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RESEARCH ARTICLE

DETERMINANTS, INEQUALITIES AND GEOGRAPHICAL DIFFERENCES IN COGNITIVE PERFORMANCE AMONGST THE ELDERLY POPULATION IN SOUTH KOREA

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ABSTRACT

Using the most recent 2018 Korean Longitudinal Study of Aging (KLoSA) survey data, this study aimed to examine the key determinants of cognitive impairment (CI) and to explore the inequalities and geographic differences of CI amongst the South Korean elderly population.

The findings show that being super-aged, poor general health, and lack of exercise are positively associated with CI, while household wealth, educational level, participation in social activities and regular exercise all have a significant negative effect on CI. Compared to males, female respondents are more likely to experience CI. We found little difference between the specific determinates for the two subsamples. Inequalities in the prevalence of cognitive impairment were greatest in rural areas as well as amongst the respondents living in the Chungcheong region, Seoul Metropolitan Area and the Kangwan region.

The results are helpful for the early intervention and prevention strategies to tackle the cognitive impairment problems of the elderly.

KEYWORDS

Aging; cognitive impairment; super-aged society; socio-economic inequalities; South Korea.

INTRODUCTION

Since the establishment of the Sixth Republic in 1978, South Korea has experienced a rapid demographic transition and is considered to be one of the most rapidly aging societies [1, 2]. It is estimated that 5.7% of the total population is aged 65 years or more and this is projected to reach 46% by 2067 [3]. At the same time, assuming the medium population growth scenario, South Korea's life expectancy is projected to exceed 90 years [3]. According to the United Nations (UNs) benchmarks, before 2030, South Korea is expected to become a super-aged society [4]. With its rapid transformation and relatively young social welfare system, the material, physical and mental

wellbeing of the elderly populations remains one of the key social policy issues.

Cognitive performance is a critical wellbeing factor because it is related to whether or not, individuals can manage their daily activities independently and maintain effective communications. It can also have critical health consequences, including disability and death [5]. Cognitive performance is known to decline with age regardless of the 'cognitive reserve', although epidemiological studies suggest that this reserve can be increased through lifetime educational, social and professional activities as well as lifestyle in later life [6]. Another study in South Korea has shown that the primary cause of cognitive decline is related to heredity, family history of dementia, brain trauma, disability and lifestyle [7]. Quantitative analyses of factors affecting the level of cognitive performance show that socio-economic factors, health status, health behaviour and geographical location can all constitute risk factors. For example, a recent study of an elderly population in Shanghai, China, showed that low income, non-married status and being a male were all associated with a higher probability of CI [5].

Specifically, in the South Korean context, a study conducted on 4,369 rural elderly in Sokcho found that cognitive performance was positively associated with their level of education, age, and being a female [8]. Although existing literature examines drivers of cognitive decline in later life [9, 10], recent evidence examining specific risk factors of impaired cognitive performance in South Korea is still lacking. Our study aims to fill this gap by statistically analyzing data from the most recent Korean Longitudinal Study of Ageing (KLoSA) survey. Previous literature has indicated that being aware of the potential risk factors should be a priority, as effective strategies need to be developed to prevent further cognitive impairment [11]. Thus, in addition to providing predictive models of the identified risk factors, this study will contribute to ongoing policy debate by providing a discussion on key selected policy implications in the South Korean context.

DATA AND METHODS

DATA

We used data from the 7th wave of the KLoSA (Korean Longitudinal Study on Aging) which is a comprehensive nationwide household survey designed and implemented by the Korea Employment Information Service (KEIS). It applies a multi-stage, stratified probability sampling technique using census-based enumeration districts (EDs), residence, and accommodation type [12]. The survey started in 2006 has been repeated every two years. It currently covers all regions in South Korea except for the Island of Jeju. The 7th wave was conducted in 2018 on a sample size of 6,940 consisting of 6,136 from previous panels and 804 new observations.

