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Spatial and Temporal Variability of the Impact of Sociodemographic, Economic, and Health-Related Factors on Depression of Older Adults in South Korea

GEO 511 Master's Thesis

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Abstract

Background: The mental health of older adults in South Korea has become an essential issue in terms of health cost and social concerns. The high incident of depression in older adults makes them the major contributors to the rising suicide rate in South Korea. Knowledge in the temporal and spatial variability of the relationship among sociodemographic status, economic conditions, physical health, and health-related behaviors with depression can help understand regional differences and adopt policies according to region. However, the effects of regional variations of depressive symptoms and potential factors in older adults are rarely analyzed by previous studies. Moreover, only a few geographical studies exist on the depression of older adults concerning temporal perspectives.

Aims: This study aims to fill these research gaps by investigating the spatial patterns of depressive symptoms and how the impacts of sociodemographic, economic, and health-related factors on depressive symptoms change over space, as well as discussing their temporal changes.

Method: This study was conducted based on the Korea Longitudinal Study of Aging (KLoSA) data collected biannually from 2006 to 2016. Global Moran's I and Local Moran's I were adopted in this study to explore spatial patterns of depressive symptoms. The spatial variability of the relationship of each variable with depressive symptoms was investigated by using Spatially Local Regression (SLR). Temporal variability of the relationship was explored by comparing the changes of significantly local coefficients for period of 10 years. Spearman correlation coefficients were calculated to analyze the impact of migration on depression.

Results: The significant spatial clustering of depressive symptoms in the entire country is observed in six survey years, and the specific locations of spatial clusters are identified. Significant local coefficients of all variables are observed and some coefficients are statistically significant in multivariate regression. Annual household income, educational level, and physical health show a consistently negative impact on depression over space. Gender, age, contact frequency with children, in-person social contact meetings, coresidence with adult children, drinking and exercise habits have both significantly positive and negative effects on depression in different districts, counties or cities. For temporal analysis, annual household income, physical health, the number of in-person social contacts, marital status, and educational level maintain negative effects on depression in all survey periods, and age keeps the positive influence. Other variables show both positive and negative influences among the six survey years. Migration is not correlated with depression.

Our findings could provide a guide to help local governments in South Korea formulate policies to improve mental health in the elderly according to their local situations.

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Chapter 1

Introduction

1.1 Background

"Population aging" indicates the switch in population age structure, which implies that the proportion of older people becomes larger and younger people becomes smaller [1]. The aging of the population has been regarded as one of the most common social issues among high-income countries [4, 123]. This issue is particularly notable in six East and North-East Asia (ENEA) countries including China, South Korea, Japan, Mongolia, North Korea, and the Russian Federation. In 2015, the older people (over 65 years old) in these six countries accounted for 56% of the older adults in ENEA, accounted for 32% for older adults in the world [1].

Moreover, according to the simulation from the research of Organization for Economic Co-operation and Development (OECD), the number of older adults has been growing in South Korea in recent years. The proportion of older adults is predicted to reach 38% of the total population in 2050, making South Korea a super-aged country compared to other countries [56]. Aging population can cause a series of social problems; for instance, older adults tend to no longer work for the society after retirement, while requiring more health care. Therefore, the aging of the population contributes to an increase in the fiscal expenditure of social health insurance. Korea's public expenditure on health and daily care is predicted to rise to 6-9% of the total GDP in 2050, which is the most significant among OECD countries [118].

The mental health of older adults is another critical issue in terms of health cost and social concerns. For the older adults over 65 years old, 1 out of 5 of them have mental illness, such as dementia or depression [61]. As the most common mental disorder among the elderly, depression is highly associated with a significant increase in the cost of medical services [108]. This mental issue is also one of the major causes of suicide. According to

OECD's data, South Korea has the highest suicide rate among OECD nations in 2019. Figure 1.1 shows the causing factors for suicide, whereas Figure 1.2 exhibits the suicide rate changes among different age groups of South Korea in 2017. Figure 1.1 indicates that among all reasons, 31.7% suicides were resulted from mental disorders (the other reasons being economic status - 25%; and physical health - 26%). Figure 1.2 shows an increasing trend of suicide rate with ages. In particular, a sharp rise in suicide rate can be observed after 60 years old, implying suicide is more prevalent in the elderly population. Older adults are less likely to make use of professional mental health services than younger adults, even though the mental problems of the elderly seem more severe than younger people [64]. This brings about more critical mental illness issues among older people.

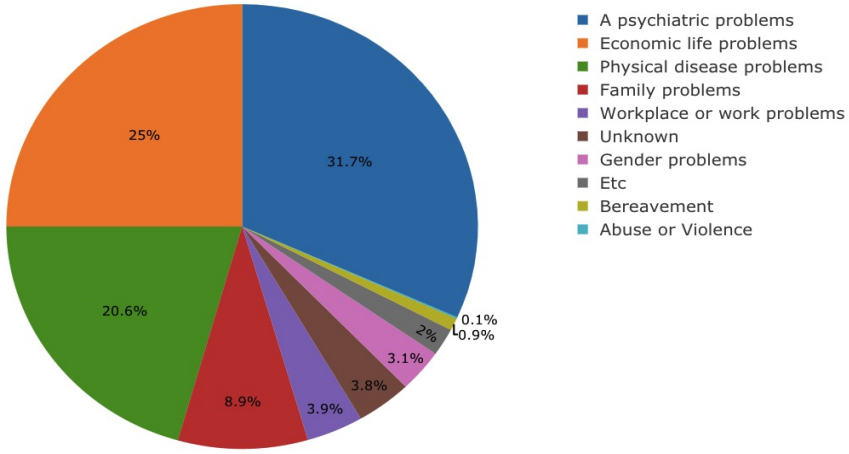


Figure 1.1: Suicide causing factors in South Korea (2017)

Depression is one of the dominant mental health issues along with dementia. It has a significant impact on individuals, families, and societies. It is usually associated with one's weakened social and occupational functions and worsened mortality, causing most suicide than other reasons (50% suicide are associated with depression) [66]. Moreover, depression results in social costs due to the reduced productivity and increased usage of healthcare resources, not to mention enormous suffering of both individuals and their close persons [64]. South Korea is facing such issues of depression, the previous research reported that almost 95% of Koreans live under stress. Furthermore, 28% of older Koreans are feeling depressed, which is around 10% higher than the U.S [27].

Depression can be affected by multiple factors related to social context (e.g., educational background, in-person social contacts), demographic status (e.g., gender, marital status), economic conditions (e.g., yearly income), health-

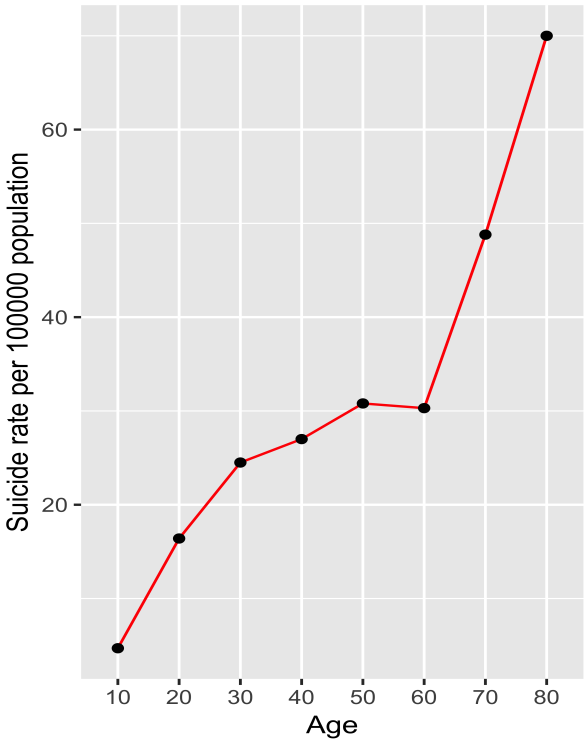


Figure 1.2: Suicide rate in different age (2017)

related behaviours (e.g., drinking and smoking habits) and physical health (e.g., self-reported physical health). For instance, females tend to have a higher risk of suffering from depression [122]; employment is related to more depressive symptoms among older men compared to middle-aged women [57]. Also, one's living environment, more specifically, physical and social surroundings, are known to be significant factors in depression. Truong and Ma (2006) [105] came up with three different conceptual models to expound on which neighborhood characteristics have impacts on depression. These models respectively look at structural features, circumstance stress, and neighborhood disorder. The model of structural features consist of the poverty rate of inhabitants (i.e., the proportion of them living in poverty), the number of female-headed households, ethnic composition, and the population migrated rates. The circumstance stress model investigates the gap between the accessibility of resources (e.g., health service) for people in a geographical area, as well as the stressors that they receive from their residential surroundings (e.g., crimes). The neighborhood disorder model concludes that there is an association between the increase of depressive symptoms and physical (e.g., rundown houses, backward transportation infrastructures, unfinished buildings), and social uncivilized phenomena (e.g., underworld groups, public drunkenness, drug businesses, and clamorous

neighbors) [31, 105].

In summary, the growing of depressed population in late life can cause a series of social (e.g., suicide) and economic (e.g., increasing financial expenditure) problems. Understanding of the mechanism behind depression (the social/demographic/economic factors that can cause depressive symptoms) could better help treat depressive older adults. In this context, since 2006, South Korea has biannually conducted a nationwide panel survey for a longitudinal study of aging, which is named Korea Longitudinal Study of Aging (KLoSA). To investigate various aspects of the long-term aging processes of older adults, KLoSA looked at numerous social, demographic, economic, and physical health-related factors (e.g., family relationships, financial situations), alongside with depressive status. Furthermore, since participants have been recruited systematically from each census region, the panel data could also provide information on an individual participant's residential region. This provides us with the necessary data or information for subsequent regression analysis in geographic perspectives.

1.2 Research Gaps

1.2.1 The Research Gaps of Previous Research

With the increased interest in depression of the elderly, a growing number of studies investigated relationships between depressive symptoms and social, demographic, economic, and other factors. For instance, in terms of demographic factors, cohabitation with adult children has a positive effect on depressive symptoms of widowed women [33]. Moreover, from economic perspective, wealth may play an essential role in better access to various health care services associated with depressive states which contributes towards lower depression [75]. However, gaps still exist in previous research, which can be summarised as follows:

1. According to Tobler's (1970) first law, "everything is related to everything else, but the near things are more related than distant things." [102]. Average depressive symptoms in one region are similar to its neighboring regions. The similar spatial observations are grouped into classes and form spatial clusters [52]. Even though, spatial cluster analysis then contributes to exploring spatial patterns of depressive symptoms of older adults and highlighting the clustering regions with a high prevalence of depression. There are still limited investigations of spatial clustering and neighborhood impacts for depressive symptoms of people in late life.

2. Living environments or neighborhood characteristics are linked to depressive symptoms as well [5, 110]. However, with the KLoSA data,

there are no investigations on how living environments impact depression directly and indirectly and how sociodemographic, economic, and health-related factors make distinctive impacts on depression in different regions (e.g., urban vs. rural areas).

3. Only a few geographical studies exist on the depression of older adults concerning temporal aspects. The changes in the relationship between depression and the various factors still need more discussions.

1.2.2 Research Aim and Objectives

Research Aim

This thesis aims to fill those research gaps by (1) exploring the spatial/regional patterns of depressive symptoms, (2) investigating how the impacts of sociodemographic (e.g., marital status, gender), economic (e.g., income), and health-related factors (e.g., drinking and exercise habits) on depressive symptoms of older adults are spatially varied, and (3) discussing how these effects change over years.

Core Research Questions

To achieve study goals, four core research questions will be answered in this thesis:

1. How are the depressive symptoms spatially clustered among residential regions of older adults in South Korea? Where are the spatial hotspots and coldspots of depressive symptoms?
2. How are positive/negative effects of sociodemographic, economic, and health-related factors on depression of older adults spatially distributed in different regions?
3. Do older adults who have migration experience (i.e., older adults have migrated within past two years) feel lonelier and more depressive than those who remain in one place?
4. Does significant impacts of those factors on depressive symptoms of older adults change over the ten years from 2006 to 2016? How do they change?

Details of these four research questions will be illustrated in Chapter 3.

Chapter 2

Theoretical Background

2.1 Theoretical Background

2.1.1 Depression

Depression is a type of mental disorder characterized by low mood and aversion to activities; it can be mainly classified into mild/moderate/major depression, persistent depression, and seasonal depression. Their common manifestations are long-lasting depression, lack of self-confidence, deliberately avoiding the crowds, and sometimes even having a sense of guilt, feelings of a significant decrease in physical energy and inability of gaining happiness in any activity. Such disorders can also result in physical dysfunctions among patients, such as sleep disturbances, feelings of pain, and excess or loss of appetite [32]. Depression could be long-term and short-term; it is generally caused by family genetic inheritances, personal histories, stress, and brain chemistry [10].

Depressive Symptoms

Depression feels different for different individuals, but has common symptoms and signs. The level of depression is usually relevant to the number of one's depressive symptoms. The more depressive symptoms they have, the more depressed they are. Ten common depressive symptoms are listed below, rephrased from Helpguideorg International (2019) [2]:

1. Lost of enthusiasm in daily activities. People lose their hobbies, no longer care anymore about entertainments and struggle to feel happy or pleasure in any social activity.

2. Obvious weight changes, which means lose or gain of more than 5% of body weight in one month.

3. Sleep issues. Either shorter sleeping time or always waking up in the early morning, sleepless overnight or insomnia, or oversleeping.
4. Easy to feel anxious and angry. Feeling anxious, apprehensive. Every part of the surrounding results in nervous emotions.
5. Self-hatred. Immoderately criticism of own faults or mistakes, having strong guilty feelings.
6. Inexplicable aches and pains. Increased physical discomfort, such as backaches, headaches, and stomachaches.
7. Focusing issues. The difficulty of focusing on or remembering things, hard to make decisions.
8. Energy loss. Feeling physically and mentally exhausted, experience difficulty or take a long time to finish a small task.
9. Rash behaviors. Having escapist behaviors, For example, alcohol and drug abuse, illegal driving or high-risk sports.
10. Feelings of desperation and helplessness. People believe their futures are bleak, thinking that they cannot change their current status despite being extremely unsatisfied with them.

2.1.2 Depression in Older Adults

It is usual that families and doctors ascribe the common depressive symptoms of older adults to their old ages, dementia or poor health, causing the depression of the elderly to become undetected and untreated for a long time [37]. Depressive symptoms in older adults have their characteristics and might be somewhat different from those in younger adults. For instance, sleep issues, reduction of physical energy and lassitude, feeling of helplessness and hopelessness to future and loss of living interest would happen more frequently among older people rather than in younger people [29]. Furthermore, older adults tend to be less self-hatred; for example, fewer feelings of guilty [42]. The main characteristics of depression in late life are listed below:

1. Older people with depression might have a series of physical symptoms that can not be medically explained, such as dizziness and constipation, which would lead to a high risk of suicide since they believe they are suffering from an incurable disease [37].
2. Older adults with depression are usually accompanied by memory changes [37]. Among them, older adults having major depression often demonstrated increased complaints of memory loss [18]. Treatment of depression could help reduce memory loss in the case of absence of dementia.

3. Inability of concentration, slow cognitive processing speed, and executive dysfunction are also collective in the elderly with depression [24].
4. Older adults with depression also have behavior changes. The changes are quite varied among individuals, including staying at home for a long time, anorexia, alcoholism, giving up personal belongings, and even frequently talking about death [37].

The treatment of depression in older adults can efficiently lessen the harm and substantially improve the their life quality. Treating depression requires the joint efforts of older patients and the society. Depression among older adults (over 65 years old) is difficult to be diagnosed since symptoms are almost the same with aging issues [48]. On the one hand, older adults are required to know more about depressive symptoms, understand their depressed status, actively seek help from others (e.g., families or friends), and receive corresponding treatments. One the other hand, more financial expenditures need to be invested in public services and establishment of researches associated with older adults' depression. For example, conducting researches related to behavior explanations of depressed older adults and addressing the influence of sociodemographic, economic, health-related factors on depression, which might be conducive to treatments of depression.

Behaviour Explanation of Older Adults

Fiske, Wetherell, and Gatz (2009) [39] proposed the behavioral model, describing the onset of depression in late life in terms of their limited social activities [39]. The model is illustrated in Figure 2.1. Usually, frequent activities (e.g., daily life activities, meetings with a family or friends, social volunteer activities, and religious activities) have positive impact on depression in late life. A decline in engagement in activities implies fewer interaction with surroundings of positive outcomes (e.g., making older adults feel less lonely). Individuals with long-standing vulnerabilities, such as negative cognitive styles (e.g., having self-critical cognition after activities) or social skill deficiencies can lessen their participation of activities and yield negative outcomes (e.g., a feeling of isolation and disconnection). In general, the elderly tends to have negative self-evaluation, and then reduce their activities when they are facing stressful life events. For instance, life stress events related to degeneration of cognitive ability and limitations of social functions, which play a dominant role in late life, and probably become potential threats to the group of older individuals who value social positions and personal achievements [39].

Role changes in daily life also have negative influences on rate of participation of activities, particularly for whom have experience of spousal bereavement. For example, if some activities or tasks were previously assigned to the spouse, such as household management, social planning, or driving, the

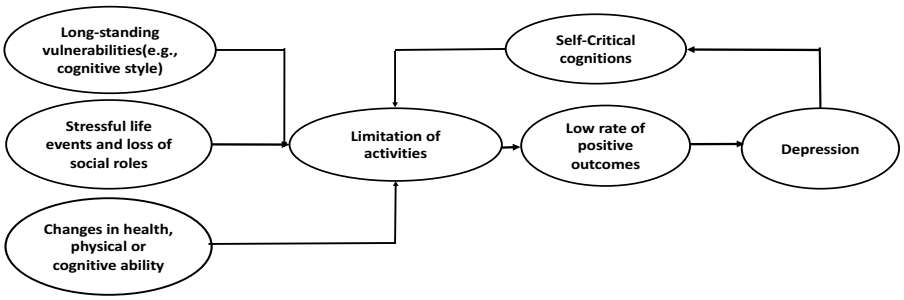


Figure 2.1: Behavioral model describing the onset of depression in late life adapted from Fiske, Wetherell, and Gatz (2009) [39].

situation would result in a negative self-evaluation and decline in activities of widowed ones. What is more, worsened physical health and reduce in cognitive ability including unexplained physical issues (e.g., headache, stomachache), the reduction of physical energy, and low cognitive speed would lead to decrease in activity frequency among older adults. Finally, the self-critical cognition might also reduce the participation in activities among depressed older adults. Self-criticism usually occurs after activities and plays a role in forcing more individuals' efforts, leading to lessening future activities. Since self-critical cognition sometimes functions to persuade people to not to take part in activities that may have failure results. In summary, both the low rate of positive outcomes resulted from limitations of activities and self-critical cognition may cause people in late life to aggravate and preserve a depressive state [39].

Factors Affecting Depression in Older Adults

A range of sociodemographic and economic factors might play roles in developing depression of older adults.

Sociodemographic factors Regarding sociodemographic factors, coresidence with adult children, age, gender, marital status, and educational level are highly associated with depressive symptoms [63]. Do and Malhotra (2012) [33] suggested that coresidence with older adults contributes to fewer depressive symptoms in widowed women, especially for the marginalized widowed woman [33]. Sicker and more depressed women would have a stronger willingness to dwell with their adult children. Females tend to have a higher prevalence of depressive symptoms comparing to males, as

it is easier for them to be exposed to social-economic risks (e.g., longer life expectancy, divorce, low income, or low educational background), disability, and poorer health than males [76]. Current marital status is also linked to depression in late life. To be specific, married persons are less likely to be depressed than the widowed, divorced, separated, or never-married older individuals because of less loneliness and higher household income [57, 9]. Depression is relevant to age as well; older people are more likely to suffer severe depression, which is mainly caused by more physical health issues and limited cognitive capacity [86]. Furthermore, higher educational levels are associated with a lower degree of depression, because people with higher education would have more opportunities to engage in mental and physically promoting leisure activities even in their late life. Various leisure activities imply fewer productive activities (e.g., work or activities for money), which may bring people more enjoyment and easiness rather than tiredness and stress [55].

Economic factors For economic factors, different amounts of personal or household income usually determine how much money one person or a family could invest in health care services. Better accessibility for the health services can provide systematical treatments for depressed older people [75]. Health literacy can impact depressive status. Inadequate health literacy, such as having problems using preventive services, delayed diagnoses, and limited understanding of one's medical conditions would result in a higher depressive level [101]. Moreover, one's depressive state is related to whether they are employed or not. For instance, more depressive symptoms appear among older men rather than middle-aged women, while unemployment is associated with less depressive symptoms among older women but not among middle-aged women [114].

Physical health and health-related behaviours For physical health and health behaviors, older adults with physical health issues such as physical illnesses and disabilities may result in more depressive symptoms. One example is that older adults' complaints of physical illnesses and their weakening physical capacities can turn into a depression because they frequently feel unhappy and fearful about their physical issues. Another evidence is that the disability can make a person have difficulties in getting moving, sleep, and maintaining appetite [16]. Health behaviors such as smoking correspond to more depressive symptoms in older adults living alone. However, older smokers who live with others suffer less depressive symptoms. Moreover, drinking abstinence is relevant to more depressive symptoms [28].

Neighbourhood conditions Previous studies revealed the significant influence of spatial variability in neighborhood conditions (e.g., neighborhood's so-

ciodemographic and economic conditions) on depressive symptoms [117]. Older people with depression are more sensitive to their living environments because they rely more on local services and facilities and are less migrated [67]. The social stress model concludes that it is difficult for residents who live in neighborhoods with high population mobility to establish long-term social contacts with their neighbors, thus making people there more stressful and depressed [34]. The level of wealth among neighborhoods is associated with different depressive levels. For instance, less neighborhood poverty is related to lower levels of depressive symptoms [31, 67, 90]. There is evidence suggesting that depression is affected by local green spaces. Individuals who live in advantaged neighborhoods with more green areas would have lower levels of depressive symptoms, particularly in the urban areas. Green spaces could allow people to restore from stress and weariness [74]. Moreover, residing in neighborhoods with a higher percentage of older adults is beneficial to lessening depressive symptoms of the elderly. The feelings of loneliness and isolation would diminish since older adults may have more familiar topics, similar interests, and mutual understanding from each other [67].

Measures of Depression

A significant number of studies have proposed methods to quantify depressive levels, and most of them are self-reported screening measures. Beck et al. (1961) [14] created the Beck Depression Inventory (BDI). It is a 21-question multiple-choice questionnaire, and each question is related to interviewees' feelings in the previous week. There are four options for every question. For instance, the question about whether you felt sad last week. The options include 'I do not feel sad,' 'I feel sad,' 'I am sad all the time, and I cannot snap of it,' and 'I am so sad or unhappy that I cannot stand it.' A score from 0-3 is assigned to each answer. The higher final score indicates a higher level of depression. For example, the total score for 21 questions ranges from 30-63, and its high score implies the subject has severe depression. The development of BDI marks a shift in the treatment of depression from a psychodynamic perspective to a focus on the patient's thought. The Center for Epidemiologic Studies Depressive Scale (CES-D) score is one of the widely used measures of depression in recent years [4]. The CES-D score uses the 10-item form of CES-D [4]. A 2-item indicator with positive influence includes 'I felt hopeful about the future' and 'I felt happy.' Each item is scored on a four-point scale ranging from 0-3. Point 0 indicates that individuals rarely have this feeling. Point 3 is that one has such feelings almost all the time [33]. The CES-D 10 yields scores ranged from 0 to 30 for 10 items. A higher score indicates that people have higher levels of depressive mood.

Chapter 3

Research Questions

Four core research questions mentioned in the first chapter will be elaborated in this chapter, including reasoning of each research question and its sub-research questions. Each of the sub-research questions will take the spatial variability of relationships between corresponding factors and depression into consideration.

3.1 Research Questions on Spatial Clusters of Depression

Exploring and identifying the spatial clustering or concentrations of older adults with depressive symptoms are important not only to establishing hypotheses for further research but also to designing relevant health policies and services. For instance, if older individuals requiring mental health services are geographically clustered in considerable numbers in particular districts, the interventions by policies and treatments to those districts can be considered. Conversely, if individuals in need of service reside in a region with a smaller number of residents, different intervention strategies should be considered to provide mental health services and alternative local policies [31]. In this regard, the first research question is formed to explore the spatial patterns of depression.

RQ1 How is the level of depressive symptoms of older adults geographically distributed in South Korea? Where are the spatial hotspots and coldspots of depressive symptoms of older adults?

3.2 Research Questions on Sociodemographic, Economic, and Health-Related Factors

Depressive symptoms are often affected by a range of sociodemographic, economic, and health-related factors. Taking sociodemographic factors as an example, frequent participation in social activities lessens the feeling of loneliness, causing fewer depressive symptoms [79]. In contrast, social isolation has a negative influence on older persons' depressive states [21, 95]. Individuals who feel socially disconnected or lonely would be more likely to suffer from depression [54]. The impact of these sociodemographic factors on depressive symptoms can vary geographically, implying that depressive states may change following the alterations of impacting factors across different regions. In order to understand how the correlation between sociodemographic, economic, and health-related factors and depressive symptoms changes over geographic spaces of South Korea, the second research question is proposed.

RQ2 How do sociodemographic, economic, and health-related factors have effects on depressive symptoms of older adults in different regions? How are the positive/negative effects distributed over geographic spaces?

3.2.1 Research Questions on Socoiodemographic Characteristics

Age In general, the growth of age can result in weakening of one's cognitive abilities, such as memory loss, slower perception, and/or difficulty of remembering [65]. Fiske, Wetherell, and Gatz (2009) [39] discussed the contribution of cognitive capacity degradation to depression in late life. Thus, the first sub-research question is proposed [39].

RQ2-1 Does aging have negative effects on depression? How do such effects vary across regions?

Gender Females are frequently associated with a higher risk of suffering depression. One reason is that females are easier to be impacted by disadvantaged sociodemographic factors, such as the lower educational background and divorce [76]. The second sub-research question is formed as below:

RQ2-2 What is the spatial variability of positive or negative effects of gender on depression of older adults? Do female older adults have a higher depressive level compared with older males?

Marital status Previous studies have reported that marriage contributes to mental health [9]. The loss of one's spouse is frequently related to an in-

creased risk of depression. One possible reason is that they lose emotional, physical, and financial support [73]. To explore the impact of marital status on depression of the elderly, the third sub-research question is developed.

RQ2-3 Do the older people who are married or have a partner have lower risks of depression compared with those without a husband, wife, or partner? How do such positive/negative impacts distribute across regions?

Educational level In most cases, people with higher education tend to have higher incomes [43]. This means that they accumulate more assets in old age, leading to more freedom of choosing a lifestyle when they get old. It is more likely that higher income people engage in more leisure activities rather than productive activities [55], which may lead to fewer depressive symptoms in late life. The fourth sub-research question is shown as follows.

RQ2-4 Does higher education imply lower chance to suffer from depression? How do such effects vary with different regions?

Coresidence with an adult children Coresidence with an adult child contributes to the alleviation of depression for older adults compared with those who live alone. Older people who reside with their adult children would interact more with their kids or other family members [33]. The fifth sub-research question is formed to discuss this impact:

RQ2-5 Does cohabitation with adult children positively/negatively affect depressive levels of the elderly? How do such positive/negative impacts distribute across regions?

Contact frequency with children More frequent contacts with adult children contribute to the stronger parent-child relationship. A harmonious parent-child relationship conduces to lower levels of depressive symptoms in older adults [92]. However, such a contributor to depression has not been studied by previous studies. In order to fill this gap, sixth sub-research question is raised.

RQ2-6 Would older adults who contact more frequently with adult children have better depressive status than those with fewer contacts with adult children? How do such effects differ across regions?

In-person social contact frequency Loneliness and social isolation are considered to be significantly correlated with depression, particularly in older

adults [3]. Regular in-person social contacts with familiars may lessen feelings of loneliness and social isolation and thus reduce incidence of depression. Thereby, the seventh sub-research question is put forward.

