DOES SOCIAL INFRASTRUCTURE REDUCE SOCIAL ISOLATION FOR URBANITES? : USING A MULTILEVEL LOGISTIC MODEL (1088)

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Abstract. Social isolation is a global problem due to its negative effects, and various efforts are being made to address isolation. As building social infrastructure is important to prevent isolation, this study aims to understand the impact of urban infrastructure on social isolation using social surveys and statistical data from South Korea. A multilevel logistic model was used to identify the characteristics of infrastructure for solving the problem of social isolation by adding regional-level to individual-level. The analysis showed that at the individual level, gender, age, marital status, and household income were significant, while at the regional level, the ratio of single-person households, access to traditional markets, and capital status area were significant. The findings suggest that social infrastructure can have an impact on the problem of social isolation, so it's important to plan urban spaces in ways that can help alleviate social isolation when planning infrastructure.

Keywords: Social Isolation, Multilevel Logistic Model, Social Infrastructure.

1. Introduction

As the number of people experiencing social isolation around the world increases, so do the efforts of governments around the world to respond. Unlike in the past, social isolation has been recognised as an important issue requiring policy intervention, with the UK appointing a Minister for Loneliness in 2018 and Japan also appointing a Minister for Loneliness in 2021 to initiate efforts to address social isolation. Given the risk of social isolation leading to poor health(Chatters et al., 2018) and loneliness deaths, it is important to identify risks and explore what environments can be created to address their risk.

The Ministry of Government Legislation, Republic of Korea, enacted the Act on the Prevention and Management of Lonely Deaths on 1 April 2021. The Act establishes an institutional basis for systematic prevention and management of lonely deaths at the national level and requires the establishment and implementation of a basic plan for the prevention of lonely deaths every five years. The Act also includes matters related to the

creation of a social environment. These policies are important in that they recognise the influence of the social environment on social isolation, rather than just individual factors, although their practical effects cannot yet be seen at this stage. According to Carstensen et al. (2022), organising spaces for urbanites with different functions and activities can help alleviate social and physical isolation.

Social isolation has been studied as an important research issue in many studies. However, most of the studies have been aimed at identifying individual characteristics associated with social isolation and have focused on specific age, gender, and class groups as the unit of analysis. To overcome the limitation of only considering individual characteristics and not environmental influences on social isolation, some studies have considered the influence of the urban environment on the formation of social relationships. However, there is a limitation that the impact of neighbourhood is not considered in a multi-level structure with individual factors.

In order to overcome the limitations of the existing unit of analysis, this study aims to combine individual-level and regional-level factors affecting social isolation in a multi-layered structure, and to determine whether and to what extent regional factors affect social isolation. This study uses a sample of 89,768 respondents to the 2020 Social Survey of South Korea, considering both individual factors that influence social isolation as in previous studies, as well as regional factors in the 59 municipalities where they live. Zavaleta et al. (2017) described social isolation as a state of being deprived of social connectedness, and according to Mouratidis (2021), social relationships are affected by how urban environments are planned. So social isolation is connected to urban planning.

First, this study examines the conceptual definition of social isolation and the theoretical background related to personal and regional characteristics. Second, based on the data, a multi-level logistic model is used to analyse social isolation by considering personal and regional factors. Third, the results of the analysis are used to identify personal and regional characteristics that influence social isolation. Fourth, the reasons for the significant factors in the analysis will be identified, and the final part will discuss the implications of the analysis and the limitations of the study.

2. Literature Review

2.1. Social Isolation

Social isolation is a concept commonly associated with loneliness and refers to a state in which an individual has minimal contact with others or participates less in community life (Grenade and Boldy, 2008), is deprived of social connectedness (Zavaleta et al., 2017), and lacks personal relationships (Eckhard, 2018). A similar concept to social isolation is social exclusion, which, according to Bäckman and Nilsson (2011) is a situation or

process in which individuals or groups are unable to participate fully in society due to factors such as unemployment, poverty, or poor health. The difference with social isolation is that unlike social exclusion, which is concerned with emotional isolation from family and friends by examining the entire network of social relationships, social exclusion focuses on isolation from social activities, with areas such as financial poverty and labour market exclusion being the most central indicators. Previous research suggests that social networks can influence social isolation. Consequently, the social infrastructure of a city is linked to social isolation by whether or not it allows for the formation of social networks.