MEASURES

The study uses the Mini-Mental State Examination (MMSE) score, a standard measure of cognitive performance. MMSE used several domains related to thinking and learning abilities, such as memory, orientation, attention and visual-spatial skills. Based on the KLoSA classification, in line with other studies, if the MMSE is 17 or less, one can suspect dementia, if the MMSE value is between 18 and 23, it implies cognitive function decline, and if it is 24 and above, the cognitive function is normal [8, 13, 14]. For analytical purposes, in line with other studies [8, 14], we categorized this variable into a dichotomous one with values of 24 and above, indicating normal cognitive function, and the values below this threshold indicating cognitive impairment.

This study has considered standard demographic and socio-economic status measures, health outcome and health behavior variables, life satisfaction, and participation in social activities in terms of independent variables. Socio-demographic factors include age, gender, education, marital status, and household income. Age was divided into two categories (65 to less than 80 years of age, and people who are equal to or greater than 80). Education was divided into four categories based on the South Korean educational system classification (primary school, middle school, high school, and university). Living arrangements were divided into living alone and living with others. The wealth of the participants was measured by their household income and classified into wealth quintiles.

Health status was divided into three categories (very good and good, average and rather bad, and bad). This data combined the information based on a self-assessment of health status and health history. Drinking, smoking, and exercising were considered healthy behaviours. The participants were asked to choose among three options (currently drinking, not drinking, and past drinker). Regarding smoking, the participants were asked to choose among currently smoking, not smoking, and past smoker. In

terms of exercise, they were asked whether they exercise regularly or not exercise regularly. In this study, the frequency of exercising regularly is more than "at least once a week". Finally, the respondents self-assessed their life satisfaction by choosing among low, medium, and high, while participation in social activities was dichotomized and based on whether they took part in any social gathering or met close people.

DATA ANALYSIS

The chi-squared test was employed to examine differences between study subjects with cognitive impairment and those without cognitive impairment. Binary multiple logistic regression modeling was used to estimate the association between cognitive performance and different explanatory (e.g.) variables. The results of the binary multiple logistic regression analysis were expressed in OR with a confidence interval of 95%. The binary multiple regression models were specified as follows:

$$\text{logit}(Yi)=\beta 0+\beta 1X1i+\beta 2X2i+\cdots+\varepsilon i \ldots\ldots\ldots (I); \quad i=1,2\ldots n$$

Where, Yi denotes incidence of cognitive impairment with values 1 or 0 (1 = suffering from CI, 0 = normal cognition), X2i, X3i,… denote the explanatory variables included in the model, β1, β3… denotes regression coefficients adjacent to the corresponding outcome variables and εi denotes the error term.

Socio-economic inequalities were assessed using household income quintile ratios and concentration curves and indices [15-17]. We used purposeful selection procedure to select final models, as we were primarily interested in identification of risk factors rather than prediction [18]. All analyses were performed using STATA 16.

RESULTS

CHARACTERISTICS OF THE STUDY PARTICIPANTS

Characteristics of the study participants by cognitive impairment status are summarized in Table 1 (geographical distribution can be seen in supplementary material). Of all the samples, females constituted 58.1% and were more likely to suffer cognitive impairment (43.8% vs 26.3% for males). Considering age, those respondents who are classified as super-aged (80+) also had a significantly higher proportion of individuals with cognitive impairment compared to respondents in the age bracket 65-80 (63.8% vs 27.8%) Respondents who were living alone at the time of the survey and those who were not working also contained a higher proportion of individuals with cognitive impairment (49.8% and 41.2% respectively). A clear descending trend can also be noticed when considering wealth and educational level. Respondents in the wealthiest category with a university degree, having the lowest proportion of individuals with cognitive impairment (27.0% and 13.0%, respectively).

TABLE 1. CHARACTERISTICS OF THE STUDY PARTICIPANTS BY COGNITIVE IMPAIRMENT STATUS.