RQ2-7 Would the elderly feel less depressed when they have more in-person social contacts with familiars? How do such relationships differ across regions?

3.2.2 Research Questions on Economic Characteristics

Annual household income Several empirical studies clarified the role of low income result in a higher incidence and maintenance of depression. Higher income signifies less economic pressure and more medical resources for depression treatments, which would result in lower levels of depressive symptoms [120, 121]. In order to know the relationship between depression and income in older South Koreans, the sub-question related to economic characteristics is proposed as follows.

RQ2-8 Does a higher annual household income imply a lower risk of depression of older adults? How do such relationships vary across different regions?

3.2.3 Research Questions on Health-related Factors

Physical health As we explained in behavioral model (Figure 2.1), changes in health, physical health in particular, can be regarded as one important mechanism that causes depression in late life. Therefore, the ninth sub-research question is proposed to explore the specific connection among physical health and depressive levels.

RQ2-9 Are older people with poorer physical health more likely to be depressed than those who are healthier? Are there regional variations of the impact of physical health?

Drinking habits Several studies examined the association between drinking habits and depressive symptoms among older adults. Some of their results showed that males with drinking habits are at a higher risk of depression [28]. Previous studies are extended to put forward the 10th sub-research question.

RQ2-10 How do drinking habits affect the depressive status of older adults? Would it increase the chance of suffering from depression? How does this relationship change when considering various regional environments?

Exercise Habits A significant number of studies have demonstrated that exercise and physical activities serve to reduce depressive symptoms [100]. Regular exercise reduces the onset of depression [38]. In older adults, physical activity has a negative influence on the formation of depression [99]. However, the research on influence of regular exercise habits on depression of older adults is still inadequate. This leads to the 11th sub-research question.

RQ2-11 Would regular exercise habits among older adults have positive impacts on depression? What is the regional variation of such effects of exercise habits?

3.3 Research Questions on Migration

Migration and its accompanying stressors affect migrating individuals and their families. For instance, people always feel stressed when they are unfamiliar with their new living environment [17]. Older adults who move from one place to another might have a less in-person social contacts and lower contact frequency with their family members or friends. Social activities would also be reduced since they are far away from their previous communities and unfamiliar with their current communities. These changes might make them feel disconnected with their children and socially isolated. If the migrated elderly stay in a lonely state for a long time, they usually suffer higher risks of depression. Thus, the following research question is developed.

RQ3 Do older adults who have migration experience (i.e., older adults have migrated within past two years) feel lonelier and more depressive than those who remain in one place?

3.4 Research Questions on Temporal Variability

Exploring changes in these associations over the years can potentially give insights into dynamics of related factors and depression. The last core research question is raised as follows, regarding the temporal variability of hypothesized relationships above.

RQ4 Does significant impacts of those factors on depressive symptoms of older adults change over the ten years from 2006 to 2016? How do they change?

Chapter 4

Study Area, Data, and Study Design

4.1 Study Area

The analysis of this thesis was conducted for South Korea. South Korea has the highest aging rate among East Asian countries, the growth rate of older South Korean aged 65 and above is visualized in Figure 4.1. Even though the proportion is 13.1% in 2015, which is lower than Organization for Economic Co-operation and Development (OECD) nations' average rate of 16.2%, it is expected to keep a rapid growth in the next few decades [56, 58]. According to statistical data from the Korea Statistic office in 2012 and 2015, South Korea is predicted to become the super-aged country, meaning that around 20% people are older than 65 years old in 2022. It would take 7 years for South Korea to finish the progress that other countries have completed in decades, such as Japan, who used 27 years and France, who used 115 years [56, 58]. As predicted in Figure 4.1, older adults aged 65 years or more would account for 40% of the total population in South Korea in 2060, implying that at least half of South Korean would rarely or not at all engage in socially productive activities, while consuming more social resource like the medical resource.

Figure 4.2 exhibits the distribution of the aging population ratio over South Korea in 2017. The older population ratio is more than 18% from north-eastern regions (i.e., Gangwon province and North Gyeongsang province) to southwestern regions (North Jeolla province and South Jeolla province). Gyeonggi Province and Daejeon City owned the lowest aging population, ranging from 9.3% to 11.8%.

The aging population can produce a series of social issues. Young adults will shoulder a heavier burden since they have to work more to support increasing older adults. Moreover, the government needs to augment the investment in social welfare and health service system to ensure their normal operations [20]. The economic environment may also deteriorate since

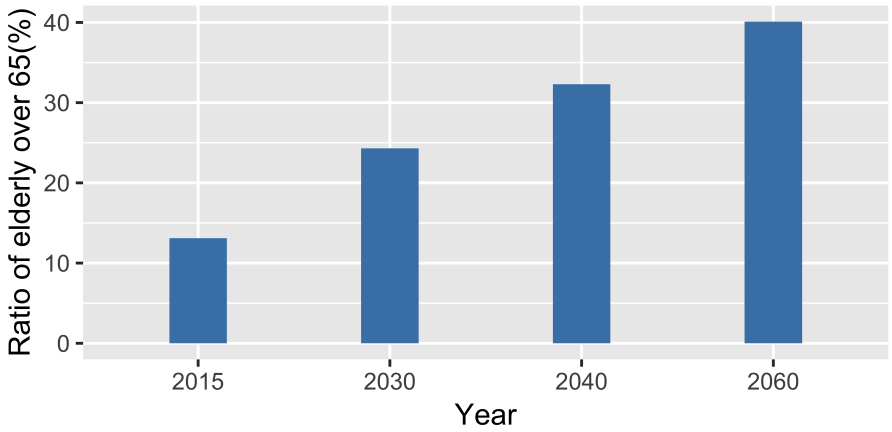


Figure 4.1: The predicted growth of the elderly over 65 years old from 2015 to 2060 in South Korea

there is inadequate labor to join social productive activities [71]. Economic conditions can usually affect mental health. For example, people living in poverty, especially the elderly, are more likely to suffer from depression. Furthermore, depression is one of the most common reasons for suicide [109].

The increased suicide rate also became the most serious social problem in South Korea. According to the researches from the World Health Organization (WHO) and OECD, South Korea has the tenth-highest suicide rate in the world and second-highest suicide rate among OECD nations in 2012. Suicide rates can vary by age. The noticeable high suicide rate in older adults has made a significant contribution to the high suicide in South Korea. In 2012, the suicide rate of people aged 70 or above was 0.19%, which is much higher than 0.048% and 0.021% of younger adults (15-28 years old and 30-49 years old) [89]. To conclude, South Korea is expected to be up against social issues related to older adults in the next few decades. Therefore, to solve these problems (e.g., suicide, medical service), it is urgent to investigate the causes of depression and the many factors affecting depression among the elderly.

4.2 Data

The data that has been used in this study is a Korean national panel survey data, called Korea Longitudinal Study of Aging (KLoSA). Korea Labor Institute established this survey in 2006 and has conducted this survey until 2016. Trained interviewers interviewed about 10,000 South Korean adults aged 45 or above who live in regular households. Participants have been systematically recruited from a total of 1,000 urban and rural districts (15

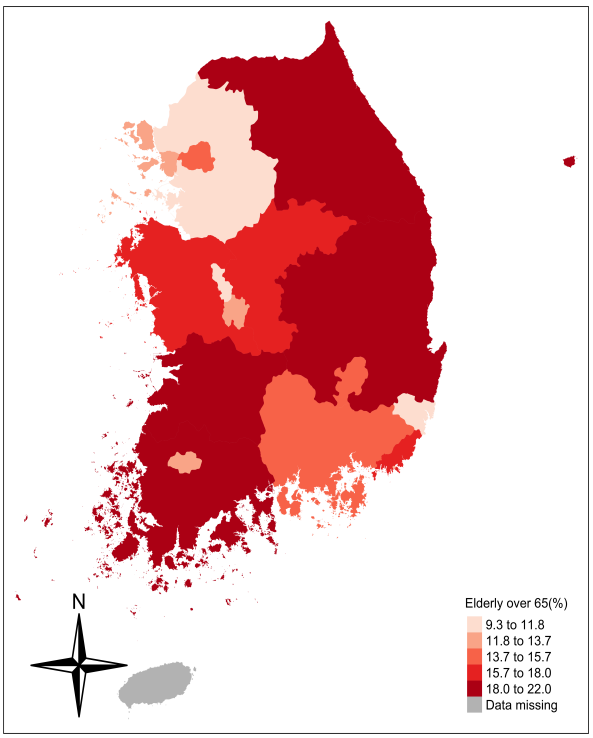


Figure 4.2: The proportion of older adults in South Korea in 2017

households in urban districts and 12 households for rural areas) among 15 metropolitan cities and provinces of South Korea [56]. The survey has been executed every two years, and all respondents have been interviewed face to face by using a computer-assisted interviewing methodology [33].

KLoSA includes information on respondents alongside with their sociodemographic status (e.g., marital status, gender, age), family relationship (e.g., cohabitation with adult children, the number of kids), health status (e.g., depressive status, self-reported physical health), income and consumption (e.g., salaries, household income), employment (e.g., (un)employment, retirement), assets, and debts (e.g., the amount of debt), and satisfaction (e.g., level of life satisfaction).

This study includes panels of data for all periods (6 waves from 2006 to 2016). Required information has been extracted, including the Center for Epidemiologic Studies - Depressive scale (CES-D) score, age, marital status, gender, academic background, contact frequency with children, in-person social contacts frequency, annual household income, self-reported physical health, drinking, exercise habits, and residential regions (districts, cities and counties).

4.3 Potential Analysis Methods

KLoSA is a panel data, which collected the information of older adults in South Korea across multiple consecutive survey years. Previous studies suggested the methods that can be used to analyze panel data, such as panel regression with fixed/random effects.

Type of Panel Regression

Fixed/Random Effects Regression A fixed-effect model is a statistical model of which model parameters are fixed. The fixed effects model is usually employed to explore the relationships between predictor and outcome variables in an entity. The entity can be a country, person, company, and so on. The predictor variables could or could not be affected by the individual characteristics of entities [12]. For instance, gender might influence people's depression status, and females might have higher levels of depression. The fixed effects model assumes that time-invariant traits (e.g., gender) are unique to each entity or individual. They should not be correlated with other individual characteristics. Hence, the effects of time-invariant variables need to be removed. It is different from the random effects model. The random effects model suggested that the changes across entities are random and uncorrelated with explanatory variables included in the model. In this case, the random effects model allows us to add time-invariant variables as an independent variable into the model [69]. Both fixed and random model can be applied in cross-sectional and time series analysis.

Type of Spatially Local Regression

Geographically Weighted Regression The Geographically Weighted Regression (GWR) is a powerful tool to estimate regression coefficients for each explicitly spatial area or location and its neighboring areas, and weighting the neighboring areas or objects by their distances from the observed area or location [41]. The basic theory is spatial autocorrelation among geographical observations, which was suggested by Tobler (1970) [102]. It is different from ordinary regression, which summarizes global relationships between the independent and dependent variables using one equation, GWR can be used to investigate the spatial variability in the correlations among variables [77]. When the GWR is applied, the number of neighboring observations is essential. The fixed or optimal adaptive bandwidth decides which points should be included to calibrate each local formula, and the kernel function is used to weight involved objects [40].

This study aims to explore geographical variations of the effects of multiple factors on the depressive status, which may show potentially differ-

ent regional characteristics. The fixed/random effects panel regression is not suitable to achieve this goal because it requires to either lose regional information of respondents (if choosing person-based panel regression) or aggregates observed variables of all the respondents by region (if choosing region-based panel regression). Meanwhile, GWR enables exploring the spatial variability of the relationships between each independent variable and depressive symptoms scores. In this study, I chose a Spatially Local Regression (SLR) similar to the idea of GWR but modified. SLR analyzes individuals of only neighboring regions for local regression same as GWR but puts the equal spatial weight of 1 for all the included neighboring individuals. The detailed methods of SLR will be described in Chapter 5.

4.4 Study Design

Figure 4.3 depicts the study design, or workflow for this project. First, the data analyzed is KLoSA data. It covers a range of sociodemographic, mental, and physical health status (e.g., marital status, gender, depression status, and self-reported physical health) of older adults in South Korea since 2006 till 2016, where all respondents are older than 45 years old.

Second, to explore the relationships between depressive status of older South Koreans and their sociodemographic, economic, and health-related factors as well as compare the changes of these relationships over time, I extracted following relevant variables from KLoSA data biannually collected for six survey years from 2006 to 2016; more details of each variable will be described in Section 5.1:

- **Depressive status**: CES-D score;
- **Sociodemographic status**:
  - Age;
  - Gender: female or male;
  - Marital status: getting married or living with a partner, separated, divorced, widowed or missing, or never married;
  - Educational level: elementary school and lower, middle school, high school, college/university, or higher;
  - Coresidence with children: co-residing with adult children or not;
  - Contact frequency with children: the total number of times that one child contacted for a year;
  - In-person social contact frequency: the total number of in-person social contacts with familiars for a year;

- **Economic status**: annual household income;
- **Health-related factors**:
  - Physical health: self-reported physical health (excellent, very good, good, fair, poor);
  - drinking habits: drinking (yes or no);
  - exercise habits: regular exercise (yes or no);
- **Migration**: having migrated for last two years (yes or no);
- **Residential region**: information of Si, Gun, or Gu (respectively equivalent to city, county, or district) that one older adult live in, which is used to geocode each respondent. The *Si-Gun-Gu* level of geographical scale is the 2nd-level Korean administractive boundary system. There are 229 regions of Si, Gun, or Gu across the country. As a tangible example, Seoul consists of 25 Gu regions (i.e., districts).

Third, preprocessing of variables was necessary to apply regression analysis to the data. As an example, assigning a four-point score ranging from 1-4 to educational levels, where 'higher' educational level gets a higher score of 4; reclassifying marital status into two groups including: (1) getting married or living with a partner and (2) getting separation or living alone. The dummy score of 1 was assigned to the group of getting married or living with a partner. Each respondent was geocoded by the ID of their residential region.

Finally, a series of analyses have been conducted. Global Moran's I and local Moran's I were employed to explore the spatial clusters of depressive symptoms and also discussed the temporal changes of spatial clusters across six survey years. The SLR briefly introduced above was applied to investigate the spatial variability of the relationships between depressive levels and sociodemographic, economic, and health-related variables. For migration, I implemented the Spearman Correlation Coefficient (SCC) analysis to study the effects of migration experience on depressive status. The temporal variability was examined regarding how the patterns and relationships observed in results of local Moran's I, SLR, and SCC vary over six survey years. Changes were visualized in line graphs and the temporal trends were interpreted.

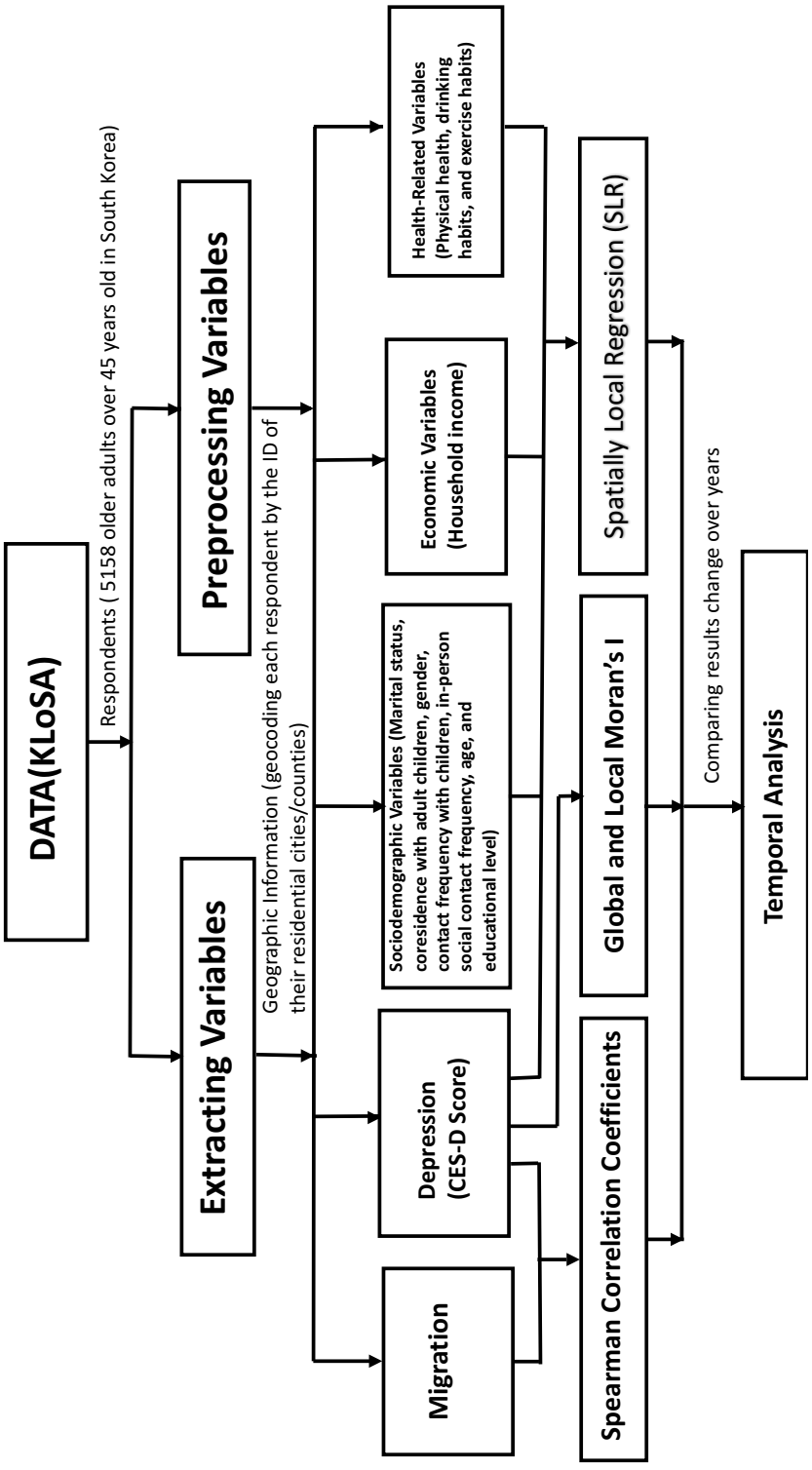


Figure 4.3: Study Design

Chapter 5

Methodology

This chapter is composed of two sections, including measures and analysis methods. Section 5.1 introduces the dependent variable and independent variables that are input to the analytical methods. To be specific, this section clarifies the reason that these variables were selected and the processing methods. Section 5.2 includes analytical methods applied to explore the relationship between the dependent variable and independent variables with or without the geographical perspective.

5.1 Measures

This section introduces the selected dependent and independent variables. The dependent variable is represented by depressive symptoms, which was measured by using the Center for Epidemiologic Studies - Depressive scale (CES-D) score. Independent variables consist of sociodemographic, economic, health-related variables.

5.1.1 Dependent Variable

Depressive Symptoms

The dependent variable is a quantified measure of depressive symptoms. Recent studies have regarded depressive symptoms as an efficient indicator to describe one's severity of depression. Self-reported and clinician-rated measures are the most commonly used methods to measure depression. The clinical trials to evaluate the depression severity needs a trained clinician to use depression-rating scales, such as the Hamilton Rating Scale of Depression (HRSD) [107]. Conversely, self-reported measure only requires the participants to fill out the questionnaire to report one's feelings of the previous week. Both Beck Depression Inventory (BDI) and the 10-short-item form of CES-D are widely used self-assessed questionnaires in recent years. The

self-reported measurement is much cheaper than clinician-rated measures since it does not need the participation of professional clinicians [62, 93, 104]. Thereby, it is more suitable for large-scale surveys (e.g., the nationwide survey) since the consulting time is much shorter than the clinical one. These advantages of self-reported measures might be the reason that KLoSA employs CES-D score for the survey.

CES-D uses 10 items to describe feelings of respondents of the previous week. Listed below are the 10 items:

1. I felt hopeful about the future
2. I felt happy
3. I felt depressed
4. I felt fearful
5. I felt lonely
6. I felt bothered
7. I had troubles in keeping mind on things
8. I felt everything was an effort
9. I am in restless sleep
10. I could not get going

For the last 8 items with negative expressions, giving 0 point implies that respondents rarely had such feelings (less than 1 day); giving 1 point indicates that the person sometimes has this feeling (around 1 or 2 days); giving 2 point means that people often feel like this (3 to 4 days); giving 3 point is that the participant keeps this feeling almost all the time (5 to 7 days). After reversely scoring the first two items with positive impacts, CES-D 10 yields scores ranged from 0 to 30 for 10 items. A higher score represents a more significant level of depression [113].

5.1.2 Independent Variables

The independent variables include participants' individual characteristics and migration.

In Korea Longitudinal Study of Aging (KLoSA) data, there are 7 categories of variables, including demographics, family, health, employment, income and consumption, asset and debts, and expectations and life satisfaction. Among them, 11 variables were included for this thesis to represent and quantify individual characteristics including sociodemographic, economic status, physical health, and health-related behaviors. These variables were measured at a respondent level.

Sociodemographic Variables

The sociodemographic variables consist of gender, age, marital status, educational backgrounds, coresidence with adult children, the contact frequency with children, and the number of in-person social contact frequency. The selected variables were preprocessed based on the research of Yang and Matthews (2012) [115].

Age Age was obtained by subtracting their birth year from the relevant survey year.

Gender Gender was treated as a dummy variable where females served as the reference group (female = 1, male = 0).

Marital status In KLoSA, there are five types of marital status including (1) getting married or living with a partner, (2) separated, (3) divorced, (4) widowed or missing, and (5) never married. To investigate the impact of getting married or living with a partner on depressive symptoms, the marital status were reclassified into two groups. The ones labeled with getting married or living with a partner remained unchanged, while the rest four types were merged into one group named 'getting separated or living alone'. Getting married or living with a partner was regarded as the reference group (dummy value = 1), as opposed to the other one (dummy value = 0).

Educational level There are four levels of educational background, including (1) an elementary school and lower, (2) middle school, (3) high school, (4) college or university and higher. A four-point score ranging from 1-4 was assigned to educational backgrounds, where higher educational levels got a higher score.

Coresidence with adult children Coresidence with adult children consists of two situations. The respondents were asked whether they resided with their adult children in the survey year, with the answer being ”yes” or ”no.” In KLoSA, the answer was reported on each of the respondent's children, if the respondent has multiple children. Therefore, older adults who dwell with any of their children served as a reference group (coresidence = 1, no coresidence = 0).

Contact frequency with children The contact frequency with children was measured by the number of contact times with all children for a year.

In-person social contact frequency Similarly, the number of in-person social contact frequency was also counted for a year.

Economic Variables

Annual household income The economic status was quantified by the annual household income. It was treated as a continuous variable in the analysis.

Health-related Variables

The health-related variables include physical health status and health-related behaviours. Health behaviors include drinking and exercise habits.

Physical health The physical health status was reported by self-rated physical health. Participants of KLoSA were asked to evaluate their physical health as excellent, very good, good, fair, and poor. Such kind of self-rated health measurement is now widely used since it could collect the overall physical health information of the respondents in a short time with a low expense [80, 81, 115]. For this thesis, 5 scores ranged from 1 to 5 were given to each item with the reinforcement of health status. For instance, the score of 1 is for the item of ”poor,” and the score of 5 is for ”excellent.”

Drinking habits Respondents were asked whether they regularly drink. People answering ” yes ” acted as the reference group (yes = 1, no = 0).

Exercise habits Regular exercise represents if participants had regular exercise habits. Answers were also given in terms of ”yes” or ”no” (yes = 1, no = 0).

Migration

As illustrated in some previous studies, migration may increase the risks of suffering from depression among older adults [17].

Migration Even though KLoSA did not provide information about the migration of respondents, the information on respondents' migration experiences can be obtained through comparing changes between their residential region of the analysis year and that of the previous survey year. If one's residential region has changed, they were labeled “yes” in the analysis year (equivalent to having a migrating experience since the previous survey year). The respondents with “Yes” served as the reference group and a dummy value of 1 was assigned, while the respondents with “no” were given a dummy value of 0. With this method, we constructed the migration data for 5 survey years from 2008 to 2016.

5.1.3 Descriptive Statistics of Dependent and Independent Variables

Table 5.1 illustrates the mean values and standard deviations of each variable in 6 survey years. The mean depressive symptoms scores have increased from 2006 to 2012, and then show a decreasing trend after 2012. Age shows that the survey is conducted every other year. Gender has almost no changes since the respondents have been recruited systematically and the sample size has been fixed, and the percentage of females is higher than males. The educational level keeps stable in six survey years, which indicates that the educational level is difficult to improve in late life.

Regarding social interactions, the proportion of people who get married or live with their partners has decreased through the years. It is probably because older people have a higher chance of widowhood as they getting older. The proportion of participants who live with their adult children exhibits a decreasing trend. Moreover, the respondents' average in-person contact frequency with their familiars have reduced from 2006 to 2016 by 18.8%.

Annual household income has been growing year by year, which might be related to South Korea's economic development or the increased investment in social welfare.

For health-related variables, the average score of physical health shows a downward trend, indicating that the self-reported physical health status of respondents has decreased with age. The number of respondents with drinking habits and the number of those with exercise habits have decreased over the years. These results imply that as respondents getting older, more participants quit drinking habits, and fewer older people exercise regularly.

Table 5.1: Descriptive statistics of input variables of this study (by year)[a].

	Year[e]					
	2006[b]	2008[b]	2010[b]	2012[b]	2014[b]	2016[b]
Dependent variable						
CES-D scores	2.7216	3.445	3.5010	3.3714	3.1331	2.7354
	(2.4813)	(2.7800)	(2.8956)	(2.8339)	(2.7261)	(2.6925)
Sociodemographic variables						
Age	60	62	64	66	68	70
(Years old)	(9)	(9)	(9)	(9)	(9)	(9)
Gender	0.5712	0.5712	0.5712	0.5712	0.5712	0.5712
(female=1, male=0)	(0.4950)	(0.4950)	(0.4950)	(0.4950)	(0.4950)	(0.4950)
Marital status	0.8519	0.8411	0.8238	0.8096	0.7896	0.76618
(Getting married/living with partners=1,	(0.3553)	(0.3657)	(0.3811)	(0.3926)	(0.4076)	(0.4233)
getting separated/living alone=0)						
Educational level	2.0320	2.0300	2.0310	2.0314	2.0314	2.0186
(~Elementary school[c] = 1,	(1.0530)	(1.0530)	(1.0548)	(1.0547)	(1.0549)	(1.0346)
Middle school=2,						
High school=3,						
University~[d] = 4)						
Coresidence with adult children	0.5397	0.4806	0.4102	0.4440	0.3940	0.3437
(Yes=1, No=0)	(0.5000)	(0.4997)	(0.4919)	(0.4969)	(0.4887)	(0.4750)
Contact frequency with children	193	171	183	161	174	177
(The number of times a year)	(246)	(220)	(233)	(298)	(193)	(196)
In-person social contact frequency	165	155	142	142	121	134
(The number of times a year)	(155)	(153)	(149)	(128)	(138)	(145)
Economic variables						
Annual household income	1986.494	2608.667	2548.748	2751.193	2691.143	2719.649
(10,000 Won/year)	(2587.062)	(3011.427)	(2196.122)	(2563.472)	(2401.203)	(2420.829)
Health-related variables						
Physical health	2.4515	2.4347	2.3856	2.3284	2.2745	2.2470
(Excellent=5, very good=4,	(1.0104)	(0.9291)	(0.8962)	(0.8853)	(0.8642)	(0.8684)
good=3, fair=2, poor=1)						
Drinking habits	0.3920	0.3887	0.3701	0.3567	0.3375	0.3172
(Yes=1, no=0)	(0.4882)	(0.4875)	(0.4828)	(0.4790)	(0.4729)	(0.4654)
Exercise habits	0.3920	0.3887	0.3701	0.3567	0.3375	0.3172
(Yes=1, no=0)	(0.4877)	(0.4828)	(0.4774)	(0.4818)	(0.4695)	(0.4722)

[a] I report the mean value of each variable, for dummy variables, the mean value represent the proportion of them coded 1.
[b] Standard deviation is in parentheses.
[c] Lower than elementary school.
[d] Higher than University.
[e] The number of respondents in 6 survey years is 5158.

