich & Meyer, 2015).

Urban planning as a public health concern. Chapter 5 illustrates the novel results of “GWR clusters” that could indicate an empirical "zoning" effect with regard to health resources. Zoning is a term in urban planning that allows housing, establishments, and workplaces to exist in close proximity. It

reminds us of the importance of zoning and land use mix, which is, to date, seldom considered in health promotion strategies.

Communities are the repository for generating and maintaining diverse resources. Changes in urban design and built environment are effective strategies for population health. Physical features of neighborhoods correlates with neighborhood social functioning in ways that improve health (D. A. Cohen et al., 2008). "Sense of place" based on the built environment becomes a meaningful public health construct beyond geographical concern. A healthy place—in terms of nature contact, public spaces, buildings, and urban forms—concerns public health implications (Frumkin, 2003). These intrinsic structure can naturally induce healthy behaviors in residents and allow these behaviors to be settled into everyday habits, and consequently impact health equity (Marmot et al., 2008; Renalds et al., 2010). Therefore, it is time to activate urban planning strategies to improve population health and well-being. This study reveals the possibility of a community region enhancing population health based on resource distribution and availability.

6.3.3. Methodological advances

This thesis has strengths regarding methodological advances. First, it applied the person-centered approach to longitudinal study design. Chapter 3 highlights the life-course perspectives and can provide longitudinal evidence for causal inferences among SSS, income, and HRQoL. GBTM, a method of Chapter 3, is a person-centered approach, as opposed to a variable-centered

approach. It enables identification of different developmental courses between individuals based on qualitatively distinct features (Nagin & Odgers, 2010). Therefore, as a method of modeling individual-level heterogeneity, GBTM can classify the population by detecting unobserved heterogeneity between groups (Nagin, 2009). This is an improvement over conventional approaches to classify the population regarding social class.

Second, SSS is used to reflect social class. SSS is a measure that connotes multiple dimensions of social class as well as a sense of control. Therefore, it performs better in predicting social cognitive tendencies and health outcomes than objective status (Kraus et al., 2009).

Furthermore, the multi group-based trajectory model of objective and subjective social status (i.e., multi-GBTM) in the period 2009 to 2013 provides a portrait of social grouping in South Korea, capturing the heterogeneity of the population. These results illustrate distinctive stratified social classes embedded within a society, which reinforce wealth and income inequality. The static pattern of SSS curves may reflect unchanging social classes rather than a volatile socioeconomic position represented as income growth.

Lastly, neighborhood effect is empirically demonstrated with the concerns of spatial heterogeneities. It has not been dealt with well, but it is a method that gives a relatively clear answer.

6.3.4. Limitations and further research

Several limitations need to be mentioned regarding this study. The EQ-5D indicator with three response levels was used in this study. It mainly detects patients who responded ‘having extreme problems’ as health outcomes. Because mild but significant illness could not be adequately detected, the indicator shows low sensitivity to health changes (Herdman et al., 2011). It therefore may dilute the SES effect on health. Furthermore, the HRQoL (EQ-5D index) and composition of social resources may involve another inherent limitation, apart from the regional relevance as research objectives. HRQoL is an index obtained by weighing and summating five different domains of health. (e.g., mobility, self-care, usual activities, pain & discomfort, and anxiety & depression). If the specific domain of HRQoL strongly correlates with a particular type of social capital, this possibly influences the results.

Furthermore, we found out conflicting implication between results with regards to the possibility and restriction in intergenerational social mobility. Therefore, further researches need to focus on the age, generations, and period effect on resource distribution and its longitudinal health effect.

The most challenging issue is the limitation due to data acquisition. This thesis cannot measure and analyze the SSS and social capital at the same time.

6.4. Overall conclusions

This study provides empirical evidence for spatial and temporal variations in SDH and their health effects. Unequal concentrations of resources exist within a household, and different efficacy levels of resources exist among communities. These circumstances broaden social inequality over time and space, further widening health inequalities. In other words, Korean society has encountered increasing family-based inequality and regional health disparities. Multiple levels of resources in households and the community function in diverse ways to mitigate risk factors and improve the health of the population.