Independent variable	All, N (%)	Cognitive impairment n (%)	Normal cognition n (%)	p-value
Age				
65 to <80	2,643 (70.69)	733 (27.75)	1,910 (72.25)	<0.001
80+	1,096 (29.31)	699 (63.75)	397 (36.25)	
Gender				
male	1,566 (41.88)	412 (26.33)	1,154 (73.67)	<0.001
female	2,173 (58.12)	952 (43.81)	1,221 (56.19)	
Living arrangements				
living alone	798 (21.34)	397 (49.76)	401 (50.24)	< 0.001
living with others	2,941 (78.66)	952 (32.38)	1,989 (67.62)	
Employment				
yes	884	198 (22.41)	686 (77.59)	< 0.001
no	2,855	1,175 (41.17)	1,680 (58.83)	

Education				
primary school	2,044	1,067 (52.18)	977 (47.82)	
middle school	646	160 (24.81)	486 (75.19)	<0.001
high school	771	161 (20.85)	610 (79.15)	
university	278	36 (13.01)	242 (86.99)	
Income rank				
highest	585	158 (27.01)	427 (72.99)	
high	745	190 (25.45)	555 (74.55)	
medium	748	236 (31.57)	512 (68.43)	<0.001
low	862	374 (43.42)	488 (56.58)	
lowest	799	422 (52.80)	377 (47.20)	
Health status				
very good and good	709	158 (22.34)	551 (77.66)	<0.001
average	1,714	494 (28.83)	1,220 (71.17)	
rather poor and poor	1,316	716 (54.43)	600 (45.57)	
Regular exercise				<0.001
exercising regularly	1,191	267 (22.43)	924 (77.57)	
not exercising regularly	2,548	1,112 (43.66)	1,436 (56.34)	
Life satisfaction				
Low	341	225 (66.01)	116 (33.99)	<0.001
medium	2,656	979 (36.86)	1,677 (63.14)	
high	742	152 (20.45)	590 (79.55)	
Participation in social activities				
yes	2,195	557 (25.39)	1,638 (74.61)	<0.001
no	1,544	793 (51.38)	751 (48.62)	
Region				
Seoul Metropolitan Area	1,766	640 (36.26)	1,126 (63.74)	
Gyeongsang	614	228 (37.18)	386 (62.82)	<0.001
Jeolla	681	262 (38.48)	419 (61.52)	
Chungcheong	531	142 (26.69)	389 (73.31)	
Kangwon	147	75 (51.22)	72 (48.78)	

DETERMINANTS OF COGNITIVE IMPAIRMENT

The results of the regression models (Table 2) showed that age, wealth, level of education, employment status, life satisfaction, self-assessed health status, participation in social activities and regular exercise are all significant factors associated with cognitive performance. More specifically, patients aged 80+ were significantly more likely to experience cognitive impairment (OR=2.43 for the overall sample; OR=2.82 for females; OR=1.99 for males).

Compared to the respondents with the lowest level of education, respondents with a university education were significantly less likely to be diagnosed with CI (OR=0.22). Also, respondents in employment were significantly less likely to suffer from CI compared to those who did not work (OR=0.66). We did not find significant differences between the male and the female samples in terms of these determinates.

TABLE 2. ODDS RATIOS, ADJUSTED ODDS RATIOS AND 95% CONFIDENCE INTERVALS OF COGNITIVE IMPAIRMENT AMONGST THE ELDERLY IN SOUTH KOREA.