5.2 Analysis Methods

This section introduces the analytical techniques applied to analyzing the preprocessed data. First, based on the study of Cromley, Wilson, and Pruchno (2012) [31], the Exploratory Spatial Data Analysis (ESDA) approach was employed to investigate the spatial hotspots and coldspots of the depression, i.e., groups of regions with the similar level of depression.

Second, Ordinary Least Squares regression (OLS) was used to examine how sociodemographic, economic, and health-related variables are associated with depressive symptoms in KLoSA data. Then, different from existing studies with KLoSA data, the Spatially Local Regression (SLR) method, similar to Geographically Weighted Regression (GWR), was applied to investigate the spatial heterogeneity of independent variables' impacts on depression.

Third, in addition to regression analysis, the correlation between the migration of respondents and depression was measured by the Spearman Correlation Coefficient (SCC).

Finally, all the identified patterns and associations between depression and related factors have been dynamic over time, and such changes were compared.

5.2.1 Exploratory Spatial Data Analysis

According to Anselin (1998), ESDA provides the techniques to describe and visualize spatial distributions, investigate the spatial autocorrelation (clusters or hotspots), discover abnormal spatial patterns, and advises spatial heterogeneity (e.g., spatial regimes) [7, 11, 50, 78]. ESDA is used to detect and describe spatial patterns, raise the hypothesis, and evaluate statistic models for spatial data. This is different from Confirmatory Spatial Data Analysis (CSDA) that aims to examine the hypothesis by the spatial statistic models [50, 51, 72].

Spatial Pattern Characterization with Exploratory Spatial Data Analysis

Spatial autocorrelation indicates observations with similar characteristics located in adjacent or close spatial areas or locations. The observations are impacted by local spatial evolution and interactions. As a result, the observations are interdependent on themselves [83]. Griffith (2009) [49] defined spatial autocorrelation as the "correlation among values of a single variable strictly attributable to their relatively close locational positions on a two-dimensional surface." [49]. The spatial cluster is a group of spatial objects georeferenced by its area or location, showing similar characteristics within the group compared to those in the other groups [88].

Spatial autocorrelation analysis can often yield both global and local spatial autocorrelation statistics. On one hand, Moran's I is regarded as the most widely used indicator of global spatial autocorrelation. It was first proposed by Moran (1948) [82]. Then, Cliff and Ord (1973) [30] contributed to a wider use of such indicator through classical work on spatial autocorrelation [46]. Researchers use gloabl Moran's I to examine whether their observations are spatially clustered in the entire area from a global perspective. The global Moran's I assumes spatial stationarity, it can only provide one statistics to explain the whole study region. On the other hand, local Moran's I is used to test local spatial autocorrelation. This is because it is unreasonable to use one statistic to summarize the whole study area, if characteristics of the study area are spatially heterogeneous; the statistic may have a spatial variation [6]. Local Moran's I helps discover the local clusters and their locations and then assess the significance of each location [6, 8].

ESDA Statistics

Global Moran's I For the thesis, the global Moran's I was first applied to explore the spatial autocorrelation and significance of CES-D scores in the whole study area. A significant positive value indicates that CES-D scores are spatially clustered in the entire country. A significant negative value implies that the CES-D score of the region is different (e.g., lower or higher) from that of its neighboring areas. The global Moran's I does not provide the location of each spatial cluster. To investigate which region is correlated with neighbors, we need to employ local Moran's I [31].

Local Moran's I The local Moran's I is used to detect the locations of the spatial clusters of average depressive symptoms scores in South Korea. The formula of local Moran's I for each region i is:

$$I_i = \frac{x_i - \mu}{\sum_i (x_i - \mu)^2 / N} \sum_j w_{ij}(x_j - \mu) \tag{5.1}$$

where w_{ij} is the spatial weight matrix considering the closeness or adjacency of the region i to the region j. In this study, x_i is the average CES-D score of KLoSA by region. N is the number of regions. Local Moran's I quantifies the relationship between observed CES-D score in the region i and its neighboring regions.

A positive local Moran's I statistic indicates the spatial clusters with similar CES-D scores. The spatial clustering of similar values consists of two categories, a *High-High* cluster (hotspot) and a *Low-Low* cluster (coldspot). The High-High cluster describes the spatially clustered regions with similar high values. The Low-Low cluster indicates that a group of geographical areas have similar low CES-D scores. If the local Moran's I statistic gives the result close to zero or equal to zero, it implies that there is little or no autocorrelation between the region and its neighboring regions. If the local Moran's I statistic yields a negative value, it connotes that there is a spatial dispersion and a group of regions with dissimilar values spatially clustered. There are two types of spatial dispersion: the *Low-High* and the *High-Low* clusters. The Low-High cluster occurs when the region with the low CES-D score is surrounded by high-score areas. The High-Low cluster is the opposite case that appears when the high-score region is neighbored by low-score regions [119].

5.2.2 Analytic Strategy

For more confirmatory analysis, OLS, SLR, and SCC were carried out. Temporal variability was observed by examining changes of the results from each analysis over six survey years.

Ordinary Least Squares

OLS is a kind of linear least-squares statistics used to estimate unknown coefficients in a linear regression model. OLS selects parameters by minimizing the sum of the squares of the distance between the observed dependent variable and such variables predicted by a linear function [60]. The OLS regression tests the influences of each sociodemographic, economic, and health-related variables on depressive symptoms scores at a global scale. It is also employed for both global and local regression models in this study. The details on how to interpret the OLS regression analysis results are listed below [94].

1. Coefficients can give insights into the relationships between dependent and independent variables.
2. Akaike Information Criterion (AIC) was used to test which model is relatively fit to data. In general, a model with the lower AIC is regarded better. In the analysis results, this indicator indicated that SLR is better than OLS regression.
3. Variance Inflation Factor (VIF) was employed to identify if two or more variables have colinearity. Variables with a VIF of greater than 7.5 are recommended to be excluded.
4. Adjusted R-Square is commonly used to see which model can explain more variation of a dependent variable. Here, I compared adjusted R-Square values from both OLS regression and SLR to check which model explains more variations of the depressive symptoms scores.

Spatially Local Regression

For KLoSA data, an accurate residential location with geographic coordinates of each individual is not available because of privacy and confidentiality issues. The highest granularity of location information available in KLoSA is participates' residential area in the Si-Gun-Gu level (e.g., Jongno gu in Seoul, one of 25 administrative districts of Seoul) equivalent approximately to the U.S. county level. With this data constraint, applying GWR with distance-based spatial weights to the individual respondents makes less sense. Alternatively, the SLR was adopted in the thesis by regarding respondents in an observed region and its k-nearest regions at the Si-Gun-Gu level for a local regression.

The most typical spatially local regression, GWR, uses the bandwidth to identify the subset of the entire region around the observed point/area and then applies a kernel function to weight the surrounding points/areas, such as a Gaussian function that assigns weights to those points/areas deceased with the distance [22].

Different from GWR, in this study, as illustrated in Figure 5.1, the individuals in 10 nearest regions (districts, cities, or counties) of the observed area are included for a spatially local regression. Because there are 229 regions (districts, cities, and counties) in KLoSA, 229 subsets of respondents were generated for 229 local regression analyses. For each subset based on target and its neighboring regions, all the individuals of the subset were weighted equally by 1 and the individuals outside of the subset were weighted by 0, which is an idea of spatial filtering.

For the local regression analysis, I ran an ordinary linear regression with each subset of respondents belonging to a target and its neighboring regions (229 times in total), and the result from the local regression was assigned to the target region. Then, the spatial variability of relationship between each variable on depressive symptoms scores was visualized on the map.

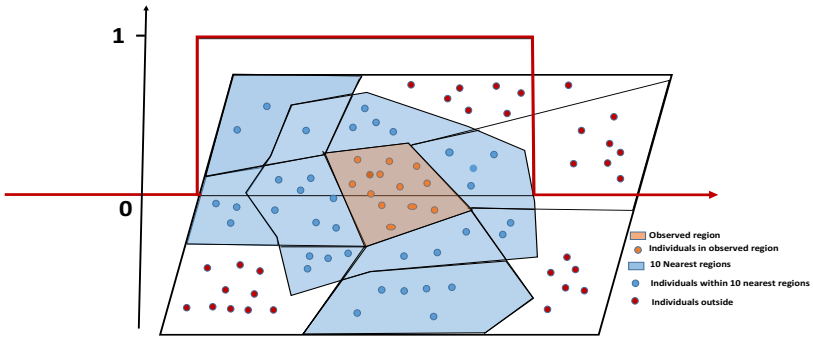


Figure 5.1: The spatial weight function of Spatially Local Regression (SLR)

The output of local R-square of the SLR was mapped to show where the model performed well. AIC was used to make a comparison with OLS to see if the SLR is preferred. Coefficients were mapped to find the spatial variations of the associations between depression levels and each variable. If the coefficient is significantly positive in one region, it indicates that this variable in these areas significantly contributes to depressive symptoms. If the coefficient of one variable is significant and negative, we can say that in these locations, this variable has significantly reduced the level of depressive symptoms. The results of SLR were also summarized to observe the percentage of districts, cities, and counties, and participants that has been significantly impacted (negative or positive).

Temporal Analysis

Multiple line graphs were used to explore changes in each variable with significant impacts on the level of depressive symptoms over survey years. I also compared the yearly percentage changes of respondents with a significant effect of each variable on depression. Then, the local R-squares are also showed in line graphs in order to see the degree of explanatory power of the variables over the years.

Spearman Correlation Coefficients

Spearman Correlation Coefficients (SCC) is a non-parametric measure of rank correlation. It uses a monotonic function to evaluate how well the correlation between two variables can be described [44]. The migration variable constructed from KLoSA data represents the spatio-temporal changes of the respondent's living environments. I applied the correlation analysis to exam the relationship between migration and depression by using SCC. The properties of SCC is that the coefficient ranged from -1 to 1. The negative SCC value indicates a negative correlation and positive SCC values means a positive correlation. The closer to 1 the absolute value of the obtained coefficient, the greater the correlation between the two variables. The correlated levels can be interpreted based on the rules listed as follows [84].

1. If the absolute value of coefficient is in the ranges of 0.9 to 1, indicating a extremely strong correlation between two variables.
2. If the absolute value of coefficient is in the ranges of 0.7 to 0.9, which means a strong correlation between two variables.
3. If the absolute value of coefficient is in the ranges of 0.5 to 0.7, which implies a intermediate correlation between two variables.
4. If the absolute value of coefficient is in the ranges of 0.3 to 0.5, which means a weak correlation between two variables.
5. If the absolute value of coefficient is less than 0.3, which means no correlation within two variables.

   The correlation can be discussable only if it is significant.

Chapter 6

Results

This chapter illustrates the results obtained from multiple analysis methods. Tables, maps, and plots are used to present the results. Section 6.1 illustrates the results from Exploratory Spatial Data Analysis (ESDA), including global Moran's I and local Moran's I. The second section reports the global and local relationship between each selected variables and depressive symptoms scores, which are confirmed by Ordinary Least Squares (OLS) regression and Spatially Local Regression (SLR). The results of temporal changes of the significant coefficients obtained by SLR are presented. The last part is the correlation between migration experience and depressive symptoms scores that was tested by Spearman Correlation Coefficient (SCC) for six survey years. The regional scale of the results is identified at the Si-Gun-Gu level as described in Section 4.4 and there are 229 regions of Si, Gun, or Gu.

6.1 Exploratory Spatial Data Analysis

6.1.1 Spatial Autocorrelation

Global Moran's I from 2006 to 2016

Moran's I gave positive values to all years (Table 6.1), which indicates a positive spatial autocorrelation or spatial clustering. The clusters have similar the Center for Epidemiologic Studies - Depressive scale (CES-D) scores in the entire country in all periods. All p-values are less than 0.01 in 2008 and 2010. It implies that the probability of these observed patterns appearing by chance is less than 0.01 for these two years.

Moreover, in 2006, 2012, and 2016, the p-values are less than 0.05; this means that the likelihood of random occurrence of this pattern is less than 0.05. Z-scores are bigger than 1.75 in six survey years indicating significantly spatial clustering in the whole period.

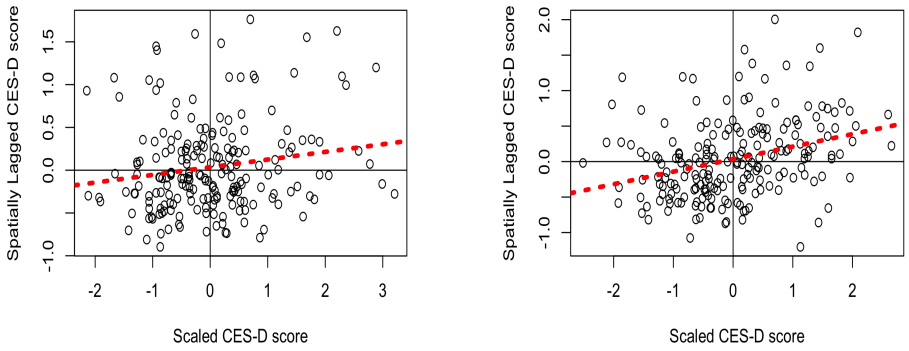
Table 6.1: Global Moran's I

	Year					
	2006	2008	2010	2012	2014	2016
Global Moran's I Statistics						
Estimates	0.0870	0.1720	0.1547	0.0642	0.1673	0.0928
Z-scores	1.9506	3.7973	3.459	1.9194	3.7764	2.1629
Significance	**	***	***	**	***	**

*** p-value<0.01
** p-value<0.05
· p-value<0.1

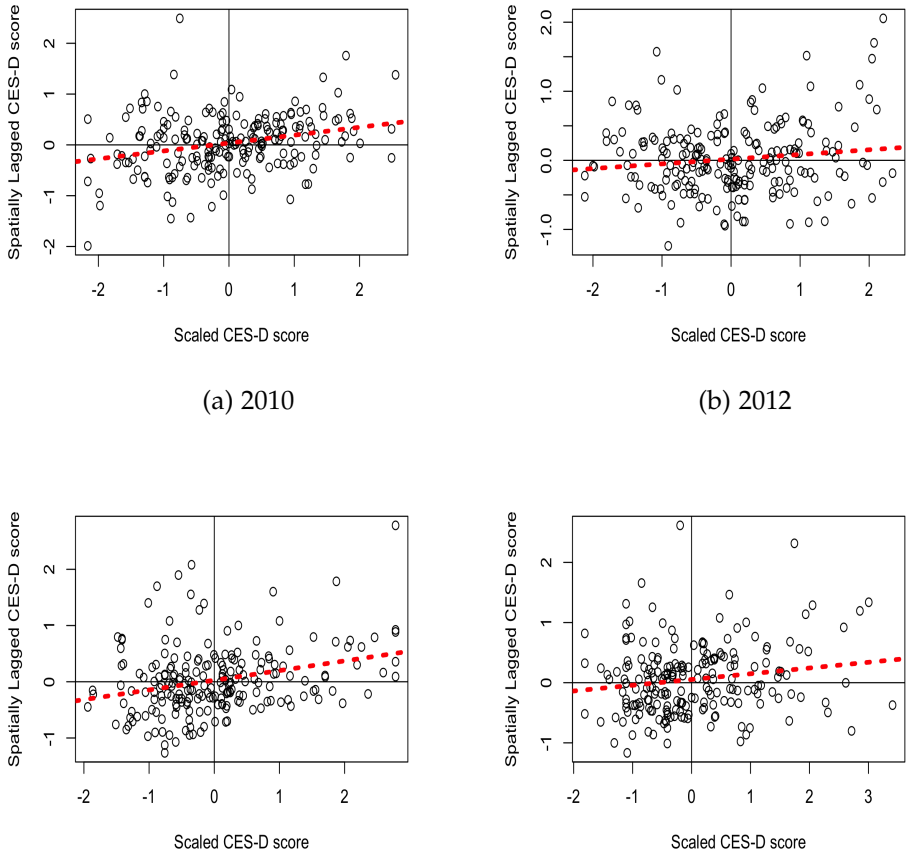
Figure 6.1 and Figure 6.2 show the scatter plots of Moran's I in the six survey years, where the regions in first quadrant have high and similar depressive symptoms scores to the neighboring area; the third quadrant captures regions which clustering with low depressive symptoms; the second and fourth quadrants include the neighboring regions with different depressive symptoms scores. In terms of these scatter plots, there are most regions that are close to the value 0 (x=0 or y=0). It indicates most areas having no spatial clustering in the six survey years.

There are fewer regions in the second and fourth quadrant, but more regions in the first and third quadrant. Last two years in particular, most districts, cities, and counties are in the third quadrant, which estimates that in 2014 and 2016, the coldspots might be bigger than hotspots in the entire state.



(a) 2006 (b) 2008

Figure 6.1: Scatter plot for Moran's I from 2006 to 2008



(a) 2010 (b) 2012

(c) 2014 (d) 2016

Figure 6.2: Scatter plot for Moran's I from 2010 to 2016

Local Moran's I from 2006 to 2016

Local Moran's I explored the spatial clusters (e.g., hotspots, coldspots) of regions that appear similar or dissimilar in depressive symptoms scores in KLoSA from 2006 to 2016.

In Figure 6.3, the depressive symptoms scores were averaged at the Si-Gun-Gu level (i.e., 211 districts, counties, and cities). Most of regions are not significantly similar to their neighboring regions (the most areas do not have spatial clusters). In contrast, a few regions show a significant and positive spatial autocorrelation throughout 10 years; it means that the regions with relatively high or low average CES-D scores are spatially clustered.

There are two categories of spatial clusters, high-high and low-low clusters.

In 2006, there are 8 high-high regions and 10 low-low ones; The biggest high-high cluster is distributed in the southeast part of Gangwon Province in 2006. The other two respectively are located in South and North Jeolla Provinces. In these regions, their average CES-D scores are higher than other regions and similar to their neighboring cities or counties. There are two small low-low clusters. Both of them are urbanized areas. In these low-low clusters, the depressive symptoms score are relatively low to other distant regions and similar to their neighboring cities or counties.

In the next five survey years, the spatial cluster with similar depressive symptoms scores keep increasing and appearing with a bigger size. What is more, it is noticeable that the size and location of one hotspot in northwest regions of Gyeonggi Province are observed unchanged from 2010 to 2014, and in this period, most significant low-low clusters are located in some rural areas.

In 2008, the locations of clusters change when compare with the pattern in 2006. The two noticeable high-high clusters are in Gyeonggi Province and South Chungcheong Province. Most of the regions in the clusters are cities.

Although the spatial pattern looks similar in 2010 and 2012, differences can be explored as well. A big high-high cluster in North Chungcheong Province in 2010 disappears in 2012, and one largest low-low cluster which is located in the northwest districts near the boundary with North Korea that has reduced, and another smaller one locates in southeastern part of the country in 2010 that is absent in 2012. What is more, a coldspot in the western coastal region in 2010 turns into the hotspot in 2012.

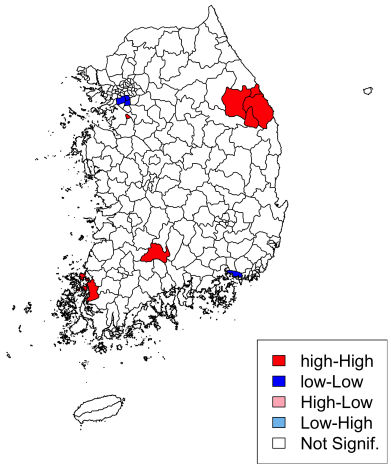
The year of 2014 captures the largest coldspot comparing with other years, which extends from the northeast coast to the junction areas of Gangwon Province and Gyeonggi Province. It covers around one third of the areas of Gangwon Province and involves 5 large cities and counties. In 2016, the unchanged hotspost in the previous four survey years gets a new region, and a big coldspot occurs in North Gyeongsang Province.

6.2 Multivariate Regression Analysis

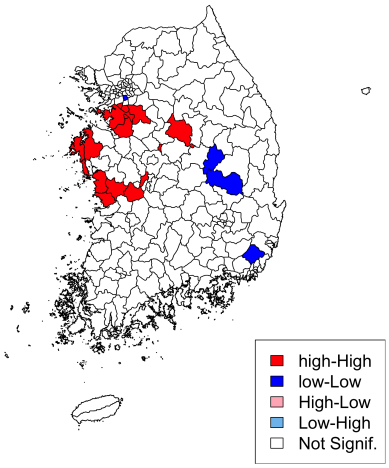
6.2.1 Confirmatory Non-Spatial Analysis

The Results of Ordinary Least Squares Regression

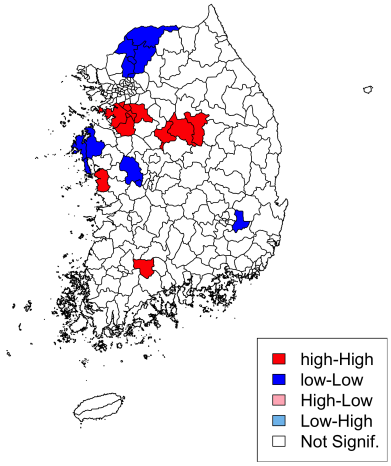
The Ordinary Least Squares (OLS) regression was used to investigate the associations between sociodemographic, economic and health-related variables and depressive symptoms scores in the entire country (Table 6.2). The adjusted R-squares is 18%, indicating that 18% of the variations in depressive symptoms scores in respondents can be explained by these explanatory



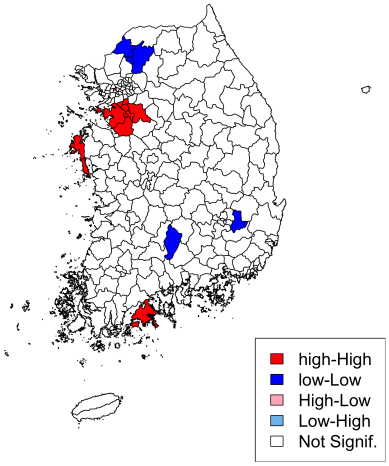
(a) 2006



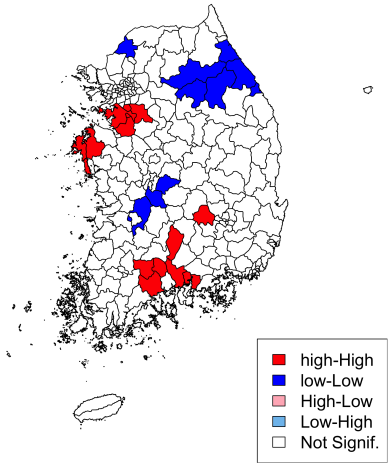
(b) 2008



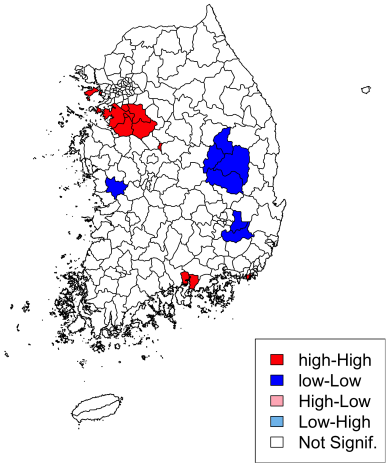
(c) 2010



(d) 2012



(e) 2014



(f) 2016

Figure 6.3: Local spatial clusters from 2006 to 2016

variables. The Akaike Information Criterion (AIC) score is 23016.23, which will be used to compare with the one that obtains from the Spatially Local Regression statistic. The model with lower AIC will be regarded better. The Variance Inflation Factor (VIF) was used to test if there is a colinearity among independent variables. The OLS model has reported that the VIF for all variables is less than 7.5, which implies that no independent variable need to be removed. The coefficients and significance are interpreted as follows.

1. The significant and positive intercept indicates a high level of depression symptoms scores without the effects from each variable.
2. The contact frequency with adult children, educational level, household income, physical health, in-person social contact frequency, marital status and exercise habits have significant and negative impact on CES-D scores. It means that the increasing contact frequency of children, more in-person social contacts, a higher household income, a better physical status, getting married or living with partners, and having a regular habits of exercise would significantly contribute to reducing the levels of depressive symptoms.
3. Gender and age have significant and positive effects on CES-D scores, which implies that females have more risks of suffering from depression and the growing age increases likelihood of being depressed.
4. Drinking and coresidence with adults children are not significant factors.

Table 6.2: The results of Ordinary Least Squares (OLS) regression in 2006.

	b Coefficients	Std.Error	T.Statistics	Significance	VIF
Variables					
Intercept	5.4825	0.3700	14.821	***	
Sociodemographic Variables					
Age	0.0087	0.0043	2.044	**	1.6502
Gender	0.1579	0.0788	2.005	**	1.5484
Marital status	-0.9073	0.0962	-9.428	***	1.1911
Educational level	-0.1805	0.0379	-4.768	***	1.6194
Coresidence with adults children	-0.1091	0.0709	-1.539		1.2724
Contact frequency with children	-0.0005	0.0001	-3.608	***	1.1922
In-person social contact frequency	-0.0012	0.0002	-5.572	***	1.0423
Economic Variables					
Household income(10,000 won/year)	-0.0001	0.00001	-3.460	***	1.1636
Heal-related Variables					
Physical health	-0.6944	0.0346	-20.079	***	1.2443
Drinking habits	0.0001	0.0740	0.001		1.3289
Exercise habits	-0.2383	0.0668	-3.566	***	1.0818
					AIC:23016.23
					Adjusted R-squared: 18%

*** p-value<0.01
** p-value<0.05
. p-value<0.1

6.2.2 Confirmatory Spatial Analysis

Local R-Squares of Spatially Local Regression

The Spatially Local Regression (SLR) refined in Chapter 5 was used to investigate the local associations between depressive symptoms scores and each explanatory variable. Figure 6.4 exhibits the spatial distribution of local R-squares values in 2006. The regions with highest local R-squares are distributed from the western regions (district/cities/counties) of North Jeolla Province to the northern areas of South Gyeongsang Province. The same level also occurs in Gwangju metropolitan city, southern counties of South Jeolla Province, northeast coastal regions in Gangwon Province, the Yeongwol County in Gangwon Province, and the cites and counties surrounding the capital city Seoul. In these areas, 30% to 47% changes in CES-D scores can be explained by the sociodemographic, economic,and health-related variables. Lower values ranged from 9% to 23% are primarily discovered in the middle areas of South Korea, which indicates that these variables can only explain 9% to 23% of the alteration in CES-D scores in those regions.

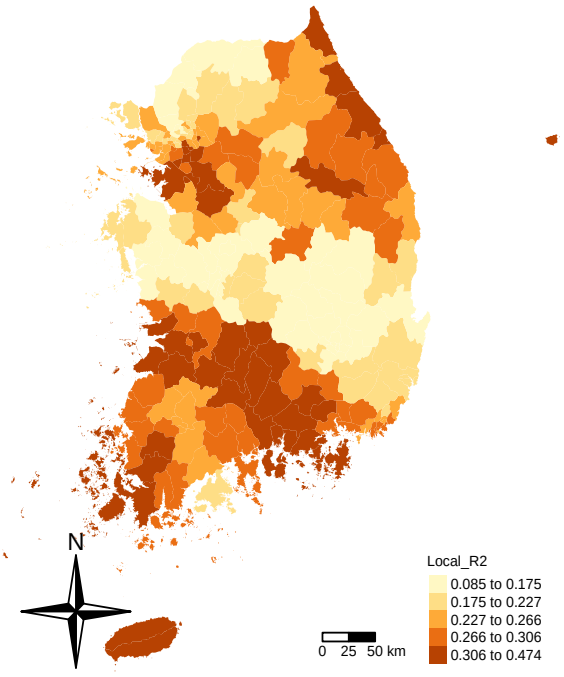


Figure 6.4: The Local R-squares of Spatially Local Regression (SLR) in 2006

Local Coefficients and Significance of Spatially Local Regression

SLR gave a set of local coefficients changed over space for each variable. These coefficients were divided according to their statistical significance levels. Table 6.3 shows the ranges of the coefficients and percentage of districts/cities/counties and respondents with a p-value less than 0.05 in 2006. In addition, following the suggestion from Cromley, Wilson, and Pruchno (2012), the spatial distributions of coefficients and significance levels were also visualized on maps, and comparing the significantly positive and negative impacts. The AIC method was employed to evaluate the developed SLR model. Burnham and Anderson (2002) suggested that, if the difference of AIC from two models is bigger than 4, the model with higher AIC will be regarded as having less statistical support, and the other model should be preferred [23]. The AIC of the SLR is 1169.377 (Table 6.3), which is much smaller than the 23016.23 given by OLS (Table 6.2). Therefore, in this study, the SLR is considered better.