Several studies have looked at how social isolation can be measured and what factors are associated with social isolation. Chatters et al. (2018) examined the frequency of contact with family and friends to measure objective social isolation, with the question "How often do you see, write or talk on the phone with family or relatives who do not live with you? Would you say almost every day, at least once a week, a few times a month, at least once a month, a few times a year, hardly ever or never?" being asked of family and friends to measure social isolation. There have been studies that have linked social isolation to loneliness and confirmed social isolation by measuring this loneliness. Gyasi et al. (2021) suggests that social isolation was measured by responding to the questions "Do you feel left out," "Do you feel isolated," and "Do you feel a lack of friendships?" with responses such as sometimes or often. In this way, social isolation can be measured in two ways: objectively ascertaining whether a person is isolated from others, based on measures such as contact, and assessing whether the person perceives themselves as isolated.

There are a number of personal characteristics that influence social isolation. Firstly, age has been shown to be significant, with older people being particularly vulnerable, with their risk of social isolation increasing as their opportunities to add new social relationships decrease (Abbott et al., 2015). However, a recent study found that even younger people reported twice as many lonely and isolated days, even with larger social networks(Child and Lawton, 2019), confirming that social isolation is a problem that can be experienced at any age. Next, gender and income were significant. In general, men were found to be more vulnerable to social isolation due to having fewer social resources and limited interaction with others compared to women, while higher income was associated with a lower likelihood of isolation from family (Chatters et al., 2018)

Among cities, metropolitan areas are more vulnerable to social isolation. Warner and Andrews (2019) found that as urban high-rise development increases and more parents and children live in urban centres, they experience physical and social barriers that prevent them from forming deeper social connections with their neighbours. Warner and Andrews (2019) interviewed residents and found that the high density of high-rise

living makes it difficult to visit acquaintances and maintain existing social relationships due to the increased cost of parking, and that spaces such as outdoor common areas and indoor walkways are not conducive to forming new relationships. Chile et al. (2014) also found that in an interview study of social isolation among inner-city high-rise residents in Auckland, New Zealand, 43% of respondents reported feeling isolated in the city centre. In this respect, large cities with dense high-rise residential areas are more vulnerable to social isolation. Therefore, it is necessary to consider the environment of large cities as a factor in the analysis of social isolation.

2.2. Social Infrastructure

According to Popova (2017), the concept of infrastructure is broadly divided into social infrastructure and economic and production infrastructure, and social infrastructure consists of healthcare, education, culture, tourism, etc. Grum and Kobal Grum (2020) refer to social infrastructure as the things that play an important role in people's daily lives, which are important elements that satisfy the needs of individuals and society, contribute to non-social interactions, and contribute to the overall development of individuals and society. These social infrastructures relate to various services, facilities and public spaces for the community, relationships and networks between community members, and create opportunities for social integration and participation (Vaznoniene and Kiaušiene, 2018). Recently, Smith et al. (2020) suggested that as COVID-19 has required physical distancing, which has led to increased social isolation, remote services, and programmes provide an infrastructure to prevent social isolation.

Social infrastructure that supports social interaction also has an impact on reducing social isolation. Ward Thompson et al. (2016) found that parks, open spaces, and so on provide support for neighbourly contact and maintaining connections between communities, which in turn mitigates social isolation, and found a link between the percentage of green space and reduced levels of stress. In other words, social infrastructure can contribute to the formation of social networks, which can mitigate social isolation and have a positive impact on mental health, such as reduced stress. Johansson-Pajala et al. (2022) stated that information and communication technologies (ICTs) are a good means of preventing and addressing social isolation and loneliness among older people, as they can grow social networks, which need to be properly supported. ICT is studied as a new type of infrastructure that contributes to solving the problem of social isolation in modern society. Jiménez et al. (2021) also found that older adults who receive face-to-face ICT training experience reduced social isolation and loneliness, which increases their overall well-being, so considerations should be included to facilitate the implementation of ICT programmes in community settings.

With the increasing awareness of the importance of social infrastructure, South Korea is also trying to introduce infrastructure with the goal of "improving livelihood". Currently,

infrastructure is well-distributed in South Korea, but there is a shortage of cultural, sports, and leisure facilities, as well as minimising the distance between facilities and residences (Kim et al., 2020). In South Korea, infrastructure includes traditional markets, which have long been at the centre of the living environment, performing various socioeconomic functions and influencing small communities (Park and Koo, 2014; Gyasi et al., 2021). Based on previous studies, it can be concluded that cultural and sports centres, leisure facilities, and traditional markets are important social infrastructure in South Korea.

3. Materials and Methods

3.1. Data and Variables

The social survey used in this study is a survey that identifies the social concerns and subjective perceptions of people related to quality of life and is used as a basis for policy formulation and research. The survey items are selected by each city for various indicators such as health, safety, environment, social integration, family, and labour. However, in the case of the Seoul Metropolitan Government, a similar survey is conducted under the name of the Urban Policy Indicators Survey (Seoul Survey), so it was used in the analysis. The scope of the study is 59 municipalities in four cities, Seoul, Busan, Daegu, and Incheon, which are representative metropolitan areas in South Korea and are at risk of social isolation as suggested by previous studies.