Independent variable	All respondents OR (95% CI)	All respondents AOR (95% CI)	Females OR (95% CI)	Females AOR (95% CI)	Males OR (95% CI)	Males AOR (95% CI)
Income quintile						
highest	0.36 (0.29; 0.46)***	1.05 (0.79; 1.40)	0.40 (0.30; 0.53)***	0.92 (0.64; 1.32)	0.41 (0.28; 0.60)***	1.35 (0.84; 2.16)
high	0.31 (0.25; 0.38)***	0.84 (0.64; 1.10)	0.34 (0.26; 0.44)***	0.71 (0.51; 1.00)*	0.37 (0.26; 0.53)***	1.10 (0.71; 1.71)
medium	0.41 (0.33; 0.50)***	0.86 (0.67; 1.11)	0.48 (0.37; 0.62)***	0.97 (0.70; 1.33)	0.41 (0.29; 0.59)***	0.81 (0.53; 1.23)
low	0.63 (0.52; 0.77)***	0.95 (0.75; 1.19)	0.57 (0.45; 0.73)***	0.87 (0.65; 1.15)	0.90 (0.64; 1.26)	1.18 (0.80; 1.73)
pest (ref)						
Gender						
female		1.17 (0.98; 1.40)*				
male (ref)						
Age						
80+		2.43 (2.04; 2.89)***		2.82 (2.24; 3.55)***		1.99 (1.50; 2.62)***
65 to <80 (ref)						
Living arrangements						
living alone		1.09 (0.88; 1.33)		1.10 (0.86; 1.40)		0.79 (0.51; 1.22)
living with others (ref)						
Employment						
yes		0.66 (0.54; 0.81)***		0.67 (0.51; 0.89)***		0.61 (0.46; 0.83)***
no (ref)						
Education						
university		0.22 (0.15; 0.33)***		0.25 (0.11; 0.56)***		0.22 (0.13; 0.35)***
high school		0.37 (0.30; 0.47)***		0.32 (0.23; 0.45)***		0.43 (0.32; 0.58)***
middle school		0.48 (0.39; 0.60)***		0.45 (0.34; 0.61)***		0.56 (0.40; 0.78)***
primary school (ref)						
Health status						
rather bad and bad		1.73 (1.47; 2.05)***		1.82 (1.48; 2.25)***		1.53 (1.16; 2.02)***
average or good (ref)						

Regular exercise						
not exercising regularly		1.81 (1.52; 2.16)***		1.77 (1.41; 2.24)***		1.90 (1.44; 2.50)***
exercising regularly (ref)						
Life satisfaction						
low		2.39 (1.80; 3.16)***		2.31 (1.63; 3.28)***		2.53 (1.56; 4.10)***
medium or high (ref)						
Participation in social activities						
yes		0.54 (0.46; 0.64)***		0.62 (0.51; 0.76)***		0.43 (0.33; 0.55)***
no (ref)						
Region						
Gyeongsang		1.07 (0.86; 1.33)		1.02 (0.77; 1.36)		1.09 (0.77; 1.55)
Jeolla		1.07 (0.87; 1.32)		1.13 (0.86; 1.48)		0.96 (0.68; 1.36)
Chungcheong		0.62 (0.48; 0.80)***		0.60 (0.44; 0.83)***		0.63 (0.42; 0.95)**
Kangwon		1.61 (1.08; 2.40)		1.92 (1.08; 3.41)**		1.35 (0.77; 2.37)
Seoul Metropolitan Area (ref)						
constant	1.27 (1.10; 1.46)***	0.55 (0.40; 0.75)***	1.57 (1.33; 1.86)***	0.61 (0.42; 0.88)***	0.75 (0.58; 0.98)**	0.60 (0.37; 2.37)**
n	3,739	3,739	2,173	2,173	1,566	1,566