Table 6.3: The results of local coefficients and significance of Spatially Local Regression (SLR) in 2006.

	Coefficients[a]			%(Significant)	
	Min.	Med.	Max.	Positive[b]	Negative[c]
Variables					
Intercept	-3.9820	5.1996	16.7880	74% (74%)	0% (0%)
Sociodemographic variables					
Age	-0.1000	0.0134	0.0948	21% (25%)	13% (12%)
Gender	-1.3685	0.1659	1.1401	9% (9%)	4% (2%)
Marital status	-3.2940	0.1659	0.3943	0% (0%)	48% (44%)
Educational level	-0.7468	-0.1238	0.2587	0% (0%)	18% (20%)
Coresidence with adutl children	-1.0852	-1.539	2.0335	6% (4%)	14% (16%)
Contact frequency with children	-0.0050	-0.0006	0.0032	1% (0.7%)	23% (18%)
In-person social contacts frequency	-0.0043	-0.0011	0.0026	1% (2%)	26% (27%)
Econimic variables					
Household income(10,000 won/year)	-0.0007	-0.0001	0.0002	4% (5%)	24% (20%)
Health-relaed variables					
Self-reported physical health	-1.6440	-0.7570	0.1377	0% (0%)	86% (84%)
Drinking habits	0.9125	-0.0890	-1.4910	3% (4%)	8% (10%)
Exercise habits	-1.5466	-0.1384	1.2284	2% (14%)	18% (23%)
					AIC:1169.377
					R-squared:21%

[a] Min:minimum;Med.:median;Max.:maximum
%(Significant) Percentage of local estimates with p-values less than 0.05
[b] Percentage of cities/counties and respondents(in bracket) with positive coefficients and p-values less than 0.05
[c] Percentage of cities/counties and respondents(in bracket) with negative coefficients and p-values less than 0.05

Two maps for each variable in 2006 are shown as follows (Figure 6.5 to Figure 6.8). The left map shows the spatial variability of the relationship between depressive symptoms scores and the corresponding variables. The right map exhibits the locations where the variables perform significantly.

Intercept

The intercept from local model indicates the distribution of depressive symptoms levels without the effect of each variables. It is ranged from -3.9820 to 16.7880 (Table 6.3). 74% of regions are significant and positive.

Sociodemographic Variables

Age The coefficients of age are distributed between -0.1 and 0.0948 (Table 6.3). A significant and positive association between depressive symptoms scores and age is found in both cities and counties across North and South Chungcheong Province. Another positive effect is observed in the counties close to the capital city Seoul (Figure 6.5a, Figure 6.5b). Those regions had 25% of the respondents. The effect suggests that a higher age represents a higher level of depression. A negative relationship also exists over the state, which is discovered as a shape of narrow strip locating along the northeast coast in Gangwon Province and also found in South Jeolla Province, 12% of respondents live there. Their growing age is not the factor that could make them suffer from a higher level of depression.

Gender The coefficients of gender are from -1.3685 to 1.1401 (Table 6.3). A significant and negative relationship between gender and depressive symptoms is found in the southwestern coastal areas in Gyeonggi Province and northeastern coastal regions in Gangwon province (Figure 6.5c, Figure 6.5d). Two percent of the participants live there. This negative effect means that females in these areas tend to have a lower level of depression. In contrast, a significantly positive relationship occurs in some rural areas in North Jeolla Province and two counties in North Gyeongsang Province, where have 9% of respondents. Females among them are easier to be exposed to depression.

Marital status Marital status are observed to be negatively influencing depressive symptoms scores in almost half of the entire state (Figure 6.6a, Figure 6.6b) (ranging from -3.924 to 0.3943 (Table 6.3)). This result reveals that getting married or living with partners might play an essential role in preventing older adults from depression in this country. The positive effect is found in a small area, but it is not significant. The significant pattern is discovered in the northeastern and southwestern regions of South Korea (covered 48% of the study area and 44% of the respondents).

Educational level The educational level coefficients ranges between -0.7468 and 0.2587 (Table 6.3). The education coefficients are significant and negative in Daejeon metropolis and parts of North and South Jeolla Province (Figure 6.6c, Figure 6.6d). 20% of respondents live in these regions and who have

higher levels of education would get fewer feelings of depression. Negative impacts are also found in the country, but they are not significant.

Coresidence with adult children As illustrated in Table 6.3, the coefficient of coresidence with adult children is in the range of -1.0852 to 2.0335. In the southeastern parts of South Chung-cheong Province, Sejong Special Autonomous City, Daejeon Municipality, the northern part of North Jeolla Province, and the mid-part of South Jeolla Province (Figure 6.6e, Figure 6.6f). In these regions, the depressive symptoms scores in around 16% of respondents are significantly negatively affected by the coresidence with adult children. It implies that dwelling with adult children has lessened their levels of depression. A significant positive pattern is observed in the northeastern coastal areas of Gangwon Province, where 4% of participants reside. Coresidence with adults children will increase their risks of suffering depression.

Contact frequency with children The local coefficients of contact frequency with children ranged from -1.0052 to 0.0032 (Table 6.3) indicating both positive and negative effects in this state. The regions with significant and negative impacts occupy 23% of regions. They are observed in the middle and southern parts of South Gyeongsang Province, the capital city Seoul, counties of Gyeonggi province, and the southernmost counties in South Jeolla Province (Figure 6.7a, Figure 6.7b). Around 18% of the respondents live there. For these older adults, more frequent contacts with children have reduced their feelings of depression. Significant and positive effects are also found in the westernmost part of South Chungcheong Province. However, the area is much smaller than the significantly negative pattern, and only include 0.7% (Table 6.3) of respondents.

In-person social contacts frequency The significantly negative coefficient for the in-person social contact frequency is found in the eastern and western coastal areas in South Chungcheong Province, western coastal cities or counties of North and South Gyeongsang Province, and the adjacent regions of South Gyeongsang Province, North and South Jeolla Province (Figure 6.7c, Figure 6.7d). The reduction of depressive symptoms in older adults in these areas are related to a frequent in-person social contacts. Cities with a significant positive coefficients are also present, but the areas are very small. These cities are only one percent of all the regions (districts/cities/counties), and have 2% of participants. Moreover, the local coefficient varies from -0.0043 to 0.0026.

Economic Variables

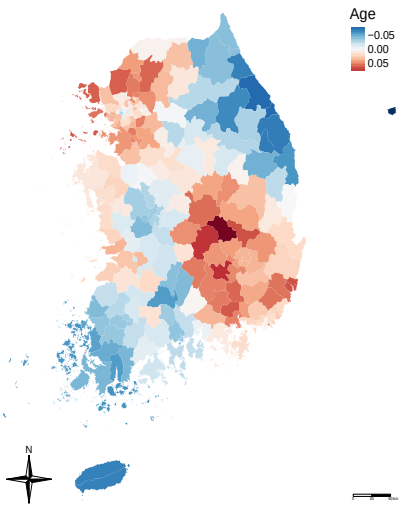
Household income The local coefficient of annual household income is in the range of -0.0007 to 0.0002 (Table 6.3). Around 24% Korean regions are observed with a significantly negative relationship between the yearly household income and the level of depression, including the northwest of Gangwon Province, the cities and counties in Gyeonggi Province near Seoul and across North and South Jeolla Province (Figure 6.7e, Figure 6.7f). This means that in those regions, the higher annual household lessens the level of depression in older adults. Counties with significant and positive coefficient gather in South Chungcheong Province, and also surround Daejeon metropolis, which indicates that older adults in those counties with higher incomes have more severe depression status.

Health-related variables

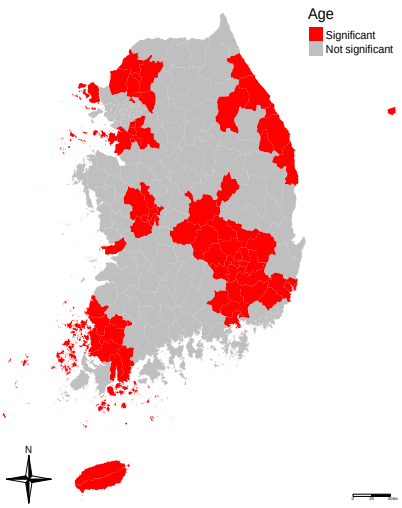
Self-reported physical health The coefficient of self-reported physical health varies between -1.6440 and 0.1377 (Table 6.3). Self-reported physical fitness negatively affects depressive symptoms scores in almost the entire state (Figure 6.8a, Figure 6.8b) (86% of cities/counties and 84% of all respondents), implying that most of the older adults in South Korea with a better status of physical health are linked to lower depressive symptoms.

Drinking habits Drinking habits is the least significant compared with other variables. Only 11% (Table 6.3) of regions are observed that drinking habits have significant effects on depressive symptoms scores. Out of all regions, around 3% are positive and 8% are negative. The regions with significant and negative impacts extend from the western coastal areas of South Chungcheong Province to the southern part of North Chungcheong Province and are also found in the northern regions of North Jeolla Province (Figure 6.8c, Figure 6.8d). In these areas, a drinking habit is related to a lower level of depression, which is dissimilar to results reported by previous studies (Table 6.2).

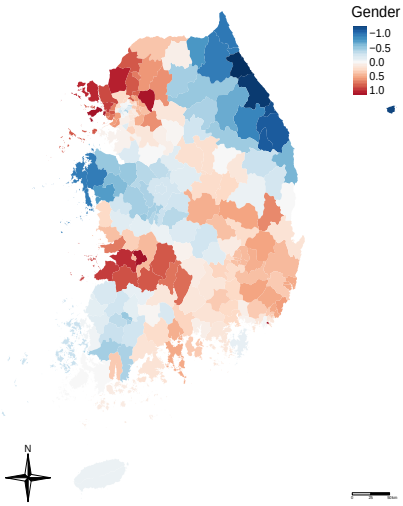
Exercise habits Figure 6.8e, Figure 6.8f and Table 6.3 illustrates that only 2% of all the regions are found having a significantly positive coefficient for the exercise habits, which is much smaller than the regions with a significantly negative coefficient (18% of regions in the entire state). This estimation validates that for older adults (23% of respondents) who live in these areas, a regular exercise habit contributes to better mental health outcomes.



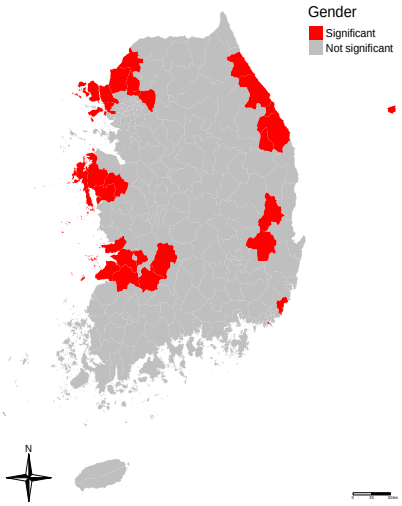
(a) Local coefficient of age



(b) Local significance of age

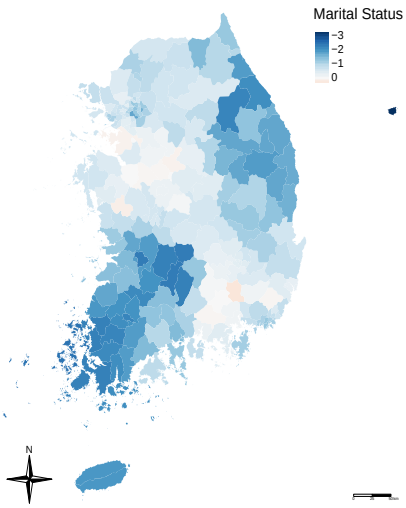


(c) Local coefficient of gender

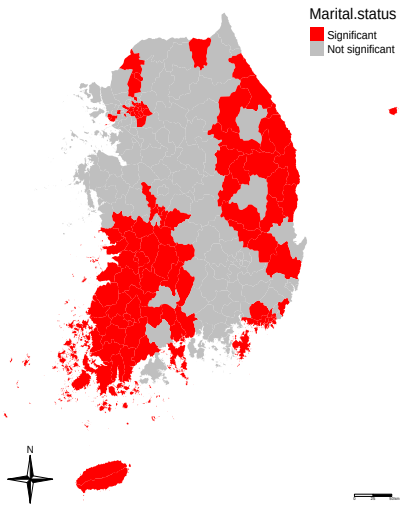


(d) Local significance of gender

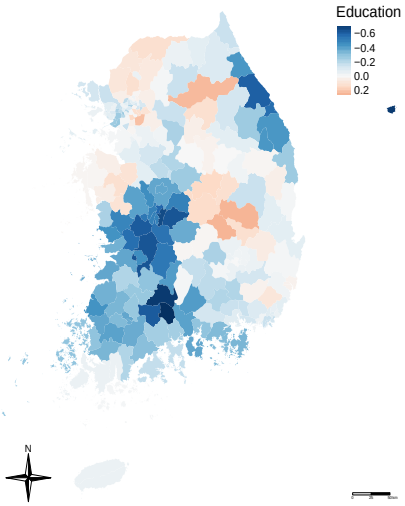
Figure 6.5: Local coefficients and significance of independent variables in 2006 (continued)



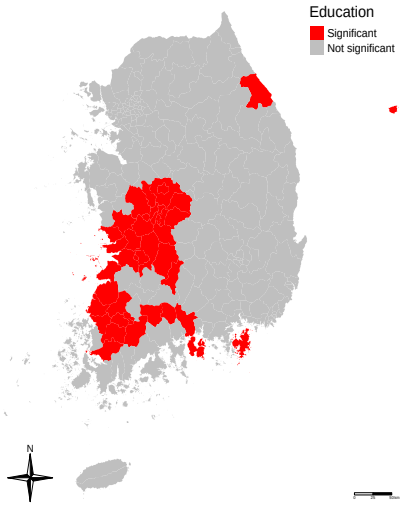
(a) Local coefficient of marital status



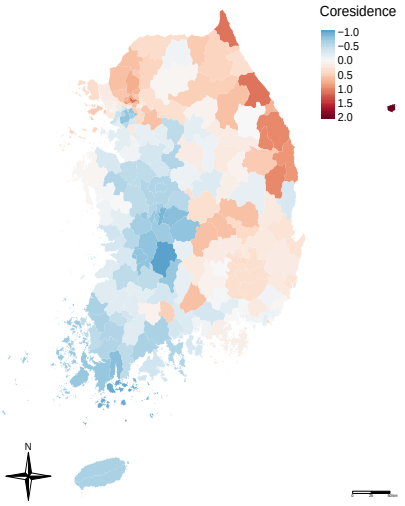
(b) Local significance of marital status



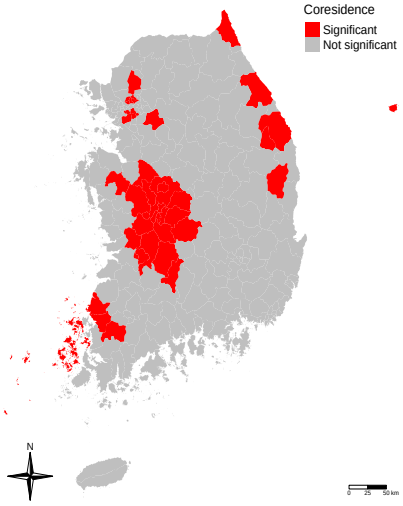
(c) Local coefficient of educational level



(d) Local significance of educational level

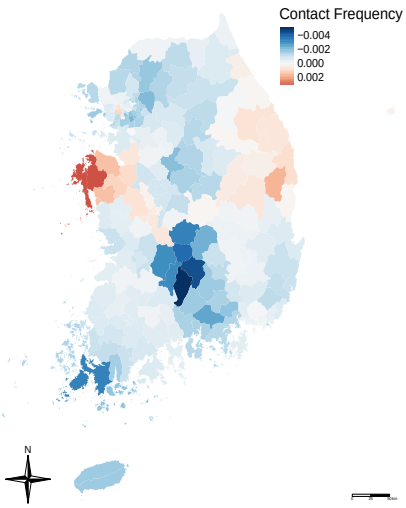


(e) Local coefficient of coresidence with adult children

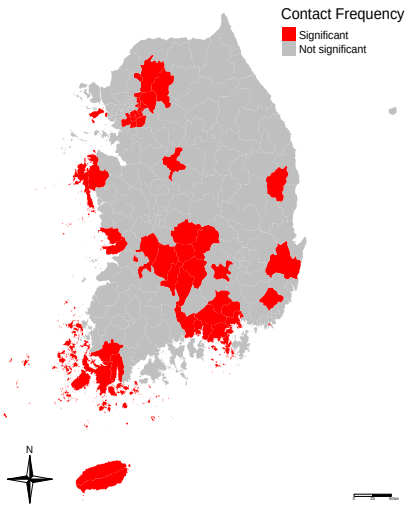


(f) Local significance of coresidence with adult children

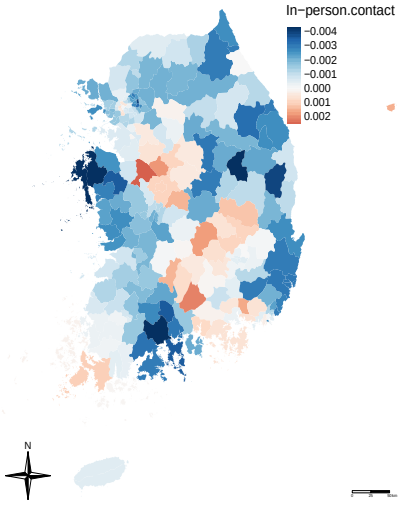
Figure 6.6: Local coefficients and significance of independent variables in 2006 (continued)



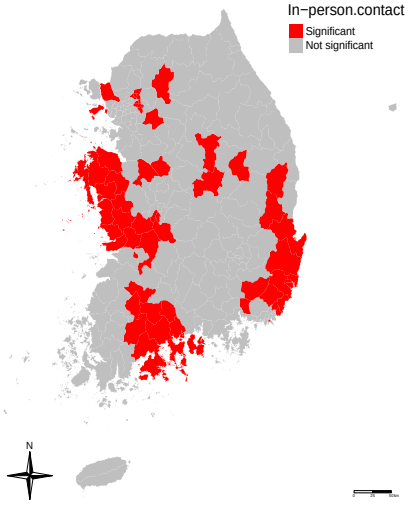
(a) Local coefficient of contact frequency with children



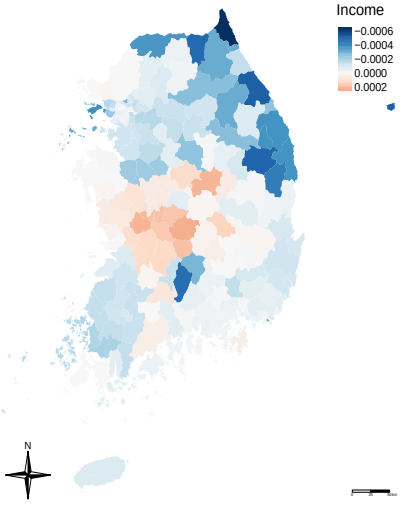
(b) Local significance of contact frequency with children



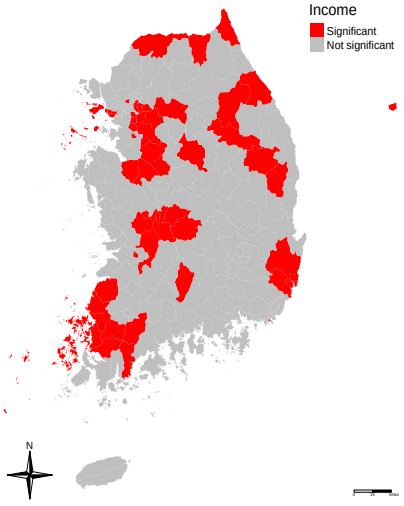
(c) Local coefficient of in-person social contact frequency



(d) Local significance of in-person social contact frequency

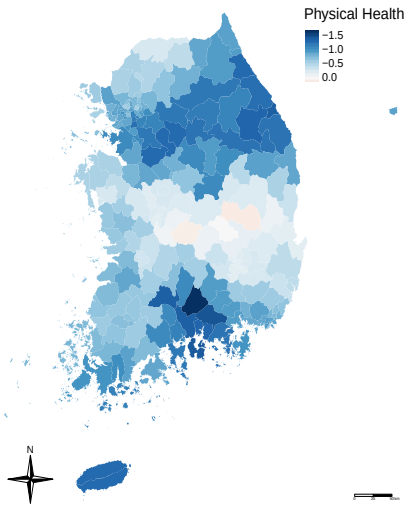


(e) Local coefficient of household income

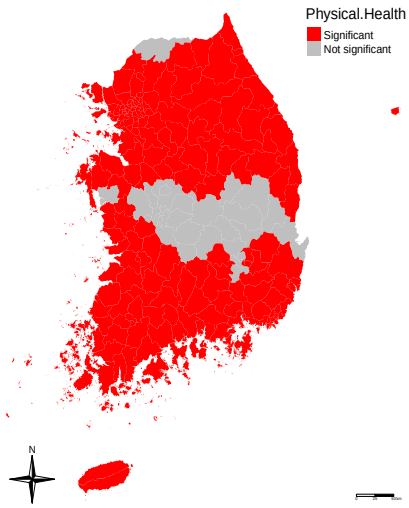


(f) Local significance of household income

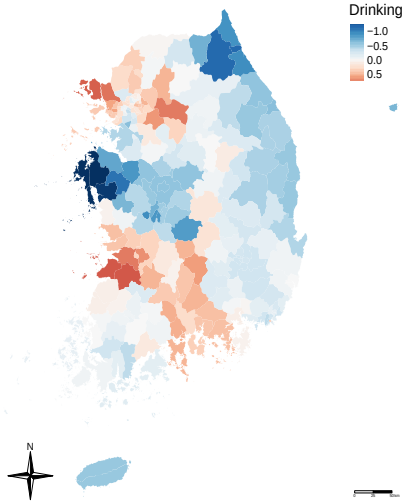
Figure 6.7: Local coefficients and significance of independent variables in 2006 (continued)



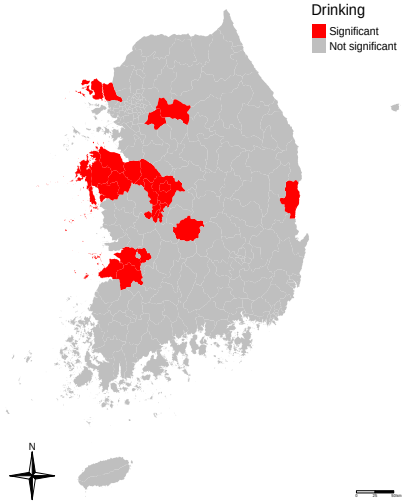
(a) Local coefficient of physical health



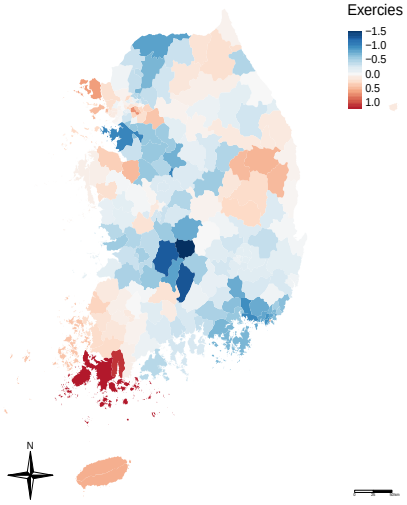
(b) Local significance of physical health



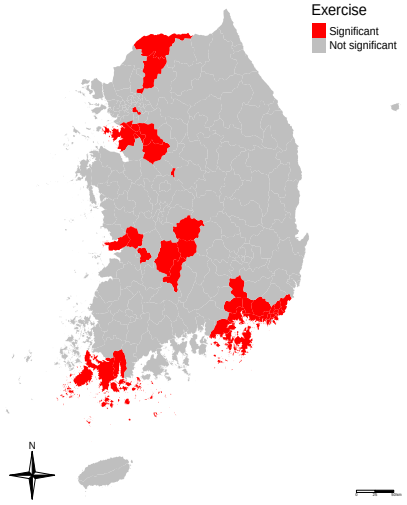
(c) Local coefficient of drinking habits



(d) Local significance of drinking habits



(e) Local coefficient of exercise habits



(f) Local significance of exercise habits

Figure 6.8: Local coefficients and significance of independent variables in 2006

6.3 Temporal Analysis

Temporal studies were implemented in this thesis to observe the yearly changes in the explanatory power of each sociodemographic, economic, and health-related variables. Their effects on the depressive status changes in years that have also been investigated.

6.3.1 Changes in Local R-Squares

Figure 6.9 gives the biannual changes in R-squares from SLR and OLS models. The R-squares of SLR is still higher than the OLS regression, indicating the independent variables in the SLR model perform better in explaining variations in depressive symptoms scores among the six survey years. The overall R-squares in SLR fluctuate among the years and reach a peak in 2008, implying that the selected variables are most relevant to the variations of depressive symptoms scores in this survey year. However, the OLS regression has maintained a downward trend. These results again confirm that the SLR is more fitted in this study than the OLS regression in all survey years.

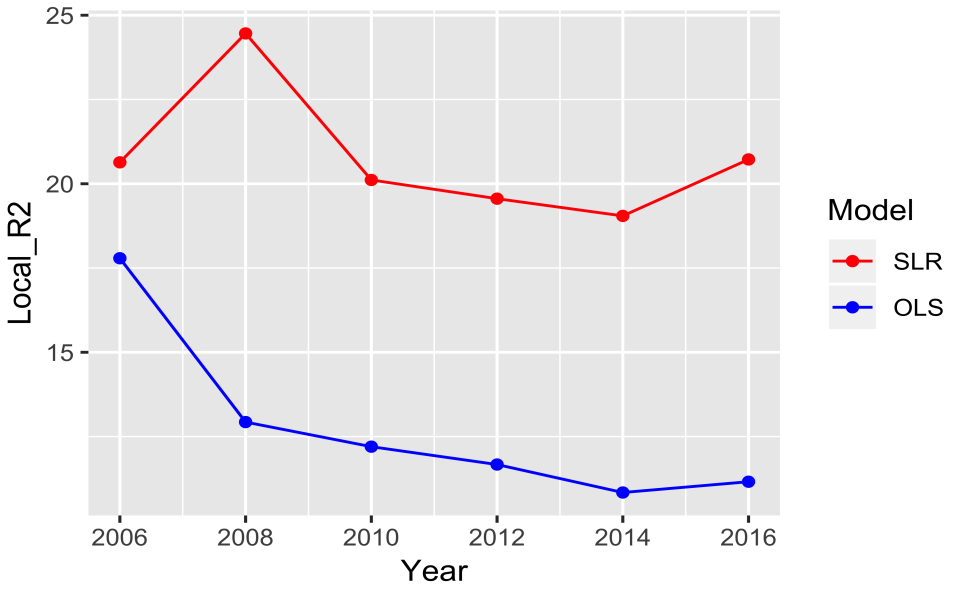


Figure 6.9: The Local R-Squares given by SLR and OLS regression in 2006-2016

6.3.2 Significant Effects Changes of Independent Variables on Depression

Multiple line graphs were used to show the variations of the average coefficient. Only the local coefficients with a p-value of less than 0.05 will be averaged and involved in the temporal comparison. Moreover, bar plots were also used to show the changes in the percentages of respondents whose depressive symptoms scores are significantly positively or negatively affected by each variable.