The results illuminate significant findings regarding SDH and the substance of society. First, the results have identified unobserved heterogeneities in society. A person-centered approach (i.e., trajectory analysis) provides distinctive social groupings with a longitudinal perspective. South Korea is moving toward a rigid society where social mobility is restricted based on household income. The benefits of economic growth are concentrated in advantaged households.

Moreover, unequal resource allocation arises inside and outside the household and among communities. Parenting burdens or family obligations may act as risk factors to one's perception of social position. However, these

resource-sharing dynamics may bring about possible upward mobility in a household, even in a rigid society.

This study has highlighted health inequalities based on resource distribution. Increasing inequality of household income exacerbates health disparities, leading to better health for the better off. Underlying objective or subjective social status has protected subsequent HRQoL trajectories from declining. These HRQoL trajectories have two distinctive aspects; one is that of the shape of the pattern that is either stable or slowly declining, but not increasing; the other is that there is an upper limit on household income for enhancing the health trajectory. That is, it is better to protect against health deterioration than to enhance health at higher levels.

The results of social resources in the community empirically demonstrated the neighborhood effect. There is a spatial pattern in health, which reinforces regional health disparities. Furthermore, clustered community resources are crucial in determining health. Interestingly, the effectiveness of resources depends on local processes, representing a consistent and robust regionality. This suggests that spatially shaped social processes work differently across neighborhoods, which have been defined as administrative areas.

Third, these results have implications for public health policy and provide clues for discovering blind spots regarding the health of disadvantaged groups and individuals, and for determining the volume or type of resources and target households or regions. The objectives and targets

of public health policies should be tailored to each region. Above all, a policy should be developed that is focused on resource redistribution to protect against longitudinal and geographic broadening of health inequalities.

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국문 초록

연구 배경

최근 인구구조의 급격한 고령화와 경제 수준의 발전에 따라 건강패러다임은 생명 연장과 같은 단순한 양적 지표뿐만 아니라 건강관련 삶의 질(health-related quality of life, HRQOL)과 같은 질적 지표에 주목하고 있다. 그러나 경제 자원 및 인적 자원 만으로는 포괄적이고 다층적인 삶의 질을 설명하는 데에 한계가 있다. 단순히 개인이 보유한 자원의 양 그 자체 보다도, 유의미한 자원이 생성되는 기전과, 사회적 관계를 통한 자원의 분포 및 자원의 활용가능성에 대한 폭넓은 고려가 필요하다.

이에 본 연구에서는 사회적 자원과 주관적 사회계층 인식 지표를 활용하여 자원의 개념을 보다 폭 넓게 이해하며, 가구 및 지역사회 수준에서 다층적인 자원의 분포 구조를 포착한다. 또한 다층적 자원이 시간과 공간에 따라 어떻게 분포하는지 확인하며, 이에 대한 건강 영향을 파악하고자 한다. 결과적으로, 삶의 질에 대한 사회적 결정요인의 이해의 틀을 확장시키고, 우리 사회에 내재된 계층 기반의 불평등 현황을 파악한다.

주요 연구목적은 첫째, 가구 환경 및 개인의 자원이 주관적 사회계층 인식의 형성에 미치는 영향을 파악하며, 가구원간 인식 차이를 파악함으로써 가구내 자원의 공유의 기전을 파악한다. 둘째, 건강관련 삶의 질 궤적을 파악하고, 주관적 사회계층 인식과 객관적 사회경제적 수

준에 따른 삶의 질 궤적을 파악한 후, 두 궤적의 연관성을 분석함으로써 사회경제적 지위의 종단적인 건강영향을 파악한다. 셋째, 지역사회의 다차원적인 사회 자원의 구성체를 정의하고, 인구집단의 건강에 영향을 미치는 주요한 사회 자원을 파악한다. 넷째, 건강관련 삶의 질의 공간 상관을 파악하고, 사회 자원이 건강에 미치는 효과를 공간적인 비정형성을 기반으로 파악한다.