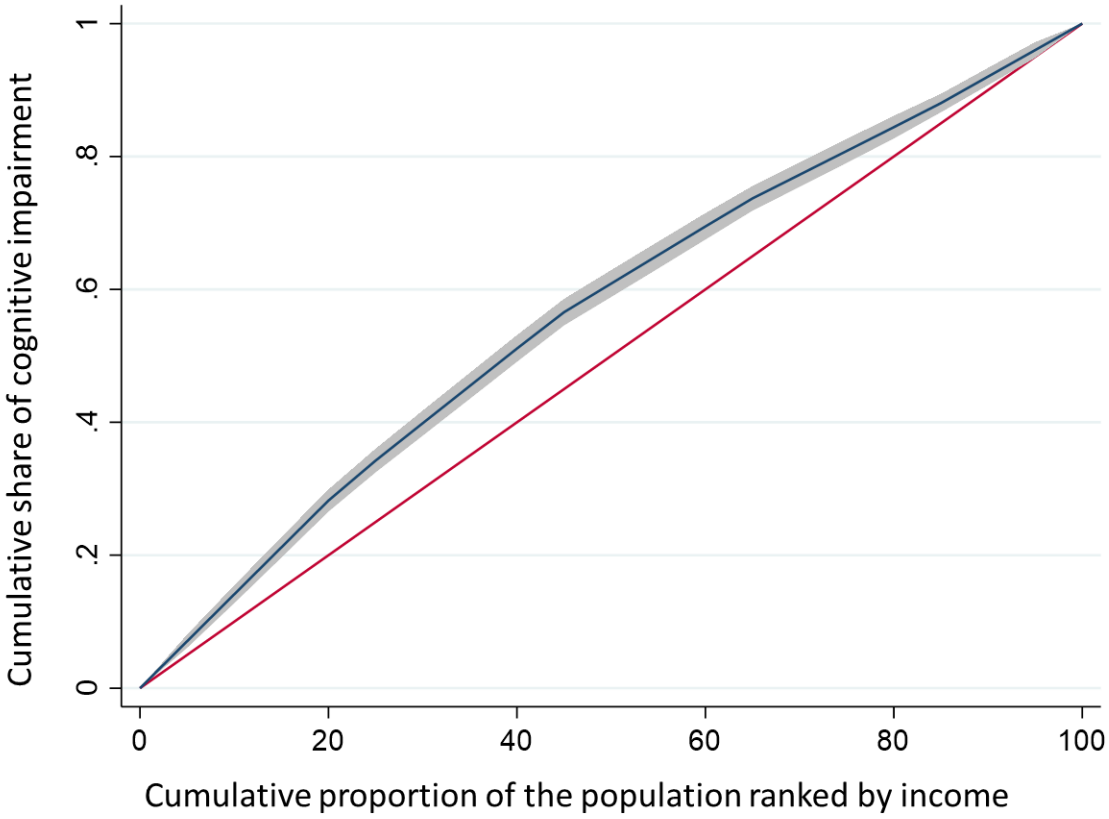
* p < 0.1, ** p < 0.05, *** p < 0.01

SOCIO-ECONOMIC INEQUALITIES

Figure 1 shows the income-based inequalities in the prevalence of cognitive impairment amongst the elderly in South Korea. The difference between the distribution of this variable, between the richest and the poorest population quintiles, was 25.8%. The relative inequality measured by the rich to poor quintile ratio was 2.0 for the overall sample. The negative value of the Wagstaff concentration index (-0.24) indicates that the prevalence of cognitive impairment was disproportionately distributed amongst the poorest strata of the population.

A similar analysis conducted for each wider region in South Korea shows that the greatest inequalities existed in the Chungcheong region (CC=-0.35, QR=3.53), followed by the Seoul Metropolitan Area and the Kangwon region (CC=-0.25, QR=2.1 and CC=-0.34, QR=2.5 respectively). In contrast, the smallest wealth-based inequalities in the prevalence of cognitive impairment were found in the Gyeongsang region (CC=-0.14, QR=1.1). See Fig. S3 and S4 (supplementary material) for more details.

FIGURE 1. CONCENTRATION CURVE MEASURING THE INCOME-BASED INEQUALITIES IN THE PREVALENCE OF COGNITIVE IMPAIRMENT AMONGST THE ELDERLY IN SOUTH KOREA. NOTE: CC= -0.24.



DISCUSSION AND CONCLUSIONS

This study is aimed at examining the factors influencing cognitive impairment amongst the elderly population in South Korea. The results of our analyses show that respondents' age, household wealth, level of education, employment status, participation in social activities, geographical location, and regular exercise are key determinants of cognitive performance for this population. The factors associated with cognitive impairment are similar for males and females, although age has a more substantial effect in the female sub-sample (OR=2.82 vs OR=1.99 for males). In comparison, participation in social activities has a stronger impact in the male sub-sample (OR=0.43 vs OR=0.62 for females).

The results of this study are largely in line with the existing literature on cognitive performance. For example, a study conducted among the rural elderly residents in South Korea's Sokcho area showed that education was positively associated with cognitive impairment [8]. Those with a mean education below six years were significantly more

likely to suffer from cognitive impairment. In line with our results, existing research also found that age and gender are both positively associated with lower cognition (stronger association was found among the female respondents) [8]. However, contrary to our results, living status was found to be a significant predictor of cognitive impairment [8]. Other studies have shown that living does not have a direct effect on cognitive performance but can affect it indirectly through the association with loneliness and social isolation (19, 20). The results of this study are consistent with recent research conducted in Spain, where it was observed that loneliness and social isolation are significantly associated with cognitive performance [21].