Sociodemographic Variables

Age Age has a consistently positive influence on the depressive symptoms scores in the six years, indicating a growing age has significantly increased the level of depression in the participants, and this effect is stable in time (Figure 6.10a). This positive effect has strengthened from 2006 to 2012 but has decreased in the last two years. The number of respondents who are involved in this correlation has shown a fluctuation. Moreover, most respondents are observed in 2012.

Gender The significant positive correlations between gender and depressive symptoms have occurred in the first five observed years (2006, 2008, 2010, 2012, and 2014), but a negative one appears in the last year (Figure 6.10b). Both of the coefficients and percentage of respondents fluctuate in these six years. It is noticeable that most respondents have affected by the positive relationship in 2008. In summary, in the most years from 2006 to 2016, females tend to have higher depressive levels.

Marital status Marital status is observed maintaining a negative relationship with depressive symptoms during the survey period, and the coefficients are fluctuated (Figure 6.10c). The percentage of participants in 2006, 2014, and 2016 is much higher than the three middle years (2008, 2010, and 2012). What is more, getting married or living with partners contributes to reducing the level of depression in around 40% of respondents in 2006, 2014, 2016, and about 20% of respondents in 2008, 2010, and 2012.

Educational level The educational level shows a significantly negative correlation with depressive symptoms scores in all periods, and such effects exhibit an decreasing trend (Figure 6.10d). Moreover, changes in the percentage of respondents are also observed, which fluctuate in time. These results mean that impact of the educational level on depressive symptoms scores is consistent in time, and a changed number of respondents among years in KLoSA who have a higher educational level would like to suffer from lower levels of depression.

Coresidence with adult children In 2008, 2014 and 2016, the coresidence with adult children has a significantly positive impact on depressive symptoms scores, but in other three years, the relationships are negative (Figure 6.10e). Most respondents (27% of the respondents) are affected by the a positive correlation in 2008, indicating coresidence with adult children plays a more important role in increasing depressive symptoms scores in older adults comparing with other single year. Even though the positive relationship captures most respondents in 2008, the total number of respondents in the negative years is more than positive years, indicating for most people, a dwelling with adult children can lessen the level of depression. Hence, in terms of the total number of people, the negative relationship is more common in older Koreans during the survey years.

Contact with children From 2006 to 2014, the contact frequency with children has significantly negative effects on depressive symptoms scores, and the impact has become stronger after 2008 (Figure 6.10f). This negative correlation influences most of the respondents in 2008, involving 29% of the respondents. In contrast, in the last year, the relationship is positive. There are most negative correlations in the survey period revealing that in most time, the respondents are in the relationship that a frequent contact with children has reduced their feelings of depression.

In-person social contact frequency The in-person social contact frequency also keeps a significantly negative relationship with depressive symptoms scores in all survey years (Figure 6.11a). The coefficient shows a decreasing trend indicating a reinforced negative impact. For the last four observed years, the percentage of respondents maintain high (ranged from 42% to 48%) and decease in a small amount. These results show the negative impact of in-person social contacts frequency on depression is temporally homogeneous. Furthermore, depression levels in around half of older adults of KLoSA have been reduced by more frequent in-person social contacts after 2008.

Economic Variables

Household income The household income consistently negatively affects depressive symptoms scores during the survey period. The corresponding percentage of respondents changes among years (Figure 6.11b). In the first one and the last two observed years, the number of relevant participants is similar (25% and 23%). A peak is observed in 2010, around 33% of older adults in KLoSA who have a higher income suffering fewer feelings of depression.

Health-related Variables

Physical health The physical health has a consistently and significantly negative impact on depressive symptoms scores in most respondents (ranged from 70% to 90%) among six years (Figure 6.11c). This result suggests that physical health is the most critical factor related to depression in older adults in this study.

Drinking habits Drinking habits is less significant in the six observed years comparing with other variables, since the maximum percentage of respondents is 15% (Figure 6.11d). In four of the six years, it shows a negative correlation with depressive symptoms, indicating drinking habits play a more important role in reducing the levels of depressive symptoms, which is inconsistent with some previous studies.

Exercise habits In five of six years (2006, 2008, 2010, 2012, and 2016), the exercise habits has a significant and negative effect on depressive symptoms scores (Figure 6.11e). Combining with the percentage of respondents, the first three survey years, around 20% of older adults in KLoSA who have an exercise habit would have less likelihood to suffer from depression. Moreover, there are most participants in a negative relationship in last year (around 40% of the respondents).

6.4 Migration

Spearman Correlation Coefficient (SCC) was used to test the correlation between depression and migration experience. The result (Table 6.4) shows that the Spearman's rho of migration experience in each is less than 0.2 or bigger than -0.2, which means there are no correlation between migration experience and depressive symptoms scores from 2008 to 2016.

Table 6.4: The results of Spearman correlation coefficient 2008-2016.

	Spearman's ρ	Significance
Year		
2008	-0.0525	**
2010	-0.0291	**
2012	-0.0097	
2014	0.0260	.
2016	0.0068	

** p-value$<$0.05
. p-value$<$0.1

(a) Age

(b) Gender

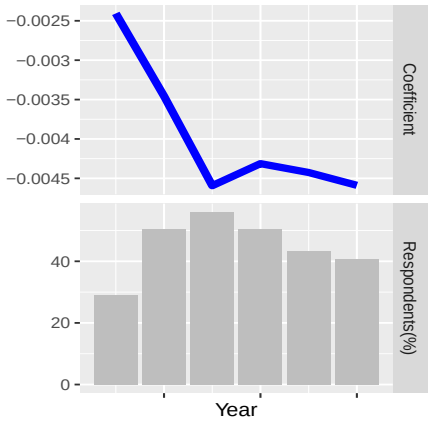
(c) Marital Status

(d) Educational level

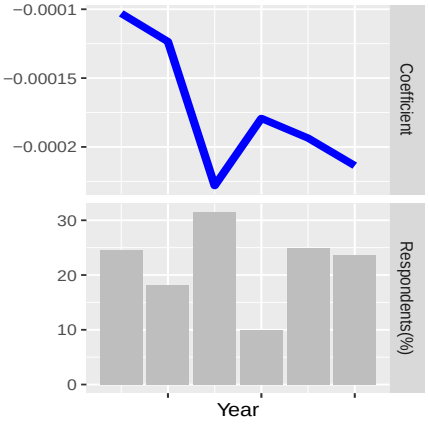
(e) Coresidence with adult children

(f) Contact frequency with children

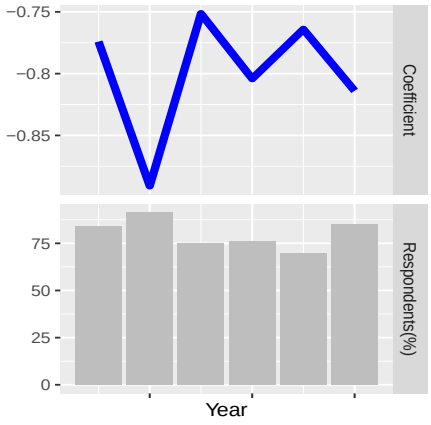
Figure 6.10: Coefficients and the percentage of respondents in 2006-2016



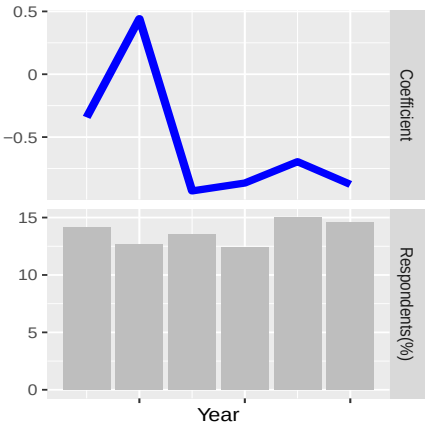
(a) The in-person social contact frequency



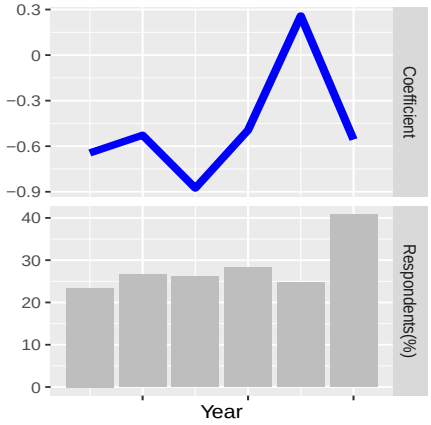
(b) The annual household income



(c) Physical health



(d) Drinking habits



(e) Exercise habits

Figure 6.11: Coefficients and the percentage of respondents in 2006-2016

Chapter 7

Discussion

This section illustrates how the results of the employed analysis methods respond to the research questions proposed in Chapter 3.

7.1 Spatial Clustering of Depressive Symptoms

RQ1 How is the level of depressive symptoms of older adults geographically distributed in South Korea? Where are the spatial hotspots and coldspots of depressive symptoms of older adults?

The implementations of global Moran's I and local Moran's I answered the first research question.

7.1.1 Global Moran's I

The results of Moran's I statistics (Table 6.1, Figure 6.1) shows that there are spatial clustering with similar depressive symptoms scores among older adults in Korea Longitudinal Study of Aging (KLoSA) in the six survey years. These findings reveal that older adults live in similar environments or neighboring regions may yield similar levels of depressive symptoms. In other word, the level of depressive symptoms in the elderly would be affected by environments of the surrounding neighboring regions.

7.1.2 Local Moran's I

Local Moran's I explored and found specific clustering locations. The high-high clusters most appear in urban areas (cities) in Gyeonggi Province in the six survey years (5 in 6 years). One potential reason is the gathering of depressive symptoms contributors. For example, respondents who are older

than other respondents clustering in neighboring regions. Moreover, participants in these nearby regions have a low physical health status compared with other areas. The spatial and temporal variability of the investigated variables or neighborhood conditions are related to the annual changes of locations of low-low clusters. For instance, the regions with a high number of in-person social contact frequency are different among years, which might result in the changed locations of low depressive symptoms scores clusters.

7.2 Spatial Variability of Impacts of Sociodemographic, Economic, and Health-Related Factors on Depressive Symptoms

RQ2 How do sociodemographic, economic, and health-related factors have effects on depressive symptoms of older adults in different regions? How are the positive/negative effects distributed over geographic spaces?

First, the Ordinary Least Squares (OLS) regression gave an insight on different effects on the depressive status of chosen variables for the entire country. Second, since effects of these factors may be different among regions (districts, cities or counties), the Spatially Local Regression (SLR) was implemented to investigate the spatial heterogeneity of such impacts.

7.2.1 Sociodemographic Factors

Significant local coefficient estimates for each sociodemographic variable were found by SLR, and significant coefficients are various in different regions in South Korea.

RQ2-1 Does aging have negative effects on depression? How do such effects vary across regions?

The OLS regression gave an insight into the fact that increasing age is linked to higher depression risks (Table 6.2). It might be caused by changes in physical health. Geerlings et al. (2000) [45] suggested that physical health issues become more frequent as people are getting older, resulting in a higher onset of depression [45]. SLR found the same relationship with the OLS regression in North and South Gyeongsang Province, and Gyeonggi province (Figure 6.5a, Figure 6.5b). Furthermore, a low average self-reported health with the high average age is observed in these areas, which suggests that the growing age could negatively impact physical health. This finding might explain why the coefficient in these areas are significant positive.

RQ2-2 What is the spatial variability of positive or negative effects of gender on depression of older adults? Do female older adults have a higher depressive level compared with older males?

The OLS regression reported that females tend to have higher levels of depressive symptoms in the whole state (Table 6.2). However, SLR estimated both significantly positive and negative impacts occurring in the study area, and most of the effects are observed positively. The positive coefficients are mostly found in North Jeolla Province and two counties in North Gyeongsang Province. North Gyeongsang Province tends to be conservative compared with other provinces in South Korea (Figure 6.5c and Figure 6.5d). There is a negative effect of conservativeness on the attitude of gender roles [19]; the female labor force is likely to participate less in paid jobs. Moreover, Glass and Fujimoto (1994) [47] reported that paid work could play a role in reducing the depression in both husbands and wives [47]. These findings might be one reason that the females live in North Gyeongsang Province have a higher risk of suffering depression. In contrast, there are less (4% of the cities and counties) (Table 6.3) negative patterns in Gyeonggi Province and Gangwon province, and most of them are urban areas. The different levels of depression among rural and urban older women were emphasized by Bergdahl et al. (2007) [15], who suggested that urban females tend to feel less depressed since they could receive better treatments [15]. Their research results might explain the observations that in some Korea urbanized regions, females have a lower level of depression.

RQ2-3 Do the older people who are married or have a partner have lower risks of depression compared with those without a husband, wife, or partner? How do such positive/negative impacts distribute across regions?

The OLS regression gave the result that getting married or living with partners significantly contributes to reducing their levels of depressive symptoms of older adults in South Korea (Table 6.2). Moreover, the result of the SLR is consistent with the OLS regression (Table 6.3, Figure 6.6a, and Figure 6.6b). Even though SLR observed a small number of cities and counties with positive effects, where perform insignificantly. These results agree with some previous studies. The feelings of loneliness and life quality might be important reasons for this effect. Alpass and Neville (2003) [3] reported that there is an essential correlation between loneliness and psychological health in older adults, primarily in the field of depression. The older adults who lose their spouses or live alone tend to feel lonelier, which in turn results in a higher prevalence of depressive symptoms [3]. What is more, Han et al. (2012) [53] argued that getting married contributes to a higher quality of life among the Koreans who are older than 40 years old, and the high quality of life can yield a better mental health outcome [53].

RQ2-4 Does higher education imply lower chance to suffer from depression? How do such effects vary with different regions?

The OLS regression gave an insight that a higher educational degree is lined to lower incidence of depression (Table 6.2). The SLR observed only significantly negative impacts of educational level on depressive symptoms scores occurring in South Korea (Table 6.3, Figure 6.6c, Figure 6.6d). The majority of these negative impacts is distributed in rural areas of North and South Jeolla Province. The lowest educational level are also found in these regions. Most of the respondents who live in these areas have lower education levels than junior high schools. The educational level is related to the usage of mental health services. Somebody with a better education background is more prone to obtain mental health services than people with lower education levels [98]. Better use of mental health services results in lower depression risks [35].

RQ2-5 Does cohabitation with adult children positively/negatively affect depressive levels of the elderly? How do such positive/negative impacts distribute across regions?

Results from the OLS regression show that this variable is not significant to depressive symptoms scores (Table 6.2). However, the SLR revealed significant patterns in 20% (4% for positive and 16% for negative effects) of Korean counties/cities (Table 6.3). This result reveals that impact of coresidence needs to be addressed in these regions. Older adults in South Korea who dwell with adult children would receive more emotional and instrumental supports from their adult children. This phenomenon could make them feel less worried about their late life, which in turn results in a lower level of depressive symptoms [70]. This might be the reason that more respondents (Table 6.3) in these regions feel less depressed when they reside with their adult children.

RQ2-6 Would older adults who contact more frequently with adult children have better depressive status than fewer contacts with adult children? How do such effects differ across regions?

In the entire state, more frequent contact with their children have lessened depressive levels for older people (result from the OLS regression in table 6.2). SLR observed a small number of cities or counties that have the opposite relationship in South Chung-cheong Province and one county in North Gyeongsang Province (Figure 6.7a, Figure 6.7b). However, the dominant relationship (23% of regions and 18% of respondents) is consistent with that of the OLS regression (Table 6.3). One possible reason is that they can get emotional support by contacting their children. Because of the development

of urbanization and the westernization of lifestyle in South Korea during recent decades, more and more adults would not live with their parents. This has resulted in a growing number of older adults who are living alone [68]. Contact with children by phone or other methods could provide the elderly with emotional support [96]. The acceptance of emotional support might alleviate the stressor, which would result in depression [91, 116]. Otherwise, loneliness or separation may aggravate depression in older adults [25].

RQ2-7 Would the elderly feel less depressed when they have more in-person social contacts with familiars? How do such relationships differ across regions?

The OLS regression reported that in-person social contact frequency is significantly negatively related to depressive symptoms scores in the entire state (Table 6.2). The SLR found that there are many more respondents (cities and counties) who are negatively affected than those who are significantly positively affected. The difference of the percentage of respondent between them reaches 26% (Table 6.3). This result indicates that in most cases, increasing in-person social contact frequency can alleviate depressive symptoms. It is similar for contacting children. in-person social contacts such as meeting with friends or family members could give older adults emotional supports [87], which reduces the incidence of depression.

7.2.2 Economic Factors

RQ2-8 Does a higher annual household income imply a lower risk of depression in older adults? How do such relationships vary across different regions?

The 8th sub-research question is to find the relationship between annual household income and depressive symptoms among older adults. According to the result of the OLS regression, a higher income is linked to lower depression levels (Table 6.2). The SLR shows the same result in 24% of the cities/counties. Most of these areas are cities and districts in the capital City Seoul (82% of these districts, counties or cities) (Table 6.3). Some previous studies suggested that higher income contributes to a lower depressed level. However, the effects might be varied according to their living environment. In KLoSA, a higher average household income is more discovered in those urban areas than in other rural areas. Muramatsu (2003) [85] suggested that the effects of income inequality are stronger on mental health than physical health, particularly in the field of depression [85]. A higher income indicates more medical resources which lead to less depressive symptoms

than the people with lower income. Moreover, the more significant gaps in revenue, the more apparent differences in depression.

7.2.3 Health-related Factors

RQ2-9 Are older people with poorer physical health more likely to be depressed than those who are healthier? Are there regional variations of the impact of physical health?

The physical fitness was measured by self-reported physical health. The findings from the OLS regression appear to approve arguments from some previous studies that older adults with better physical health would suffer less from depression (Table 6.2). Negatively local coefficient estimates are found across the country, and perform significantly in around 86% of districts/counties/cities in the study area (Table 6.3). This result indicates that physical health is a critical factor in depressive symptoms for older South Koreans. One possible reason for this correlation is that older adults are easier to suffer from arthritis, which reduces their physical mobility and results in decreased social interactions as well as exposure to amenities [36].

RQ2-10 How do drinking habits affect the depressive status of older adults? Would it increase the chance of suffering from depression? How does this relationship change when considering various regional environments?

The OLS regression reported the insignificant effect of drinking habits on depression (Table 6.2). But there are more regions with significant negative influences than regions with significant positive coefficients (Table 6.3, Figure 6.8c, Figure 6.8d). The finding of more negative parameters is somewhat different with most empirical studies which suggested that drinking habits can be linked to higher depression risks. However, drinking does not always play an adverse role in mental health. Alcohol in moderate amounts contributes to reducing stress and increasing the feelings of enjoyment and carefreeness. Tension and depression will be reduced with an equal amount [13]. We also noticed that the used variable only included information about whether the respondents have or do not have regular drinking habits and nothing on the drinking amount. When the data of the drinking amount is available, the benefits of moderate drinking to alleviate depression might provide a clue to explain why respondents with drinking habits tend to have less depressive symptoms.

RQ2-11 Would regular exercise habits among older adults have positive impacts on depression? What is the regional variation of such effects of exercise habits?

The last sub-research question is related to the relationship between exercise habits and depression. Similar to multiple previous studies, the OLS regression reported that exercise habits in older adults are beneficial in terms of reducing their feelings of depression in the entire state (Table 6.2). The SLR found the same relationship in urban and rural areas in central, northwestern, and southeastern parts of South Korea (Figure 6.8e, Figure 6.8f). The reason might be that regular exercise or physical activity can contribute to treating depression [26]. However, a small positive pattern occurs in most southwestern regions. A highest average age there is observed as well (around 70 years old). Since a growing age is generally accompanied by the increasing prevalence of muscle deficiency, and muscle repair and regeneration capacity will decrease by age [59]. It will make the elderly suffer more physical pain and restrictions on daily activities, which will lead to aggravation of depression [103, 106].

These findings answered the second question in 3 aspects with 11 variables. They are similar (e.g., marital status, physical health) or different (e.g., drinking) with results of previous studies. These findings have essential implications in terms of making policies [31]. Critical variables including annual household income, self-reported physical health, and marital status in this project, exhibit less spatial heterogeneity. This indicates that such issues need to be resolved in the entire study area. Other significant variables such as educational level, the number of in-person social contact frequency and drinking habits show strong spatially non-stationary attributes in the state, these problems should be addressed in specific local regions with respect to their circumstances.

7.3 Correlation between Migration and Depressive Symptoms

RQ3 Do older adults who have migration experience (i.e., older adults have migrated within past two years) feel lonelier and more depressive than those who remain in one place?

The Spearman Correlation Coefficient (SCC) reported that migration experience is not correlated with depression (Table 6.4). However, some previous studies explored similar research questions and stated that migrating experience increased respondents' depressive levels [17]. This result might be caused by the sample size of the older people with migration experiences (e.g., 272 respondents in 2008 have migration experience). We got information that one respondent have migrated from one city or county to another one. However, the migrating units seem a little bigger. It would be better to have a smaller geographic resolution (e.g., one census tract to another

tract). Thus the effects of migration need to be further discussed if we have detailed data.

7.4 Temporal Variability of Significant Impacts of Variables on Depressive Symptoms

RQ4 Does significant impacts of those factors on depressive symptoms of older adults change over the ten years from 2006 to 2016? How do they change?

The changes in relationships of each sociodemographic, economic, and health-related variables on depressive symptoms in six survey years are another essential part of the thesis. Variations were obtained by comparing the average value of the significant parameters of each variable. Educational level, annual household income, self-reported physical health, the in-person social contact frequency and marital status are keeping a negative correlation with depressive symptoms scores in all periods. Moreover, the significant negative influence of educational level has decreased, but the effects of in-person social contact frequency and annual household income have increased. Self-reported physical health and marital status are fluctuated but have not changed their trends. Age maintains a positive effect in all survey periods and also showed a fluctuation. These findings suggest that these factors or variables have a homogeneous impact on depression in time.

The temporal analysis also gave the result that contact frequency with children, coresidence with adult children, gender, drinking habits and exercise habits show both significantly positive and negative correlation with depression. This suggests that the effects of these variables on depression are heterogeneous in time. The presence of different relationships may be related to temporal changes in individuals' characteristics. For example, I have explained a possible reason for more people with drinking habits alleviating their depression. However, this reduction is subject to alcohol intake. When alcohol intake exceeds the appropriate range, it will aggravate the symptoms of depression [111]. Thereby, when more respondents have excessive drinking in a given year, this may lead to a shift from a positive impact to a negative one. To find out whether this hypothesis is correct or not, it is necessary to obtain data on the amount of alcohol consumed by these respondents for further discussion.

In summary, the temporal and spatial analysis found the significant effects of marital status, educational level, and physical health on depression, which are consistent or homogeneous in the state and survey years. The result emphasizes the critical impact of these three factors both in geographical and temporal perspectives. These findings can provide guidance when for-

mulating policies to protect the mental health of the elderly. For example, increasing the investment in social welfare for the elderly to improve their financial situation [97], or organizing community leisure activities to reduce their loneliness [112].

Chapter 8

Conclusion

8.1 Conclusion

In South Korea, depression has proven to be an essential problem in the elderly population, considering that depression is closely related to a growing suicide rate and the consumption of socially medical resources.

Global and local exploratory spatial statistics showed that the overall and local spatial clustering of depressive symptoms scores in older adults. Spatially local regression identified spatial variations of the impacts of diverse sociodemographic, economic, and health-related factors on depression. Among the factors, annual household income, education, and physical health appear to have a consistently significant and negative impact on depression in the space, and no opposite patterns are observed. The other variables have been found to have opposing effects in different regions.

The temporal analysis revealed that some factors have temporally consistent negative or positive impacts on depression in older Koreans. Annual household income, marital status, physical health, the in-person social contact frequency, and educational level maintain negative effects on depression in six survey years, and age keeps positive impacts on depression. It is noticeable that the negative impacts of in-person social contact frequency and annual household income on depression have increased, but the negative influence of educational level on depression shows a decreased trend. Other variables, including contact frequency with children, coresidence with adult children, gender, drinking, and exercise habits have both significantly positive and negative influences on the depressive status among older adults in South Korea. These variables are fluctuated in six survey year.

In this study, spatial and temporal methods were used to explore the spatial and temporal variability of the relationship between sociodemographic/economic status, and health-related factors with depression in older South

Koreans. Our findings can help local cities/districts/counties improve the mental health of the elderly according to their conditions. Moreover, the temporal changes in the effects of these variables on depression contribute to understanding what factors can decrease or increase the levels of depression for a long time.

8.2 Limitations

This study has some limitations. KLoSA did not provide accurate locations of each respondent (e.g., coordinates), which makes it impossible to weight neighboring individuals by distance. The self-reported depressive symptoms and self-rated physical health are not that precise like clinical diagnosis. Each respondent was geocoded by their residential districts, counties, or cities. The geographic unit is a bit large in a study with geographical perspectives, which makes it impossible to discuss the impact of the surrounding environment on the relationship between each selected variable with depression from a more precise spatial location. Some useful information is missing in the KLoSA, for example, drinking or exercise frequency, which might be better in explaining the changes of depressive symptoms than drinking and exercise habits.

8.3 Outlook

In the future, the influence of migration on depression in older adults can be further explored. If we can get the precise location of each individual or their residential community, the different migrated distance of each participant can be involved in the analysis as a part of the influence of migration on depression in older adults.

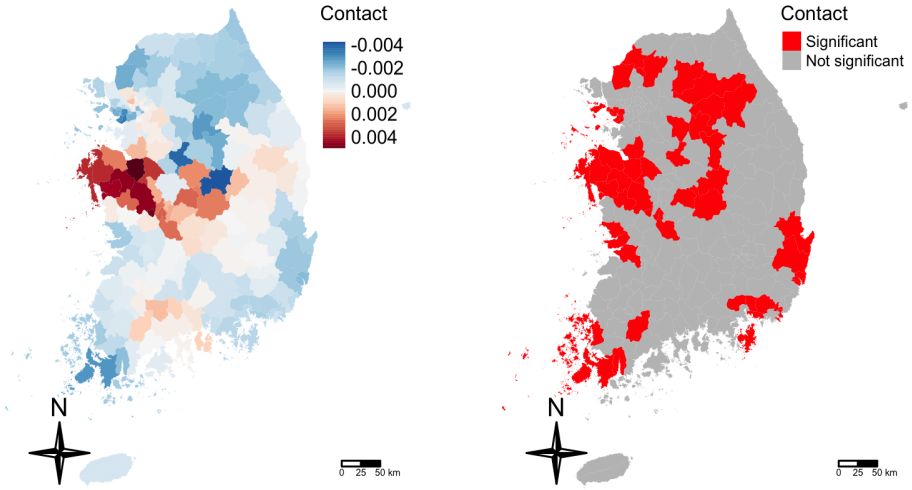
There are more regions with significant parameters showing that drinking can alleviate depression. However, this effect is not consistent over time, and, in many areas, drinking habits seemed aggravate depression. This may be related to alcohol intake. For the future research, if each respondent's alcohol intake data or drinking frequency are available, this potential association can be investigated for the elderly.

A comparative study could be applied. Similar longitudinal surveys on the elderly were also conducted in China and Japan. These datasets can be adopted to compare the depression status of the elderly in the adjacent countries. It is expected that the differences and similarities of factors between the three neighbor countries can significantly affect the level of depression in older adults.