연구 방법

첫번째 연구에서는 제 8차 한국의료패널 자료(2013년)를 활용해 3,984 가구에서 18세 이상 성인 8330명을 연구대상으로 하였고, 두번째 연구에서는 2009년부터 2018년도까지의 한국의료패널 (총10차 조사) 자료의 균형패널 대상자 자료를 활용하였다. 세번째와 네번째 연구는 지역사회 수준의 연구로서, 통계청(KOSIS)의 공개자료 및 지역사회건강조사 자료를 활용하여 250개 지역사회 수준으로 다양한 사회 자원 변수를 병합하였다.

종속변수인 건강관련 삶의 질 지수(HRQoL)는 EQ-5D 지표를 활용하여 한국인 고유의 가중치를 적용 후 산출하였다. 주관적 사회계층 인식의 지표는 MacArthur scale 을 사용하였다. 사회자본은 사회적 연결망, 신뢰, 사회 참여로 구분하고, 그 외에도 문화, 체육시설, 공원의 수와 같은 문화 자원과, 의사 수, 필수진료과 의원, 병원, 요양병원 수와 같은 의료 자원 및 지역사회의 사회경제적 환경 등을 반영하였다.

분석 방법은 첫번째 연구에서 주관적 사회계층 인식에 대한 가구원간 응답일치도를 평가하기 위하여 집단 내 상관계수를 구하였고, 분

산 분해를 통해 변수별 상대적 중요도를 비교하였다. 두번째 연구에서는 그룹 기반의 궤적 모형(Group-based trajectory modeling, GBTM)을 적용하였으며, 특히 객관적, 주관적 지위의 변화 패턴을 한번에 포착하기 위하여 2개 변수의 변화 패턴을 동시에 포집하는 다중 그룹 기반 궤적 모형(multi-GBTM)을 적용하였다. 세번째 연구에서는 주성분 분석 및 주성분 회귀분석을 사용하였다. 네번째 연구에서는 지리적 가중회귀분석(Geographically weighted regression, GWR)을 적용하고 그 회귀계수에 대해 K-means 군집 분석을 사용하였다. 통계 프로그램은 STATA 16, SAS 소프트웨어 9.4 버전, R 4.1.3버전을 이용하였으며, 지리 분석 시 QGIS 3.24 및 GeoDa 1.18.0 프로그램을 보조적으로 이용하였다.

연구 결과

번째 연구에서, 주거안정성과 같은 가구의 부의 수준은 주관적 계층 인식 하락에 대하여 상당한 완충효과를 가지고 있으나, 가구 내에서 서로 자원을 공유하는 기전에 따라 가구원 간 인식에 차이가 있는 것을 확인하였다. 특히 미성년 자녀의 수가 많아질수록 부부간 계층 인식의 격차가 벌어졌고, 자녀 세대, 가구주 세대, 가구주의 부모 세대별로 세대간 인식 차이가 있었다. 즉, 이러한 인식 격차는 가구원으로서 정체성 및 부양의무, 혹은 가구 내에서 젊은 세대에게 자원이 집중되는 양상에 기인한다.

두번째 연구의 궤적 분석 결과, HRQoL은 시간 경과에 따라 지속적으로 최고점인 1점 수준을 유지하거나, 낮은 수준에서 시작하여 하

향 곡선을 그리며 건강이 악화되는 형태만 확인되었다. 또한 한국 사회는 부유한 가구가 시간이 지남에 따라 더욱 빠르게 소득증가를 이루며 이러한 경제적 불평등이 사회적 집단화에 기여하고 있었다. 또한 이러한 사회경제적 지표는 중장기적으로 건강 궤적 확률에 영향을 미치며 건강 격차를 악화시키는 것을 확인하였다. 한편, 중장기적인 주관적 계층 인식 수준은 가구 소득의 변화만으로는 설명되지 않았는데, 이는 가구의 범주를 넘어서는 사회적 자원 및 환경의 중요성을 시사한다.