In accordance with our results, existing studies on the determinants of cognitive performance also found that educational level is positively associated with cognitive function amongst the elderly. The results are also consistent with the results of a recent study conducted amongst a middle-aged cohort in the USA [22]. This study showed that higher income and a higher level of education were both significantly associated with decreased mean total latency and a reduced number of trials required to reach criterion in the serial digit learning test (SDLT). These factors are strongly associated with varied levels of cognitive performance [22].

The prevalence of cognitive impairment amongst the elderly is higher in the poorest section of Jeolla, followed by Seoul Metropolitan Area, and the Kangwan region. However, the poorest elderly in the rural households have a higher prevalence of cognitive impairment compared to cities and small to medium towns. These results are also consistent with existing research, which found that cognitive impairment of elderly people is very high in the rural areas when compared to those living in cities [8].

While this study advances the knowledge on the determinants of cognitive performance amongst the elderly, it is not without limitations. Firstly, some variables (e.g., life satisfaction), are based on respondents' subjective assessment and could have been affected by their feelings or mood during the survey. Self-reported income and assets may have not fully captured any seasonal variations. Secondly, this study is based on a cross-sectional design and therefore, it could not capture any temporal variations in the prevalence or determinants of cognitive impairment. Future studies might therefore, consider trends or panel data analyses. Thirdly, although some efforts were made by the Panel Survey Organization of the Korea Employment Information Service to minimize bias (e.g., through training survey investigators), they could not exclude recall or response bias that could affect our findings.

As the youth and working-age population in South Korea continues to decrease, the proportion of the elderly is projected to exceed 20 percent of the overall population by 2026. Therefore, it is timely for the South Korean Government to have an even greater policy focus on the health and wellbeing of the elderly by investing further in mental health care [23]. Medical checks, such as routine screening for cognitive impairment in older adults (more than 65 years), and promotion of healthy diet and exercise, have a positive effect [24, 25]. There is also an urgent need to promote and implement anti-ageism policies in the workplace. More specifically, increased efforts are needed to enforce an age-diverse work culture that retains experienced workers over 50 years of age and creates part-time opportunities for those in retirement and low-income, or those wishing to stay in employment.

The comprehensive nature of the data collection and the inclusion of level of education, geographic location, participation in social activities, and regular exercise in this study will add new evidence to the existing literature. It will also provide further information to studies examining cognitive performance for different categories of age and gender.

This study contributes to the growing body of literature with cross-sectional evidence, and the common paths and risk factors that can lead to cognitive impairment. It is anticipated that our results will also be helpful for informing early intervention for prevention strategies with consideration to physical, social, and nutritional requirements to address cognitive impairment problems of the elderly.

CONFLICT OF INTEREST.

The Authors declare that there is no conflict of interest.

ETHICAL STATEMENT

N/a (this study is based on secondary data made available by the Korea Employment Information Service (KEIS).

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SUPPLEMENTARY MATERIAL: SOCIO-ECONOMIC INEQUALITIES IN THE PREVALENCE OF COGNITIVE IMPAIRMENT

FIGURE S1. REGION-WISE NUMBER OF PARTICIPANTS BY COGNITIVE IMPAIRMENT (LEFT) AND NORMAL COGNITION STATUS (RIGHT) IN SOUTH KOREA.