Appendix A

Appendix

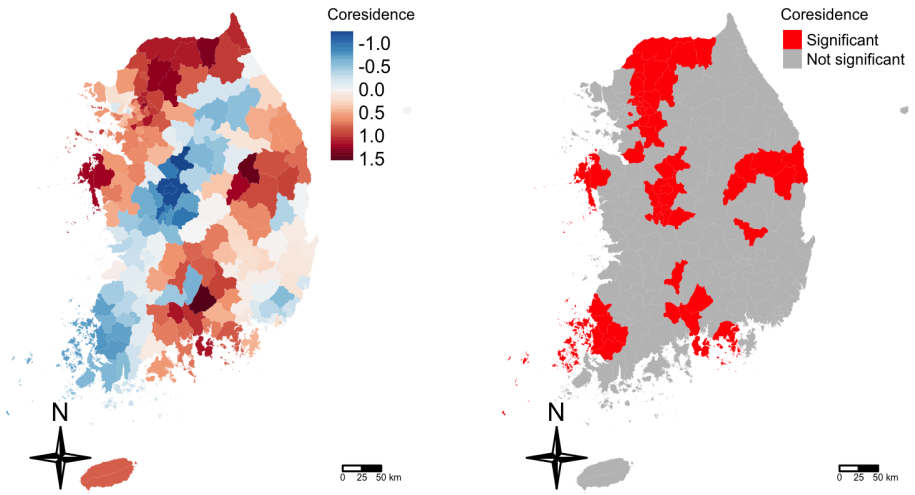
Local coefficients and significance of independent variables of multivariate spatially local regression in 2008



(a) Local coefficients of contact frequency with children

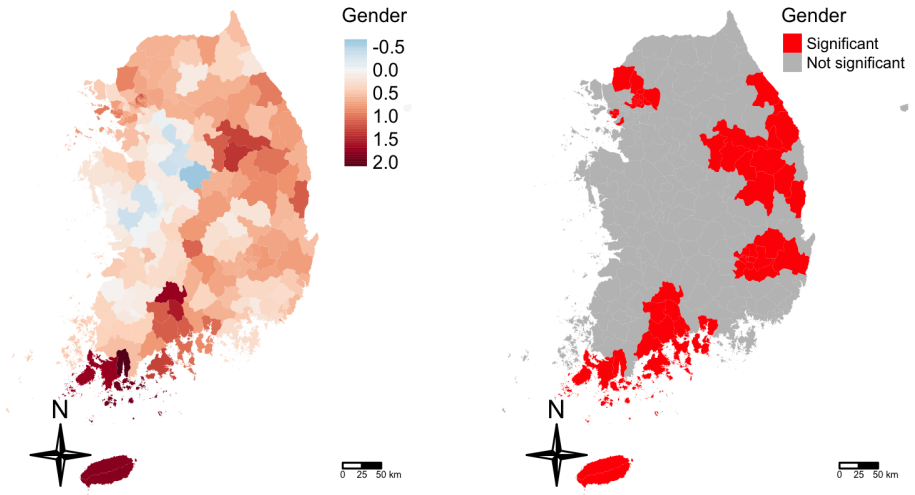
(b) Local significance of contact frequency with children

Figure A.1: Local coefficients and significance of each independent variable in 2008



(a) Local coefficients of coresidence with adult children

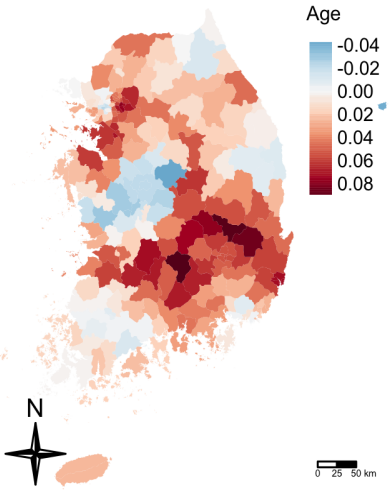
(b) Local significance of coresidence with adult children



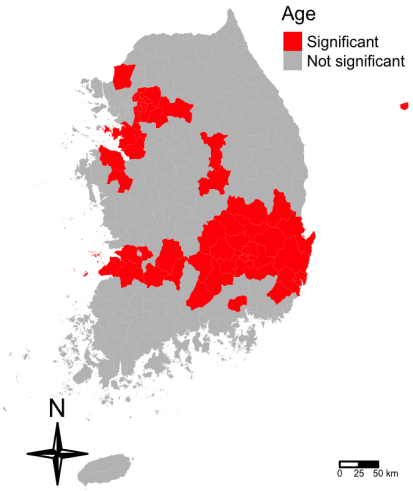
(c) Local coefficients of gender

(d) Local significance of gender

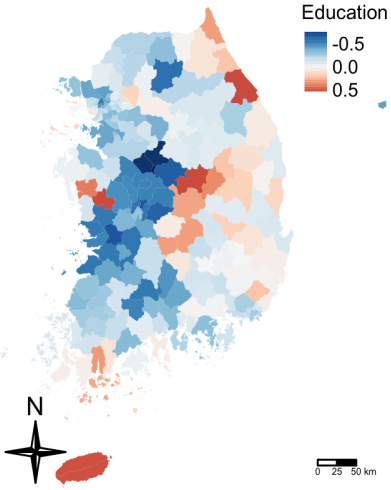
Figure A.2: Local coefficients and significance of each independent variable in 2008



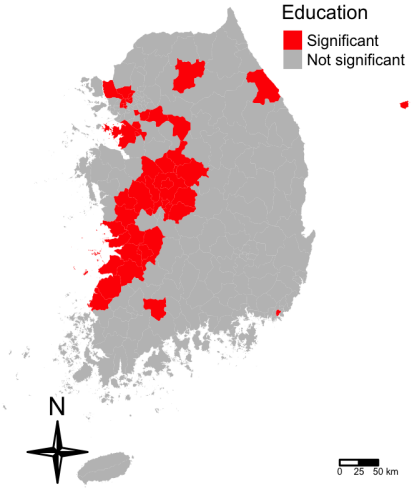
(a) Local coefficients of age



(b) Local significance of age

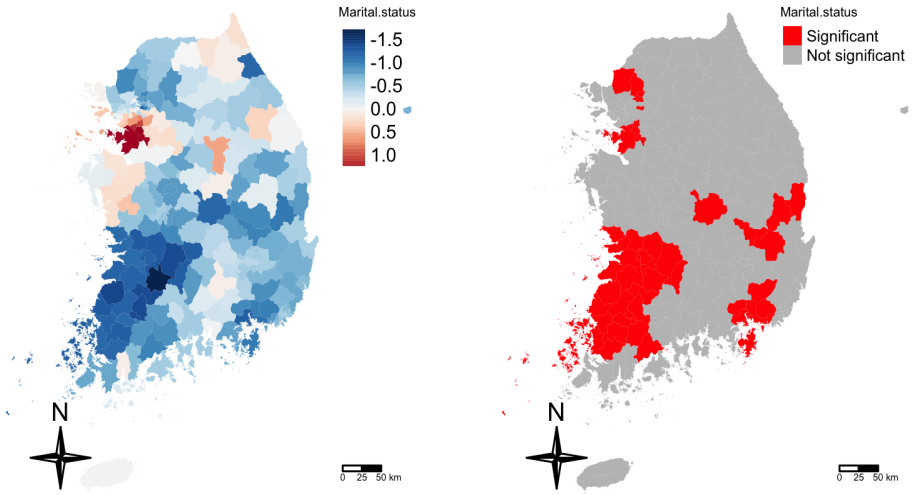


(c) Local coefficients of educational level

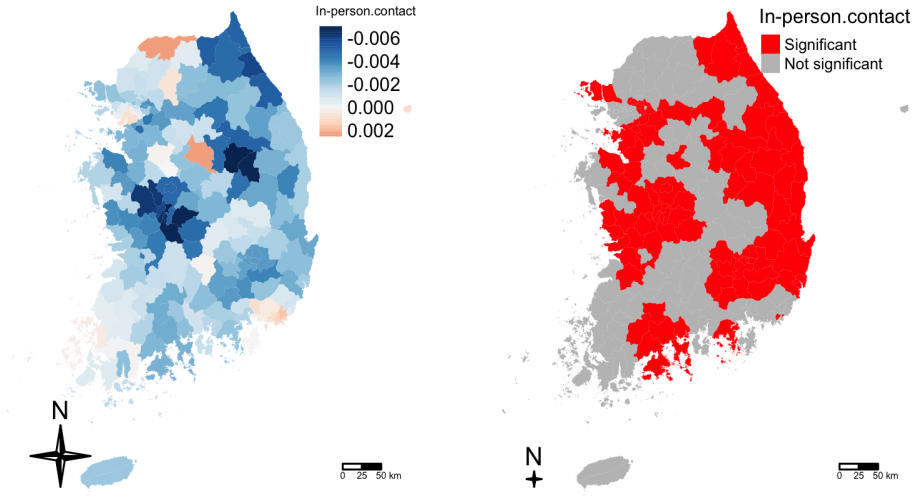


(d) Local significance of educational level

Figure A.3: Local coefficients and significance of each independent variable in 2008

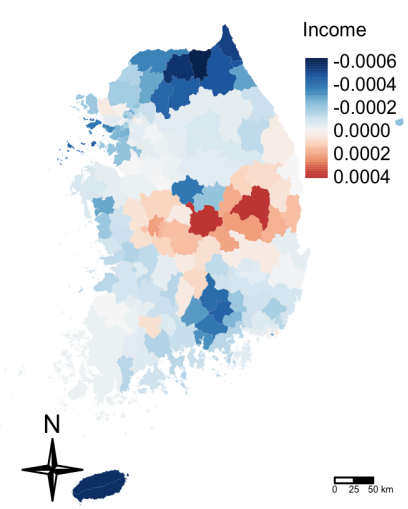


(a) Local coefficients of marital status (b) Local significance of marital status

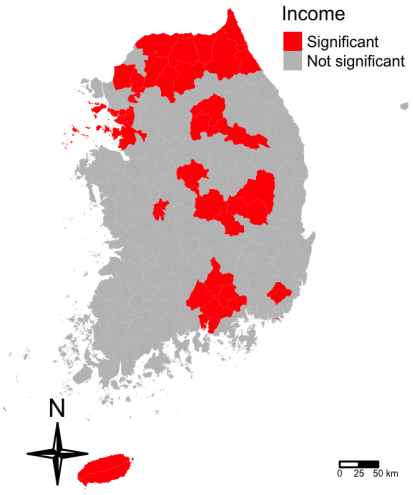


(c) Local coefficients of in-person social contact frequency (d) Local significance of in-person social contact frequency

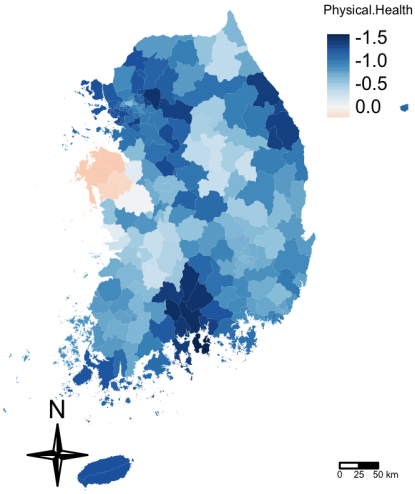
Figure A.4: Local coefficients and significance of each independent variable in 2008



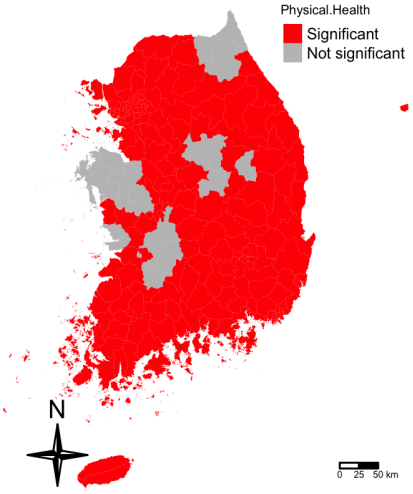
(a) Local coefficients of household income



(b) Local significance of household income

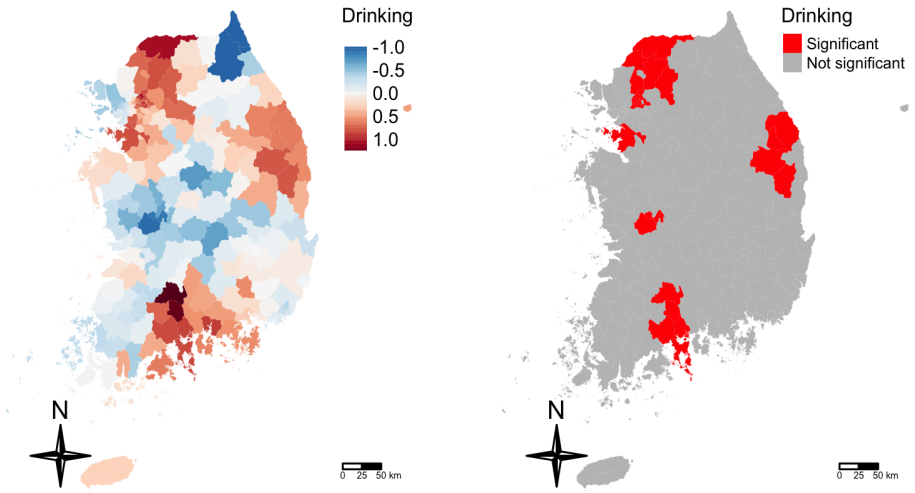


(c) Local coefficients of physical health

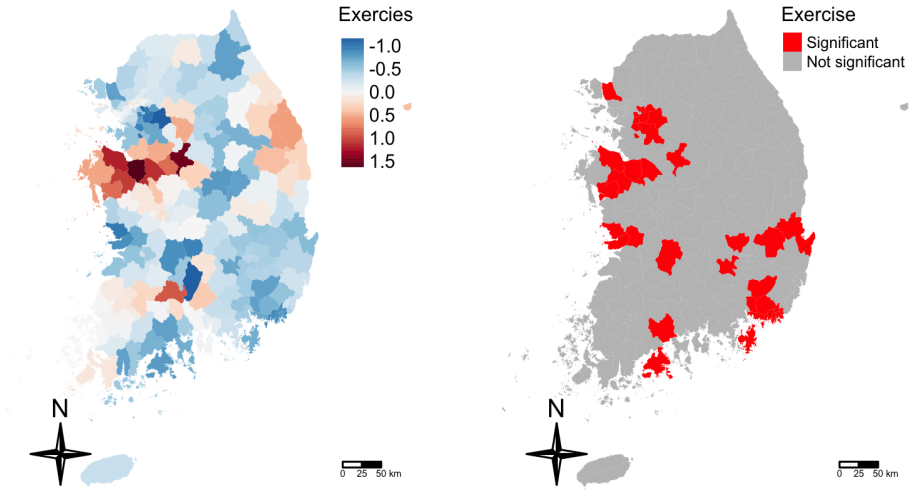


(d) Local significance of physical health

Figure A.5: Local coefficients and significance of each independent variable in 2008



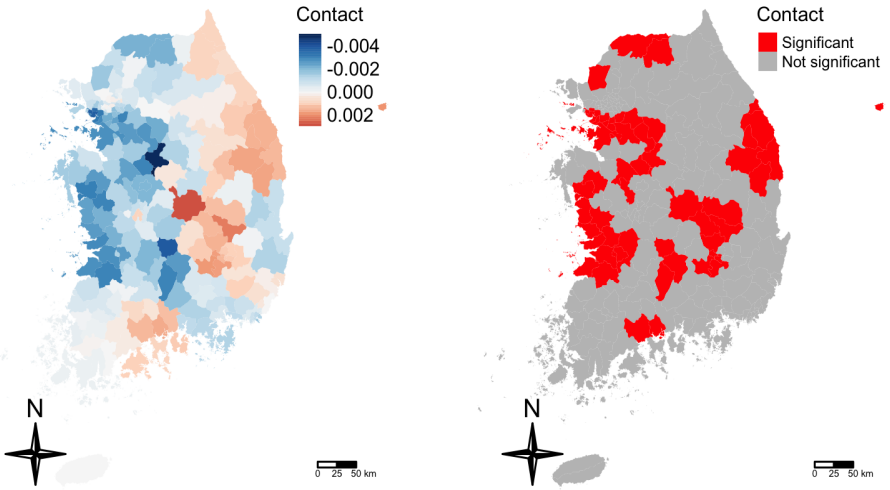
(a) Local coefficients of drinking habits (b) Local significance of drinking habits



(c) Local coefficients of exercise habits (d) Local significance of exercise habits

Figure A.6: Local coefficients and significance of each independent variable in 2008

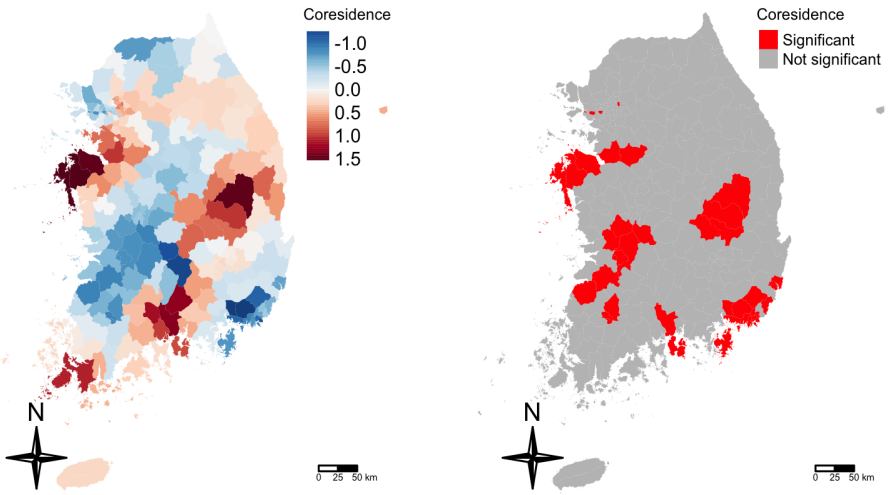
Local coefficients and significance of independent variables of multivariate spatially local regression in 2010



(a) Local coefficients of contact frequency with children

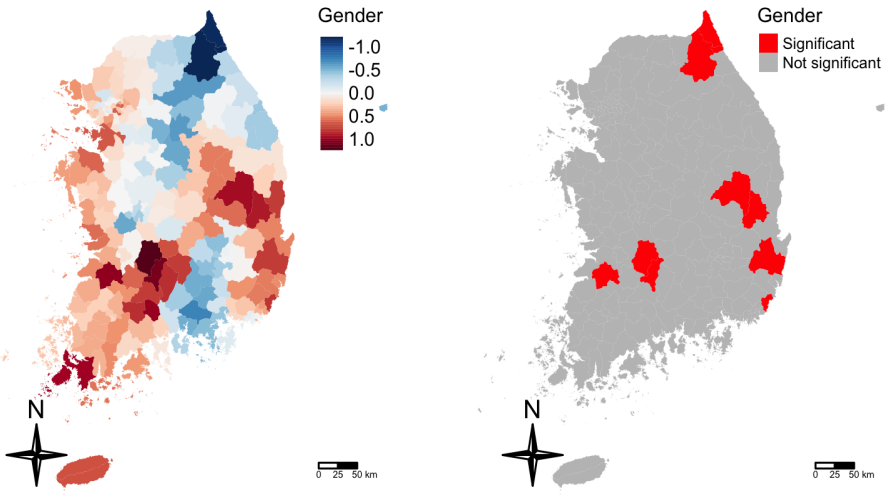
(b) Local significance of contact frequency with children

Figure A.7: Local coefficients and significance of each independent variable in 2010



(a) Local coefficients of coresidence with adult children

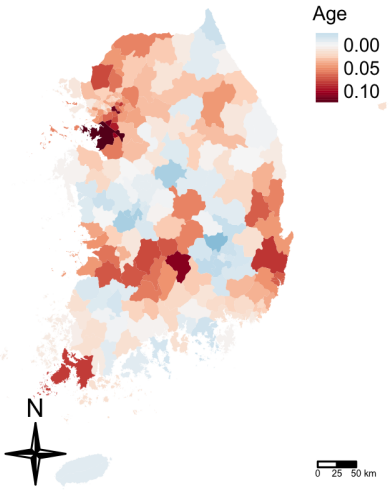
(b) Local significance of coresidence with adult children



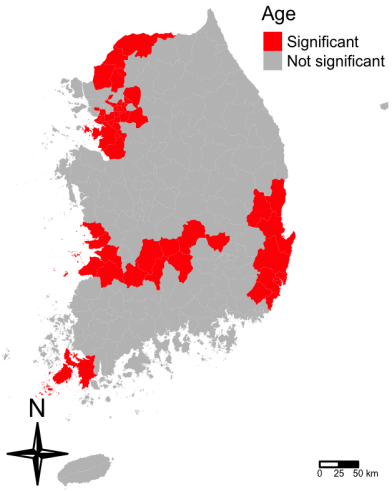
(c) Local coefficients of gender

(d) Local significance of gender

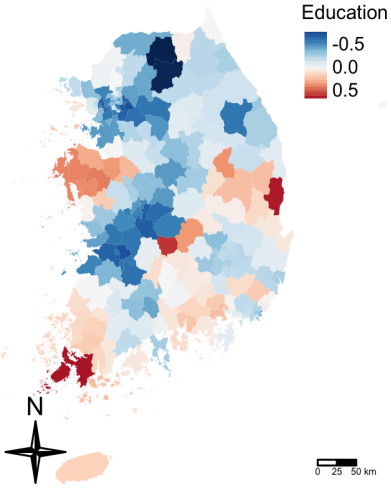
Figure A.8: Local coefficients and significance of each independent variable in 2010



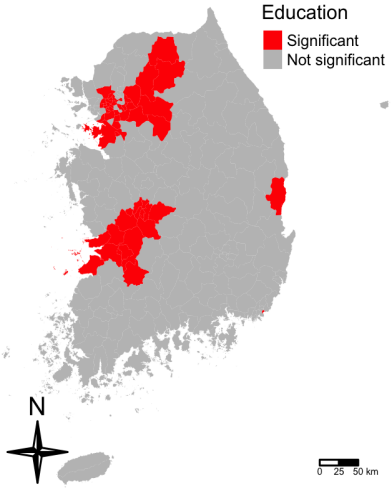
(a) Local coefficients of age



(b) Local significance of age

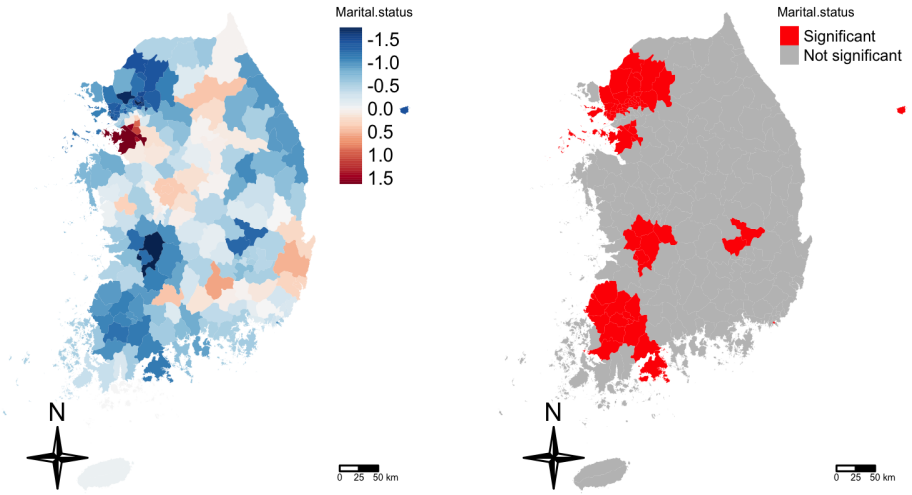


(c) Local coefficients of educational level

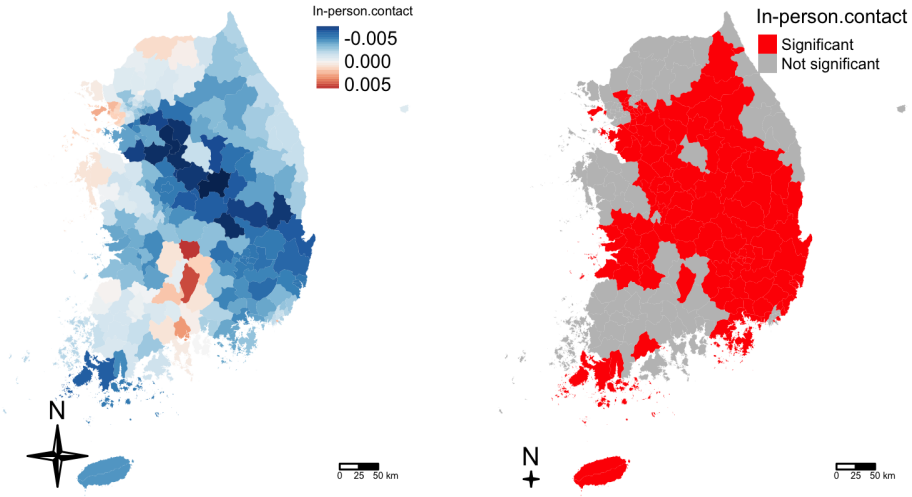


(d) Local significance of educational level

Figure A.9: Local coefficients and significance of each independent variable in 2010

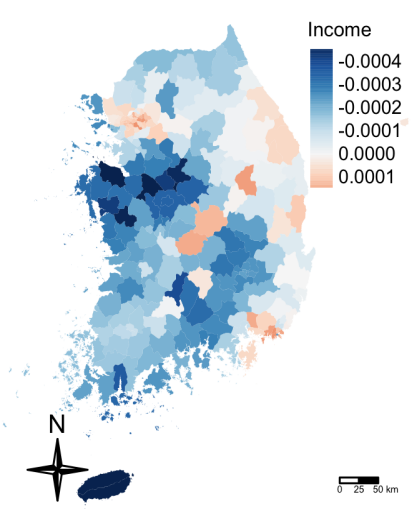


(a) Local coefficients of marital status (b) Local significance of marital status

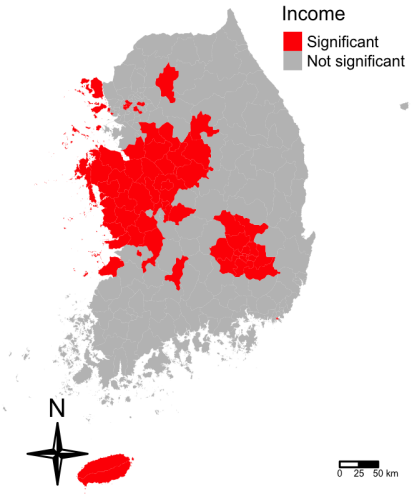


(c) Local coefficients of in-person social contact frequency (d) Local significance of in-person social contact frequency

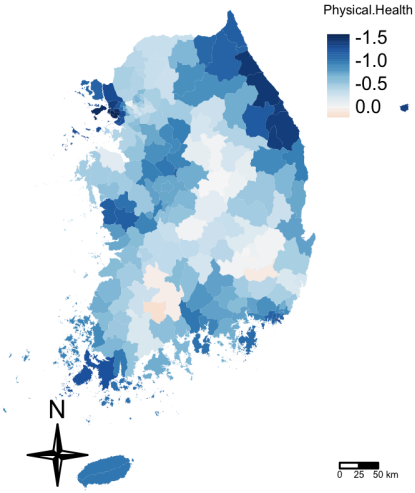
Figure A.10: Local coefficients and significance of each independent variable in 2010



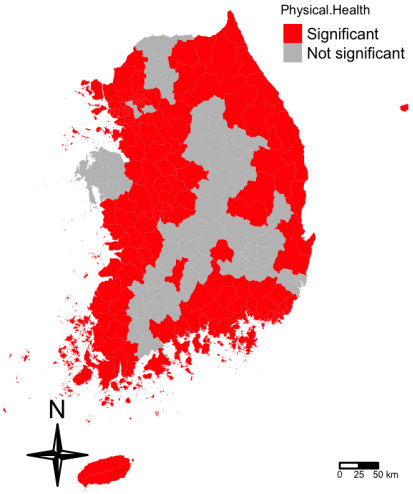
(a) Local coefficients of household income