세번째 연구에서, 지역사회는 물리적 시설 환경 및 경제적 수준 이외에도 연결형, 결속형, 인지적 사회 자본과, 의료서비스의 공급 및 수요 환경으로 유형화 되는 특징이 있었다. 이러한 지역사회의 자원 분포의 특성은 근린효과로서 인구집단의 건강관련 삶에 질에 크게 영향을 미쳤다. 특히 단순 시설의 수가 아닌, 미충족 의료필요도와 같은 실질적인 자원의 이용가능성이 인구 건강에 영향을 미쳤다.

네번째 연구에서, 지리적인 거리를 반영한 공간 분석 결과, 건강관련 삶이 질은 높은 수준의 지리적 자기상관을 가졌다. 즉 건강한 지역사회는 건강한 지역끼리 서로 지리적으로 밀접한 공간적 상관성이 있었다. 또한 각 지역사회 자원이 건강에 미치는 효과성은 지역마다 상이하며, 해당 효과성을 군집화 하였을 때 권역 단위에서 집합적으로 작동하는 것을 확인하였다. 서울 및 경기도에서는 사회 신뢰가 유의한 건강 보호 효과가 있었다. 경상도권에서는 건강관련 삶의 질 수준이 낮은 사람이 종교활동을 보다 빈번하게 참여하는 경향이 있었다. 전라도권에서는 벽지 지역의 1인 가구가 건강 위험 요소였으며, 강원 및 충청도권에서는

미충족 의료 필요도가 건강관련 삶의 질과 유의한 부적 연관성을 보였다.

결론

다수준에 걸친 자원의 분포 및 활용가능성의 격차가 건강관련 삶의 질에 미치는 영향을 확인하였다. 한국 사회는 시간 경과에 따라 가구 소득에 기반한 계층화가 견고해지고 있으며 객관적, 주관적 사회 이동의 가능성이 제약되는 경직된 사회이다. 주거안정성은 객관적 소득 대비 주관적 수준이 낮아지는데 대한 보호효과가 있다. 그러나 물리적 주거공간과 경제적 자원을 공유하는 한 가정안에서도 부양의무와 같은 가구원 정체성이 자원 활용에 영향을 미쳐 주관적인 사회계층 인식에 격차를 발생시키고 있다.

한편, 건강관련 삶의 질은 종단적으로 상향곡선을 띄지 않으므로 악화를 방지 및 보호하는 것이 중요하다. 이는 개인과 가구 수준을 넘어 다양한 사회 자원으로의 접근 가능성 및 활용 가능성이 보장되어야 가능한 일이다. 지역 사회의 자원을 유형화해보면, 물리적 시설이외에도 보건의료서비스의 수요와 공급 균형, 그리고 사회자본 환경으로 특성화 되는데, 이러한 지역사회의 자원 유형은 인구집단 건강에 영향을 미친다. 또한 건강한 지역사회는 건강한 지역사회끼리, 건강 박탈지역은 박탈지역끼리 높은 공간적 자기상관을 가지며, 자원의 효과성이 권역별로 군집화 되는 지역성을 띈다는 점에 유의하여 자원 재분배 정책을 수립하여야 한다. 즉, 향후 지역 보건 정책 수립 시에는 단순히 자원의 양을 균등화하는 정책보다, 한정된 자원의 양을 가구 유형별로, 지역별로, 어느 수준으로 집중 분배하는 것이 가장 비용효과적일지에 기반하여 지역 특화 전

략을 수립하여야 한다.

이상을 종합하면, 한 개인이 어떠한 가족 역할의 의무를 가지는지, 어느 지역사회에 거주하는지에 따라 자원의 활용가능성과 효과성은 상이함을 보여준다. 이러한 내재적 속성은 중장기적으로, 그리고 공간적으로 더욱 큰 건강 격차를 불러일으킨다는 점에서 건강 형평성 및 자원의 재분배 정책에 시사하는 바가 크다.

주요어 : 건강 불평등, 주관적 사회 지위, 자원 재분배, 가구 환경, 사회 자본, 이웃 효과, 건강관련 삶의 질
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