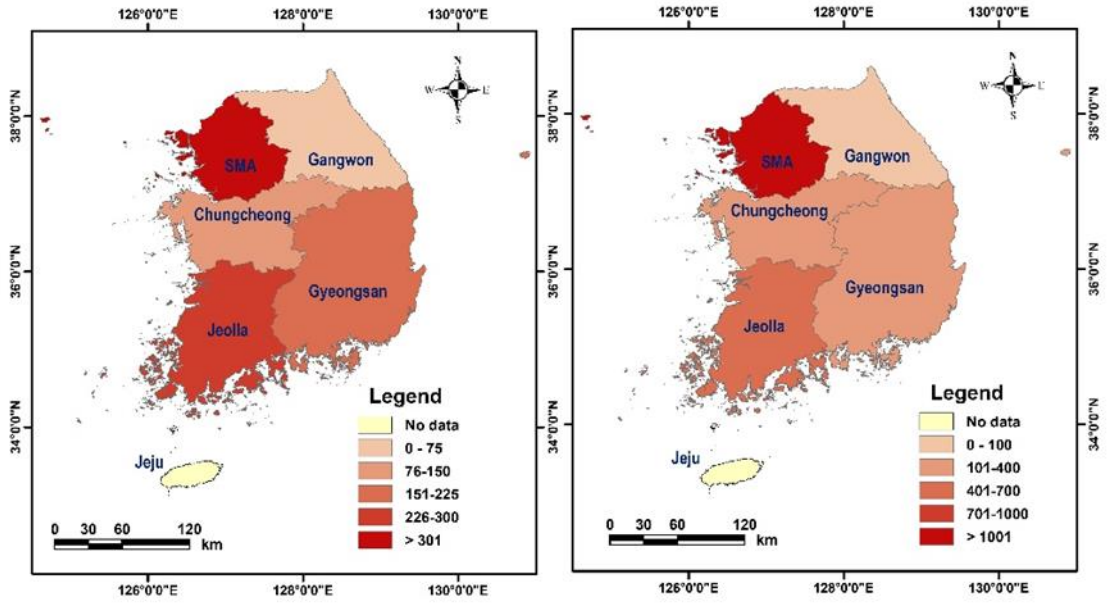


FIGURE S2. MODEL PREDICTED ODD-RATIOS OF THE COGNITIVE IMPAIRMENT OF ALL RESPONDENTS (LEFT), FEMALE (MIDDLE), AND MALE (RIGHT) AMONGST THE ELDERLY IN THE SOUTH KOREAN REGION.