(b) Local significance of household income

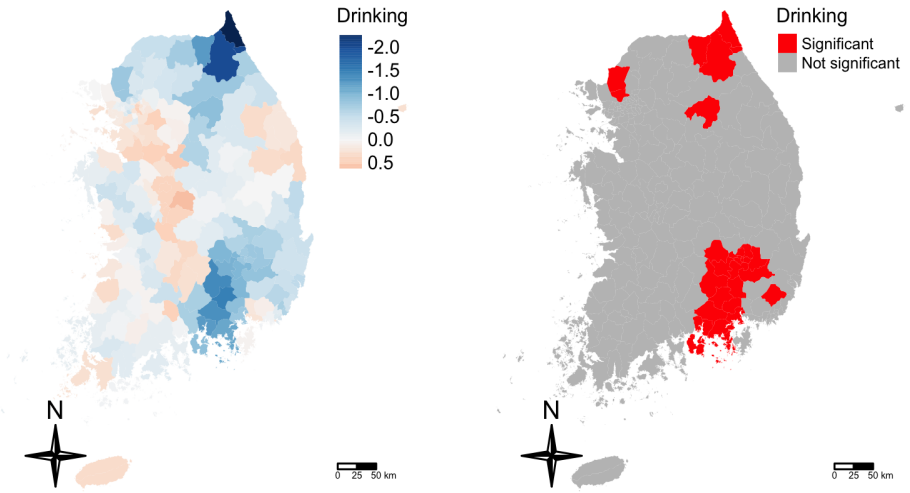


(c) Local coefficients of physical health

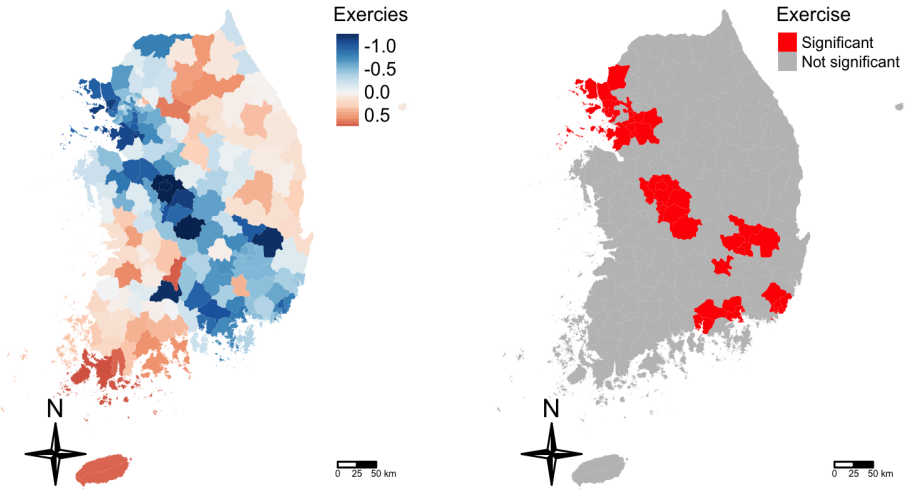


(d) Local significance of physical health

Figure A.11: Local coefficients and significance of each independent variable in 2010



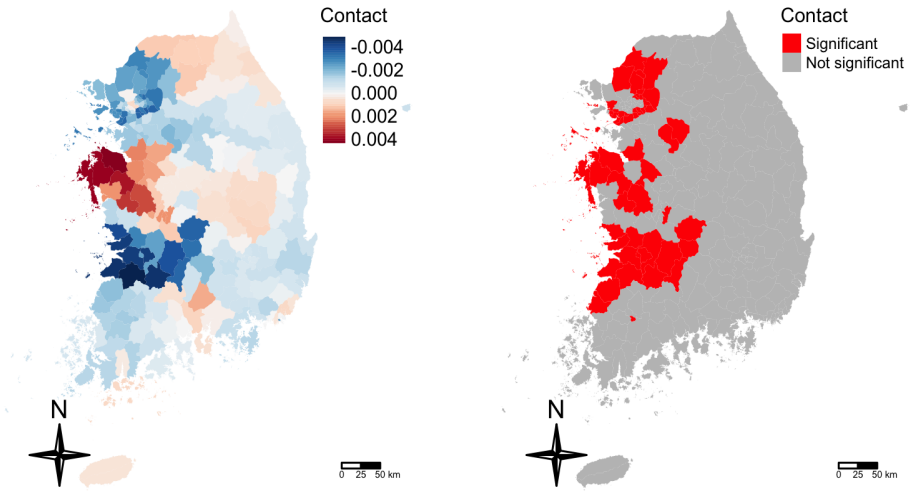
(a) Local coefficients of drinking habits (b) Local significance of drinking habits



(c) Local coefficients of exercise habits (d) Local significance of exercise habits

Figure A.12: Local coefficients and significance of each independent variable in 2010

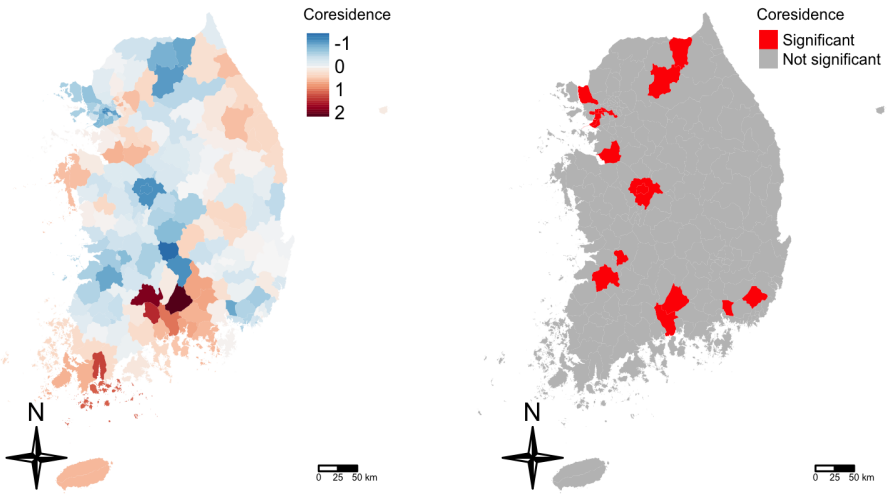
Local coefficients and significance of independent variables of multivariate spatially local regression in 2012



(a) Local coefficients of contact frequency with children

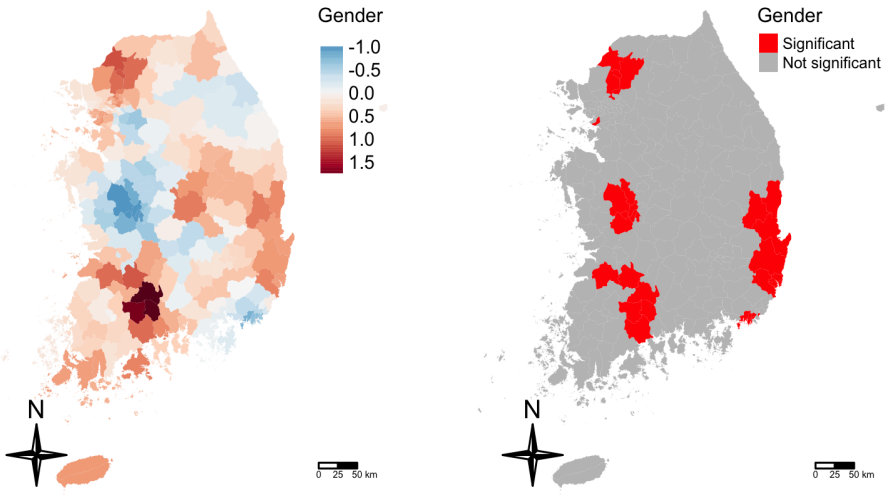
(b) Local significance of contact frequency with children

Figure A.13: Local coefficients and significance of each independent variable in 2012



(a) Local coefficients of coresidence with adult children

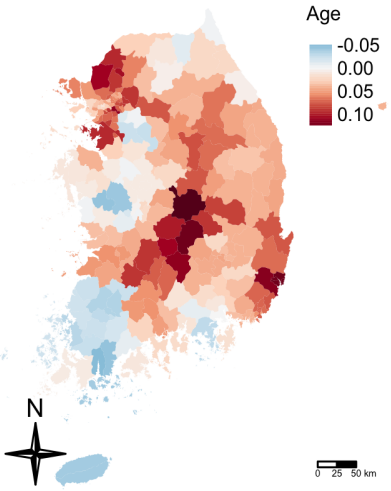
(b) Local significance of coresidence with adult children



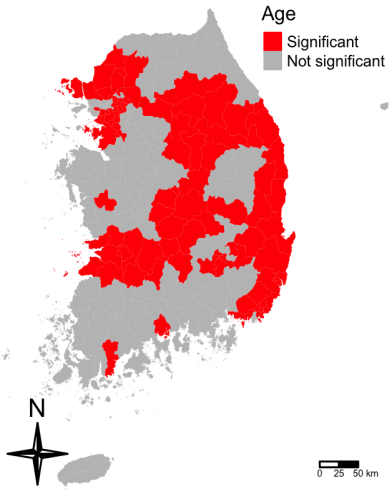
(c) Local coefficients of gender

(d) Local significance of gender

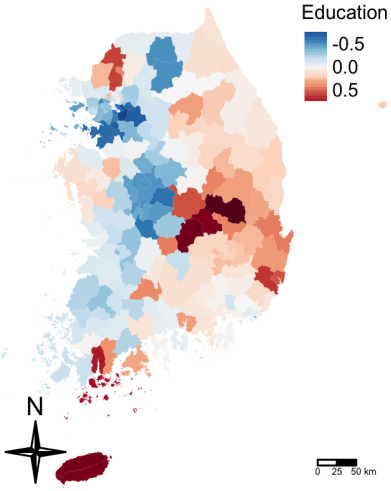
Figure A.14: Local coefficients and significance of each independent variable in 2012



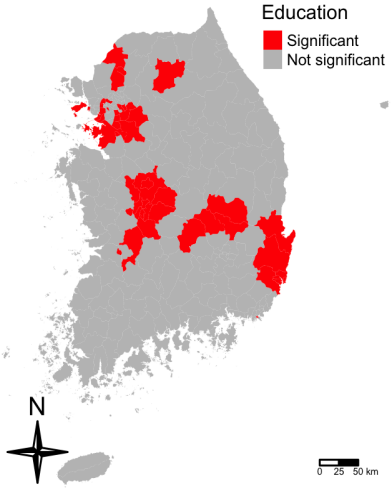
(a) Local coefficients of age



(b) Local significance of age

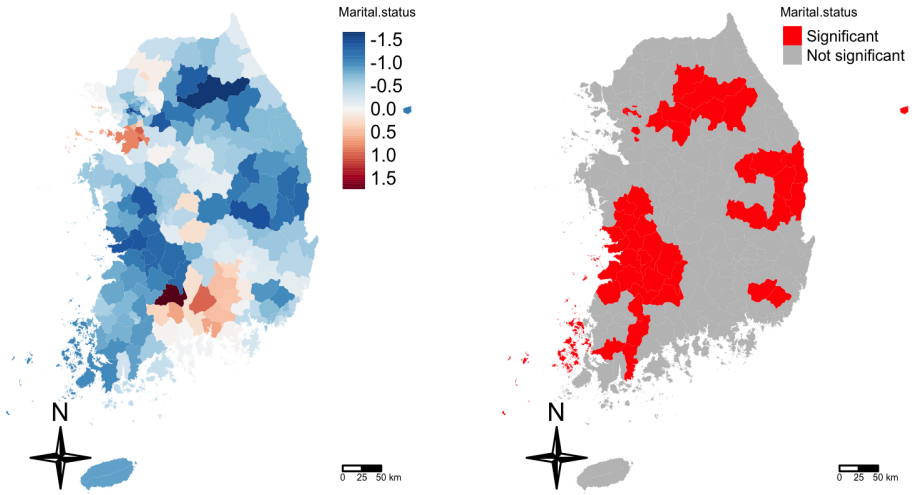


(c) Local coefficients of educational level

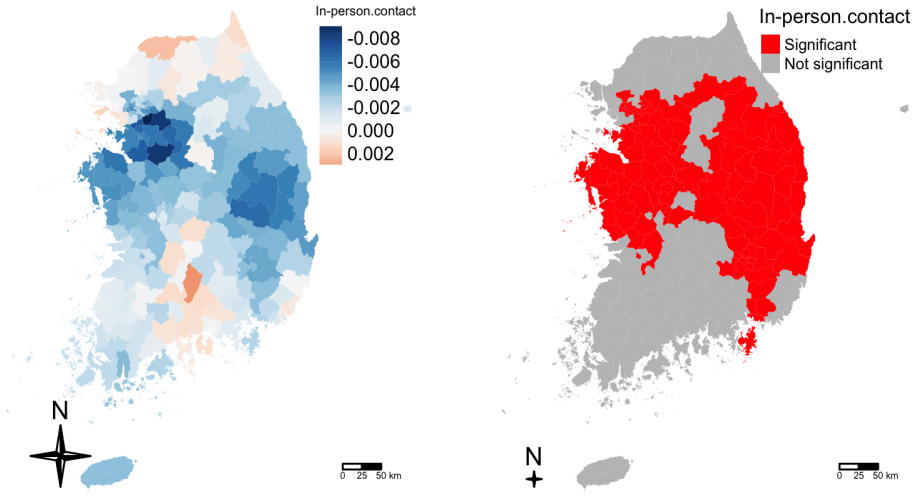


(d) Local significance of educational level

Figure A.15: Local coefficients and significance of each independent variable in 2012

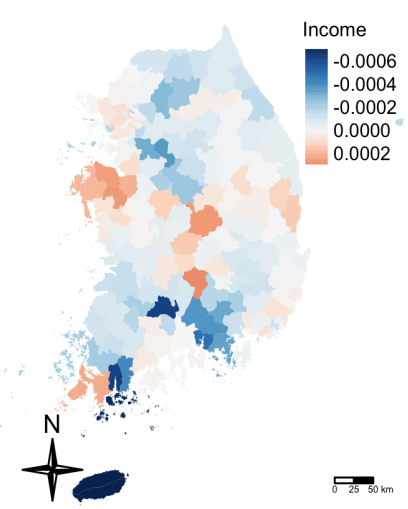


(a) Local coefficients of marital status (b) Local significance of marital status

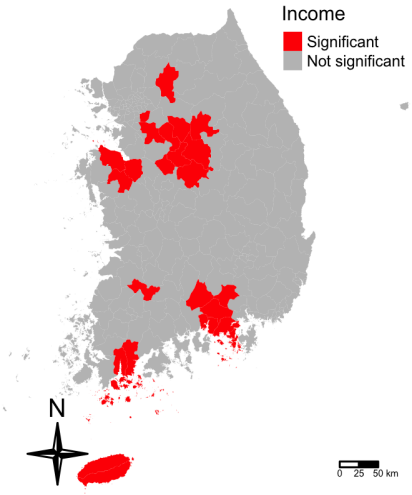


(c) Local coefficients of in-person social contact frequency (d) Local significance of in-person social contact frequency

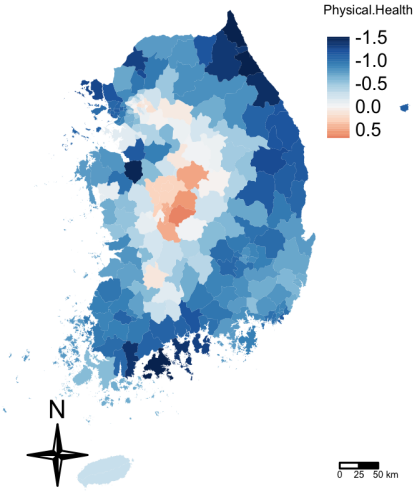
Figure A.16: Local coefficients and significance of each independent variable in 2012



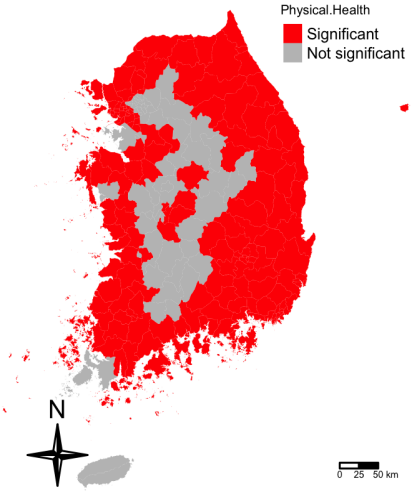
(a) Local coefficients of household income



(b) Local significance of household income

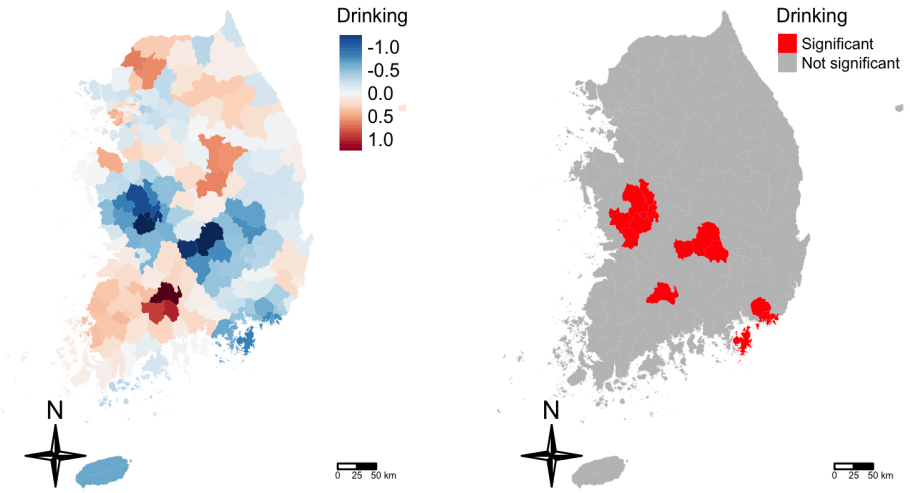


(c) Local coefficients of physical health

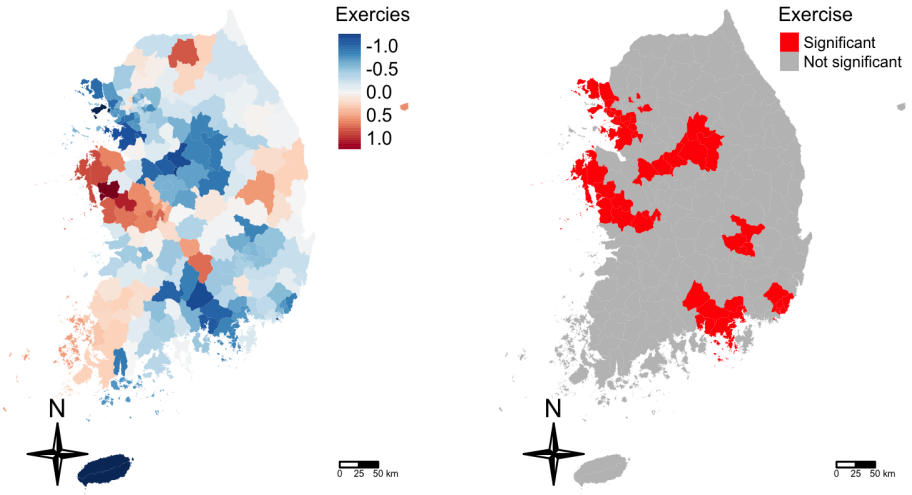


(d) Local significance of physical health

Figure A.17: Local coefficients and significance of each independent variable in 2012



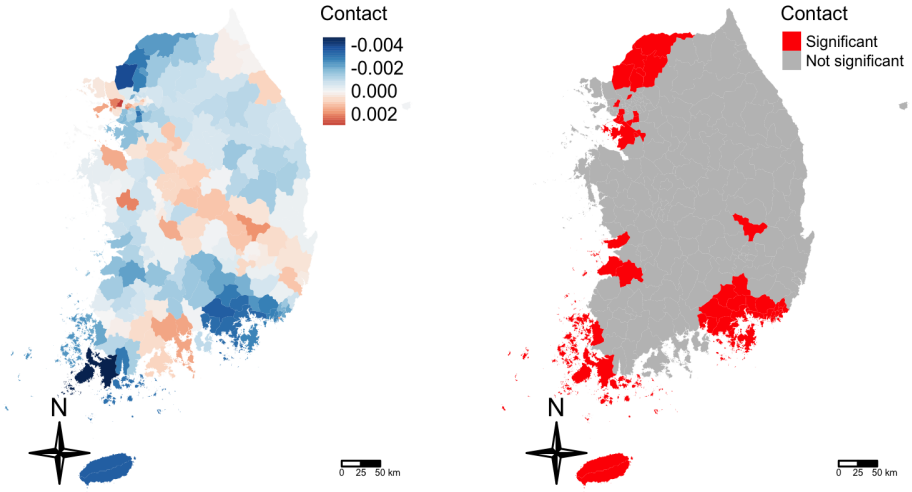
(a) Local coefficients of drinking habits (b) Local significance of drinking habits



(c) Local coefficients of exercise habits (d) Local significance of exercise habits

Figure A.18: Local coefficients and significance of each independent variable in 2012

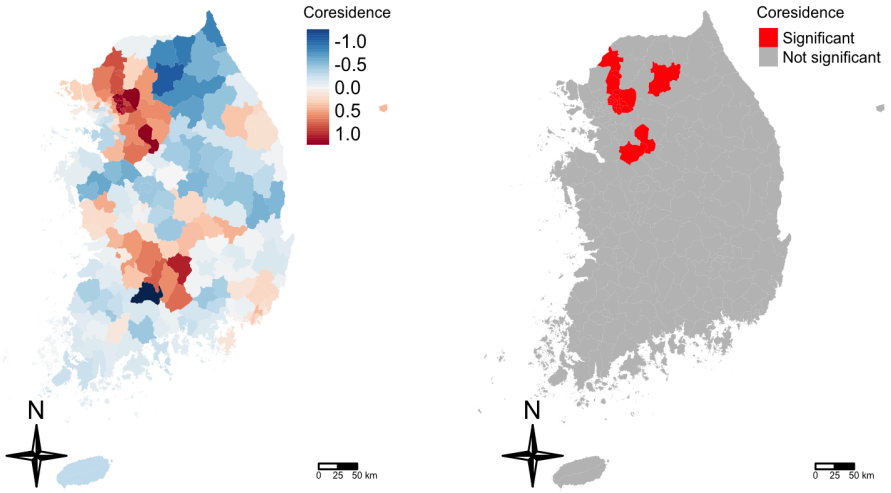
Local coefficients and significance of independent variables of multivariate spatially local regression in 2014



(a) Local coefficients of contact frequency with children

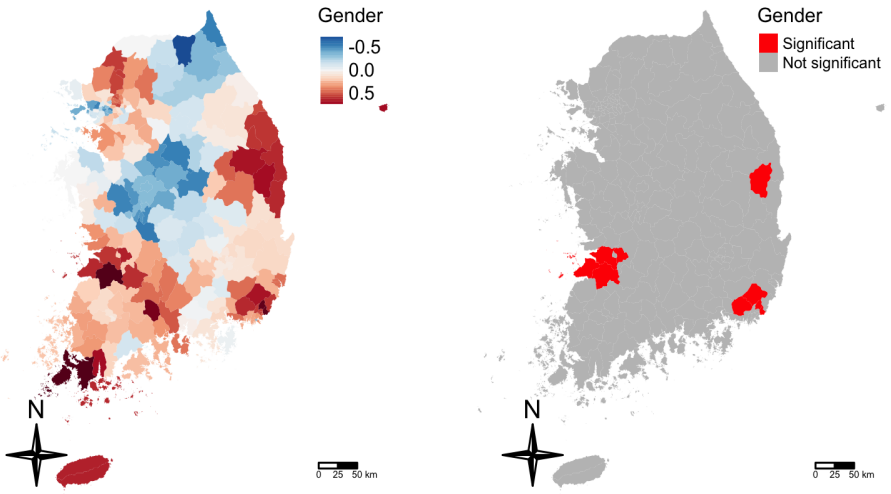
(b) Local significance of contact frequency with children

Figure A.19: Local coefficients and significance of each independent variable in 2014



(a) Local coefficients of coresidence with adult children

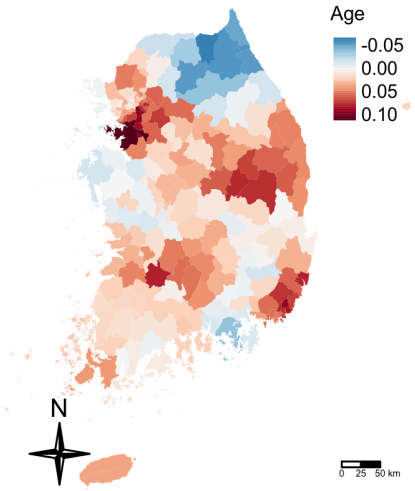
(b) Local significance of coresidence with adult children



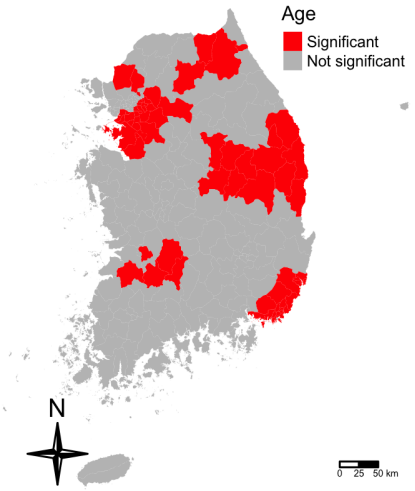
(c) Local coefficients of gender

(d) Local significance of gender

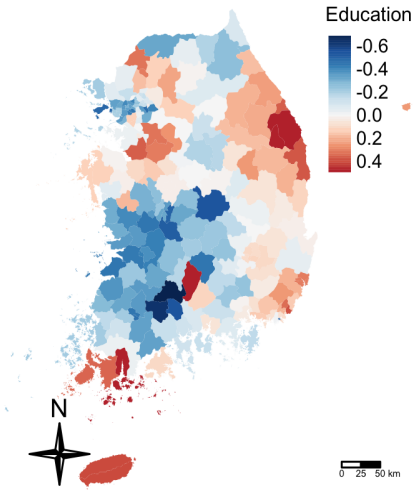
Figure A.20: Local coefficients and significance of each independent variable in 2014