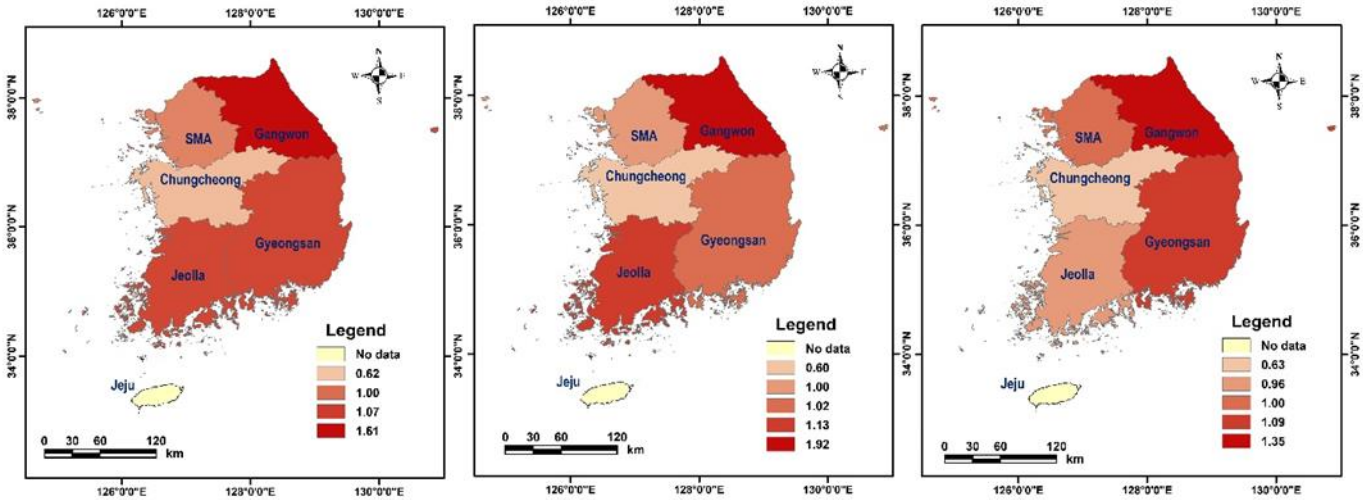
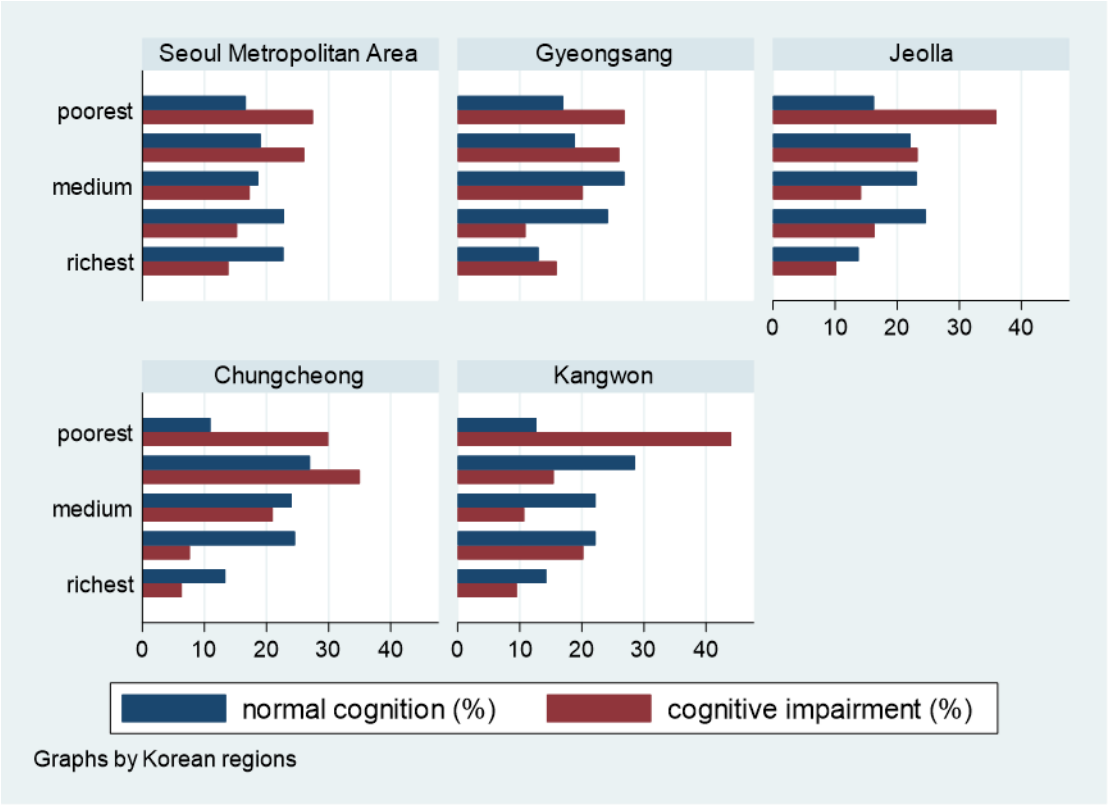


FIGURE S3. SOCIO-ECONOMIC INEQUALITIES IN THE PREVALENCE OF COGNITIVE IMPAIRMENT AMONGST THE ELDERLY IN SOUTH KOREA. NOTE: SEOUL METROPOLITAN AREA (SMA): CC=-0.25, QR=2.1; GYEONGSANG: CC=-0.14, QR=1.1; JEOLLA: CC=-0.23, QR=1.9; CHUNGCHEONG: =-0.35, QR=3.53; KANGWON: CC=-0.34, QR=2.5.



IGURE S4. SOCIO-ECONOMIC INEQUALITIES IN THE PREVALENCE OF COGNITIVE IMPAIRMENT AMONGST THE ELDERLY IN SOUTH KOREA. NOTE: LARGE CITIES: CC=-0.22, QR=1.9 SMALL AND MEDIUM TOWNS: CC=-0.15, QR=1.4; COUNTRYSIDE: CC=-0.35, QR=2.4