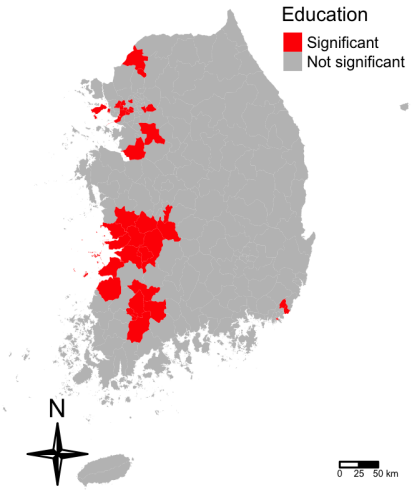
(a) Local coefficients of age



(b) Local significance of age

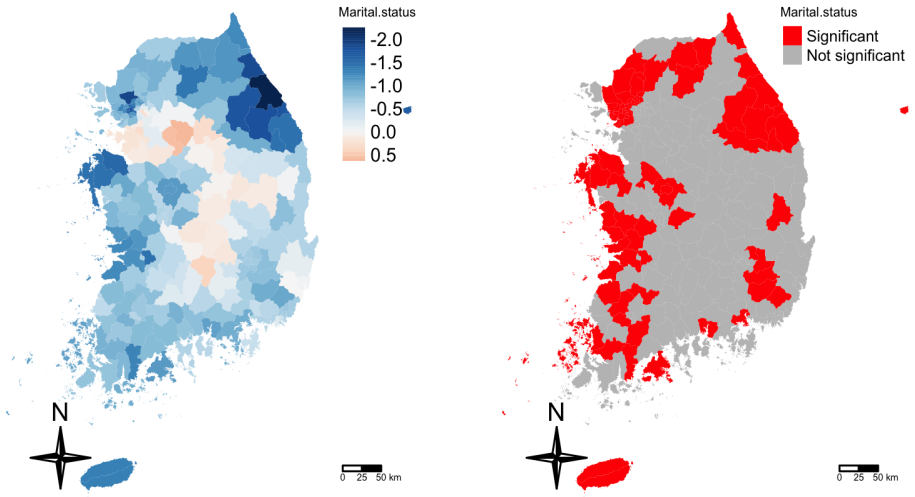


(c) Local coefficients of educational level

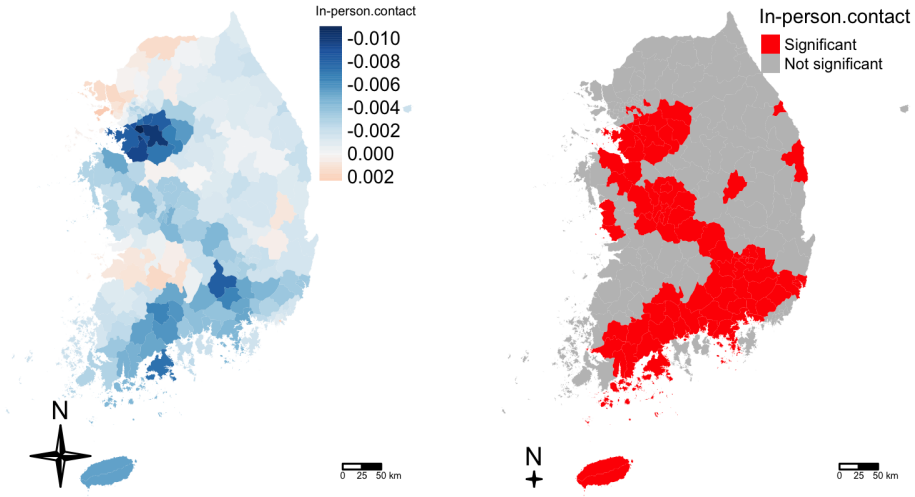


(d) Local significance of educational level

Figure A.21: Local coefficients and significance of each independent variable in 2014

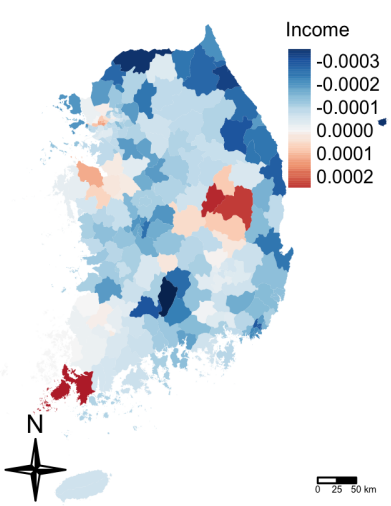


(a) Local coefficients of marital status (b) Local significance of marital status

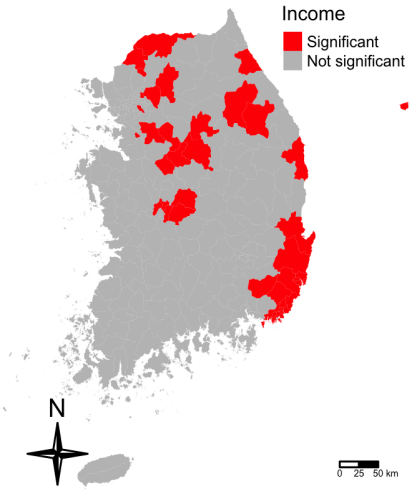


(c) Local coefficients of in-person social contact frequency (d) Local significance of in-person social contact frequency

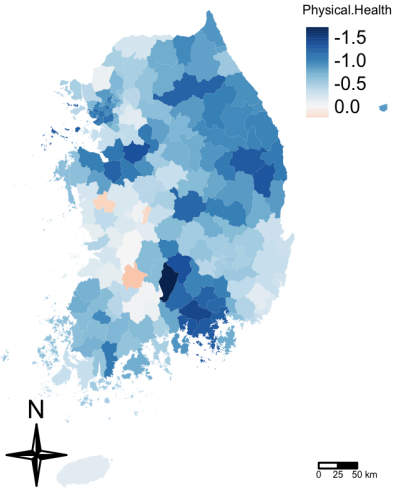
Figure A.22: Local coefficients and significance of each independent variable in 2014



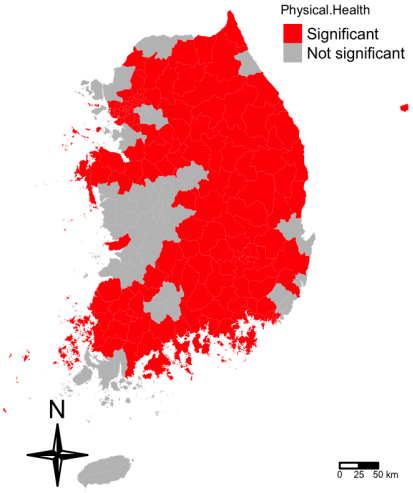
(a) Local coefficients of household income



(b) Local significance of household income

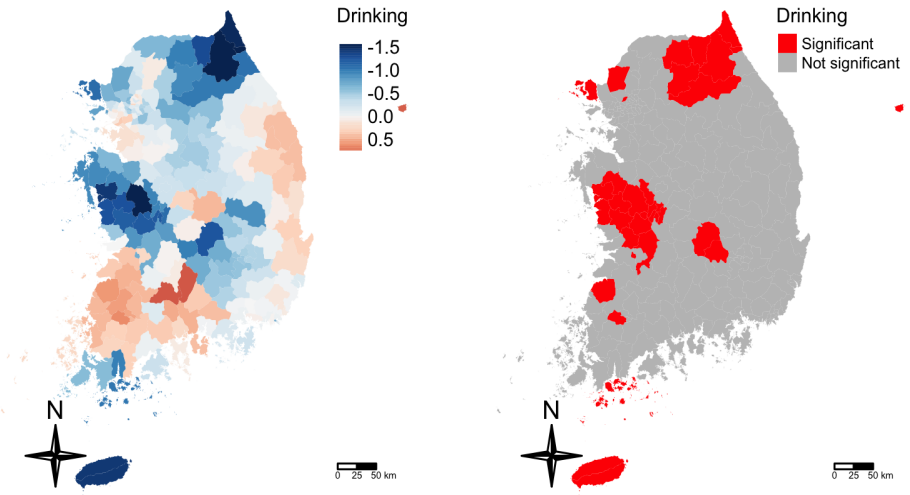


(c) Local coefficients of physical health

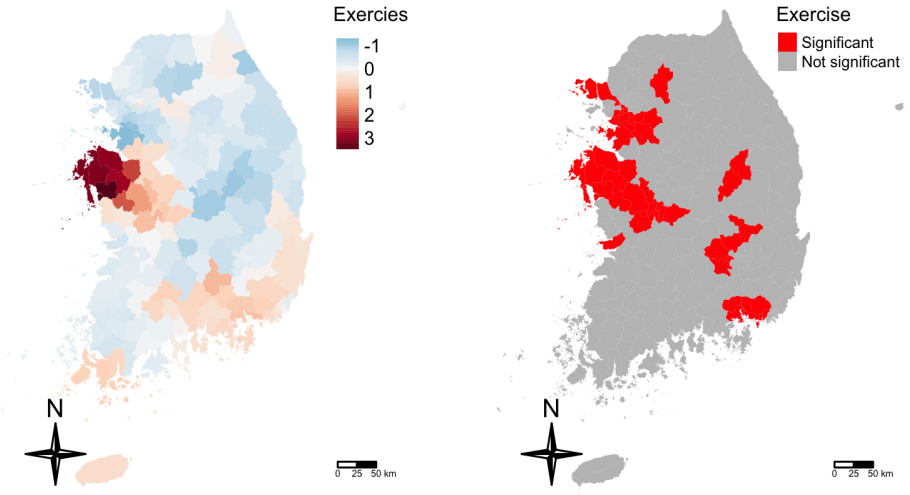


(d) Local significance of physical health

Figure A.23: Local coefficients and significance of each independent variable in 2014



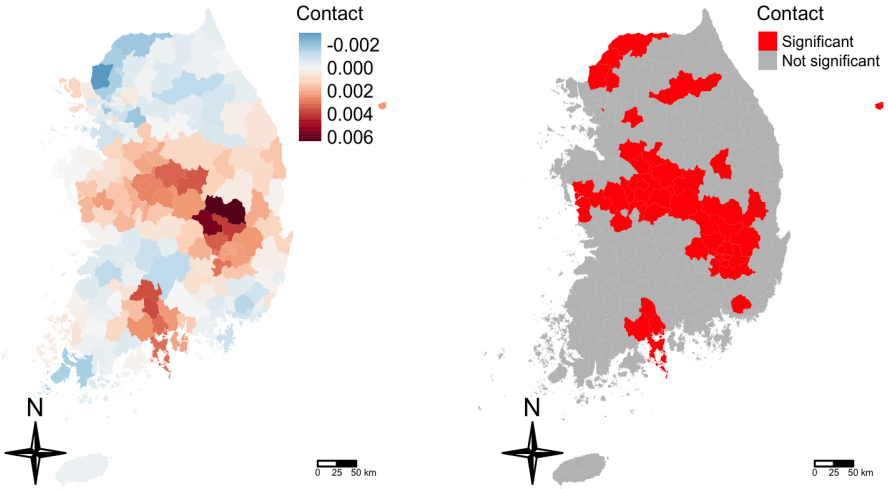
(a) Local coefficients of drinking habits (b) Local significance of drinking habits



(c) Local coefficients of exercise habits (d) Local significance of exercise habits

Figure A.24: Local coefficients and significance of each independent variable in 2014

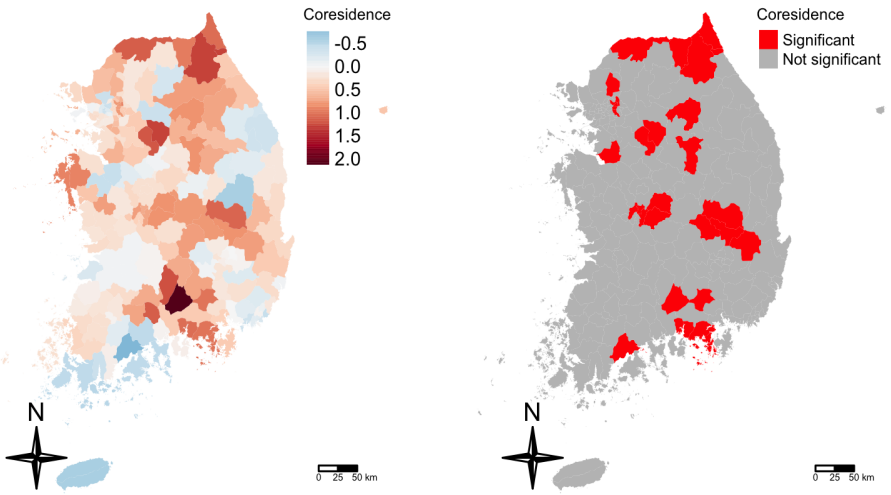
Local coefficients and significance of independent variables of multivariate spatially local regression in 2016



(a) Local coefficients of contact frequency with children

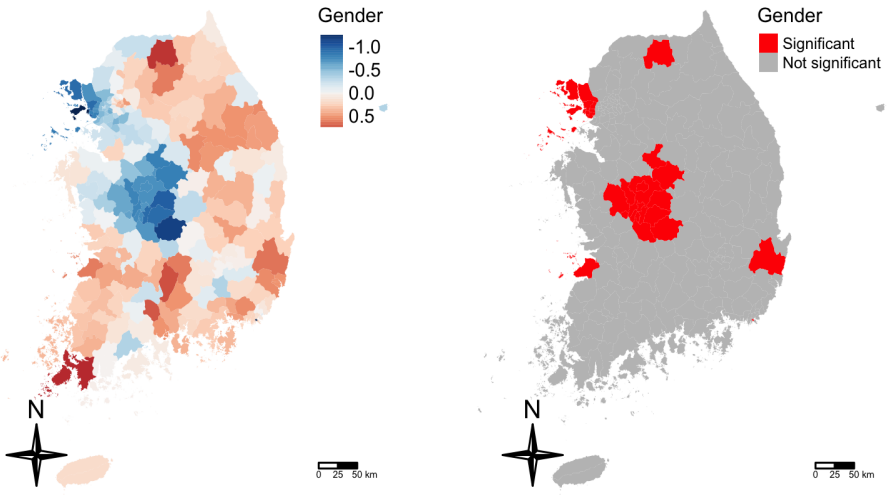
(b) Local significance of contact frequency with children

Figure A.25: Local coefficients and significance of each independent variable in 2016



(a) Local coefficients of coresidence with adult children

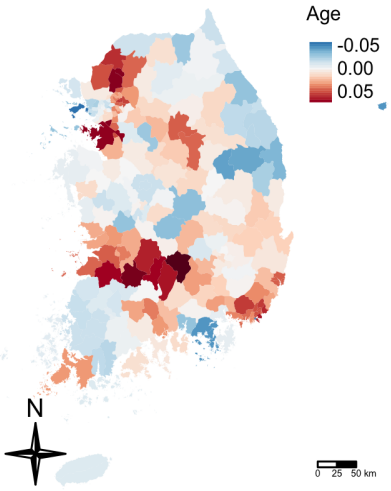
(b) Local significance of coresidence with adult children



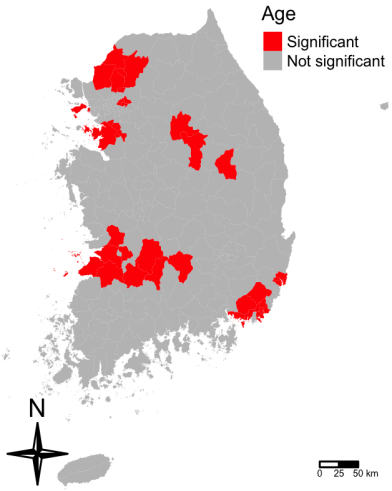
(c) Local coefficients of gender

(d) Local significance of gender

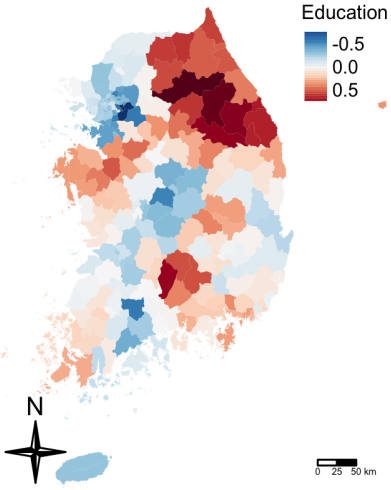
Figure A.26: Local coefficients and significance of each independent variable in 2016



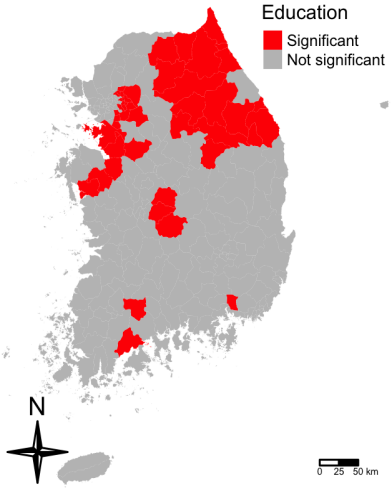
(a) Local coefficients of age



(b) Local significance of age

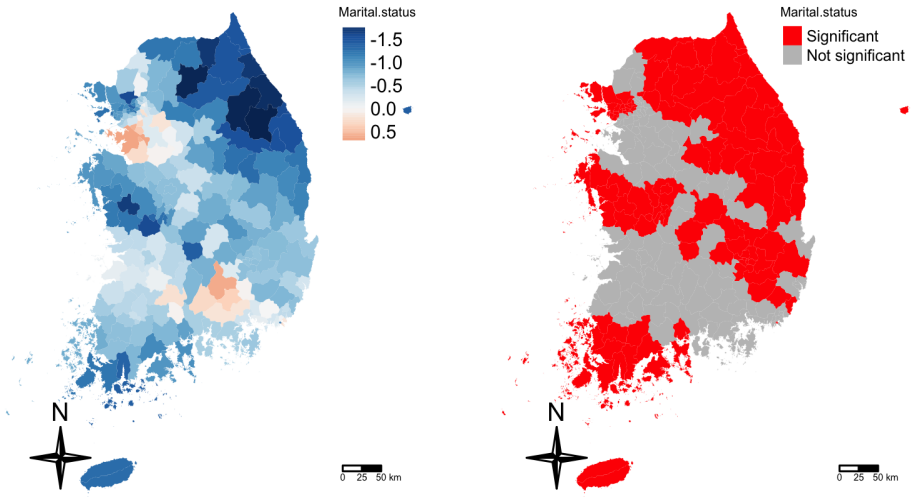


(c) Local coefficients of educational level

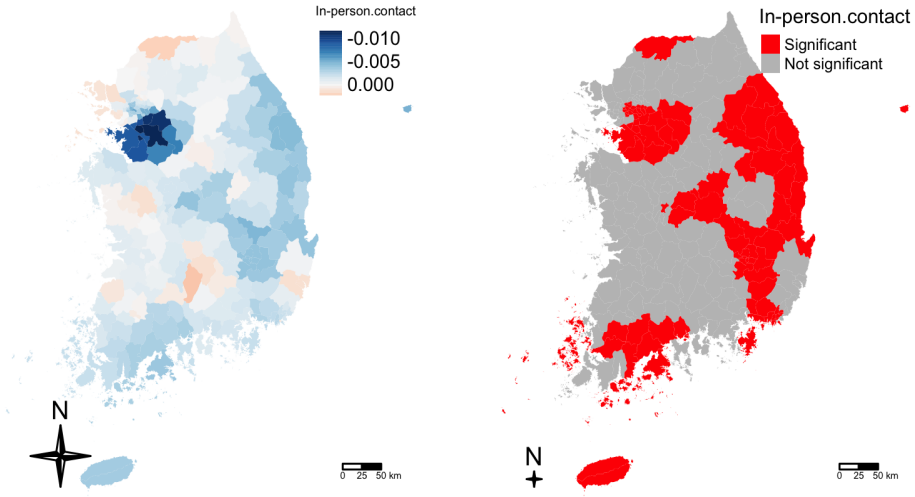


(d) Local significance of educational level

Figure A.27: Local coefficients and significance of each independent variable in 2016

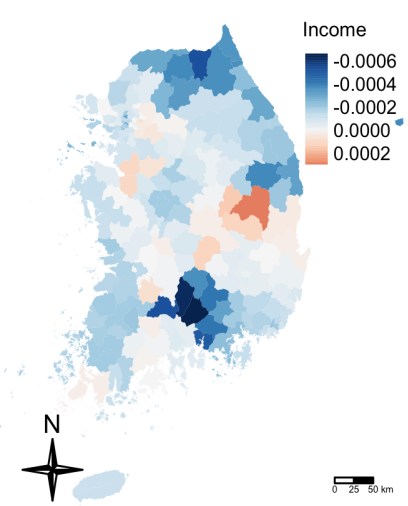


(a) Local coefficients of marital status (b) Local significance of marital status

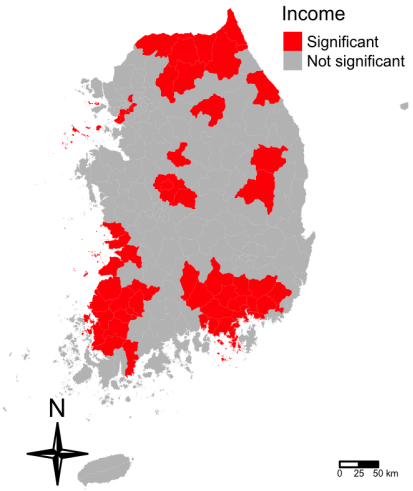


(c) Local coefficients of in-person social contact frequency (d) Local significance of in-person social contact frequency

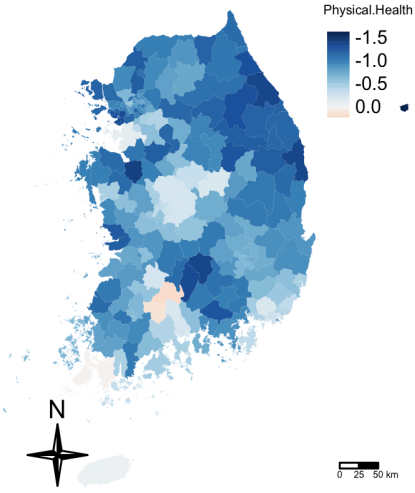
Figure A.28: Local coefficients and significance of each independent variable in 2016



(a) Local coefficients of household income



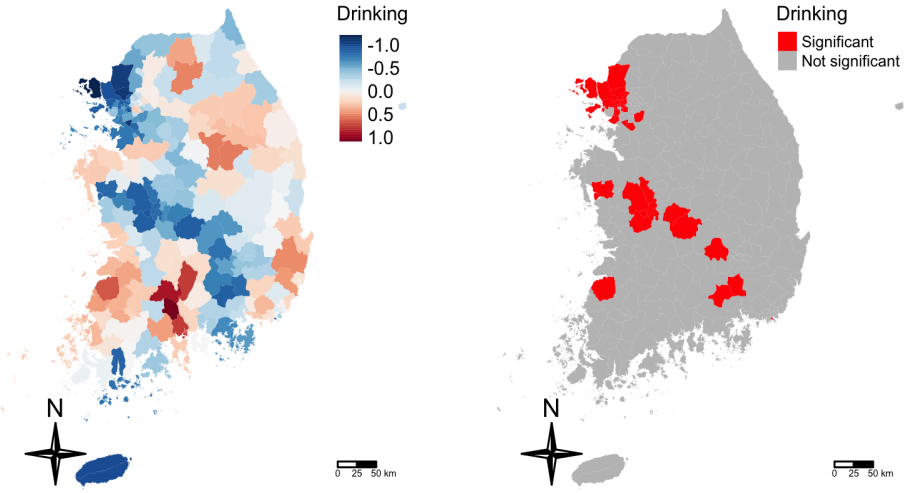
(b) Local significance of household income



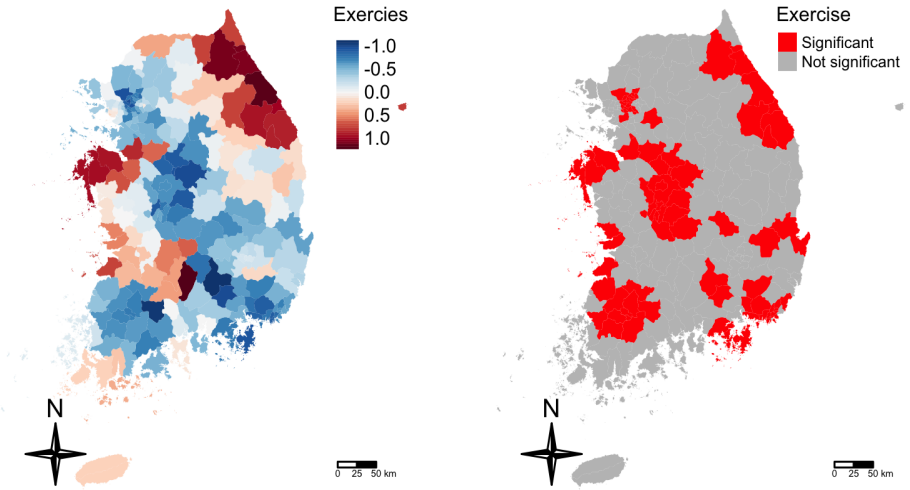
(c) Local coefficients of physical health

(d) Local significance of physical health

Figure A.29: Local coefficients and significance of each independent variable in 2016



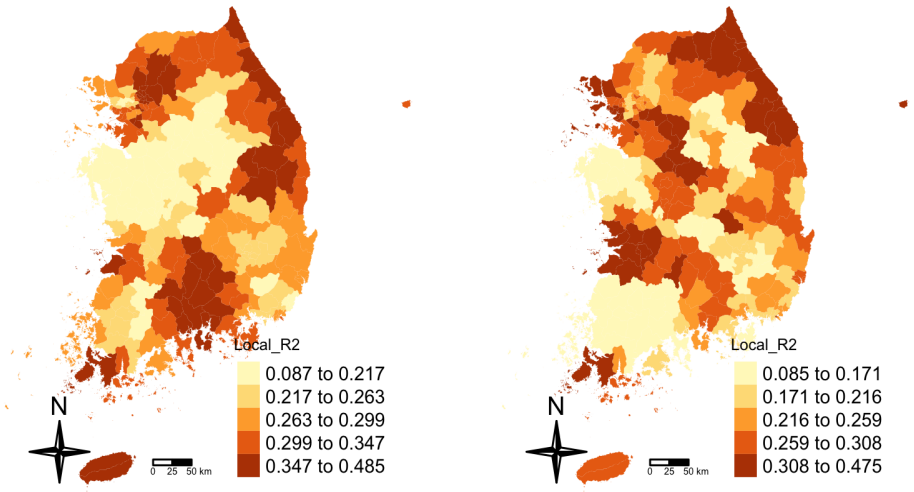
(a) Local coefficients of drinking habits (b) Local significance of drinking habits



(c) Local coefficients of exercise habits (d) Local significance of exercise habits

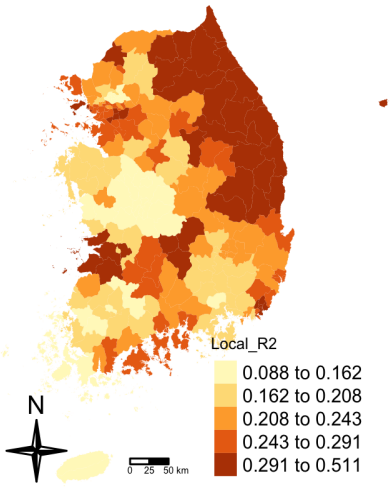
 Figure A.30: Local coefficients and significance of each independent variable in 2016

Local R Squares from 2008 to 2016

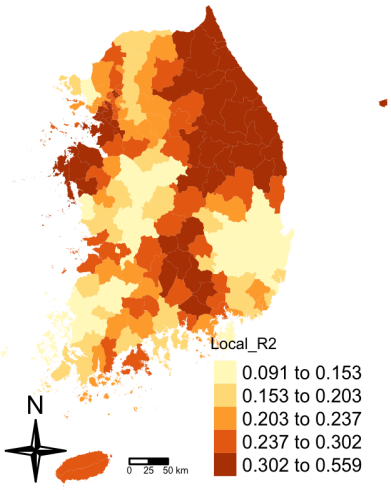


(a) 2008 (b) 2010

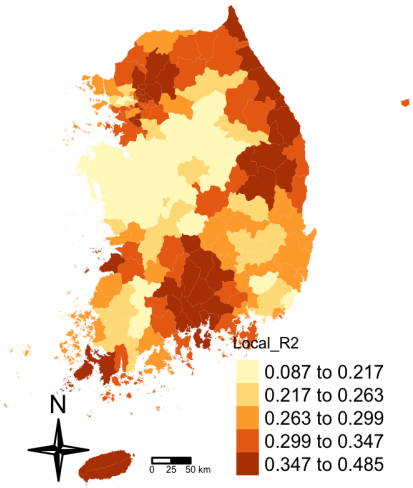
Figure A.31: Local R-Squares from 2008 to 2010



(a) 2012



(b) 2014



(c) 2016

Figure A.32: Local R-Squares from 2012 to 2016

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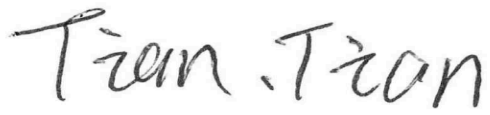
Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis



Signature_____ Date: September 30 2019