Table 1. Data and Variables

	Variables	Definition	Source
Dependent variable	Social Isolation	Whether you have someone to help you in times of need? 1= No, 0= Yes	Social Survey (2020, MDIS) for each area
Independent variables (Individual-level variables)	Sex	1=Male, 0=Female	
	Age	2=20s, 3=30s, 4=40s, 5=50s, 6=60s and above	
	Education	1=Middle school or less	
		2=High school or less	
		3=University or higher	
	Marital status	1=Non married, 0=Married	

	Economic Activity	1=No, 0=Yes	
	Average monthly household income	1=Less than 1 million won	
		2=Less than 1 million to 2 million won	
		3=Less than 2 million to 3 million won	
		4=Less than 3 million to 4 million won	
		5=Less than 4 million to 5 million won	
		6=More than 5 million won	
Independent variables (Regional-level variables)	The ratio of single-person households	$\frac{Number\ of\ single-person\ households}{Total\ households}$	Census (2020,KOSIS)
	The number of Parks (per 10,000 people)	$\frac{Number\ of\ parks \times 10{,}000}{Total\ population}$	Urban Planning Status (2020, KOSIS)
	The number of Culture and sports Facilities (per 10,000 people)	$\frac{Number\ of\ culspo\ facilities \times 10{,}000}{Total\ population}$	
	The number of Welfare Facilities (per 10,000 people,)	$\frac{Number\ of\ welfare\ facilities \times 10{,}000}{Total\ population}$	
	Access to traditional markets(min)	Travel time to traditional markets (average of car, public transportation, and walking)	Average access time by sales facility type (2020, KOSIS)
	The number of worship places (per 10,000	$\frac{Number\ of\ worship\ places \times 10{,}000}{Total\ population}$	Building Energy Usage (2020, KOSIS)

	people)		
	Capital area status	1=No 0=Yes	
	The ratio of multifamily units	Total multifamily units divided by Total housing units	Housing Census (2020,KOSIS)

The data and variables in Table 1 are organised as follows. This study focused on adults aged 20 and above who responded to a social survey. They were divided into five age groups: 20s, 30s, 40s, 50s, and over 60s; women and men; and three educational levels: middle school or less, high school or less, and university or more. The three educational levels were divided based on including graduated, attended, completed, dropped out, took a leave of absence, graduate school. Economic activity was divided into those who are economically active and those who are not. In the case of the Seoul Metropolitan Government, only the occupation category was available, so we classified "unemployed," "student," and "housewife" as non-economic activity. Housewives' domestic work can be considered labour, but it is not an activity that triggers interaction with others, which is the core of social isolation research, so it was classified as non-economic activity.

The data for regional influences come from the Korean Statistical Information Service. The cultural and sports facilities variable is the sum of the number of cultural and sports facilities, converted to the number of facilities per 10,000 inhabitants for each, and 0 for no facilities. The parks and welfare facilities variable was also created by dividing the number of facilities in each municipality by the population and turning the number of facilities into facilities per 10,000 people. However, in the case of traditional markets, the data that separates the area of each city and district was not available, so the time taken to access traditional markets was used. For the ratio of multifamily units, the number of multifamily houses was divided by the total number of houses, and for the ratio of single-person households, the total number of single-person households was divided by the total number of households. Seoul and Incheon were classified as capital cities, while Busan and Daegu were classified as non-capital cities.

3.2. Multilevel Logistic Model

As a measure of the dependent variable, social isolation, this study uses the response to the question "Is there anyone you can turn to for help in times of need?" from the social survey. In this question, the response is presented as a binary variable between 'yes' and 'no', with 'yes' indicating that the respondent is not socially isolated. The independent variables are divided into individual variables and regional variables. First of all, studies

on individual variables have used variables such as age, gender, residence, marital status, education level, employment status, and monthly income level as covariates that may affect social isolation (Gyasi et al., 2021) and similarly, age, gender, race/ethnicity, family income, education, marital status, and household status have been used as variables for socioeconomic (Merlo et al., 2006). Based on these studies, this research uses age, gender, household income, education, marital status, and economic activity variables that can be obtained from social survey data. For the regional variables, this study used the social infrastructure variables time to reach a traditional market and the number of parks, culture-sports, welfare facilities, and the places of worship per 10,000 people in the municipality. Also, study used the ratio of multifamily units, single-person households and the capital city status.

The model used in the analysis is the Multilevel Logistic Model. The goal of logistic regression is to predict the probability of a phenomenon occurring for an individual based on the value of a certain variable, and the dependent variable is binary. The multilevel logistic model considers the statistical dependence of the individual's probability on the region of residence (Merlo et al., 2006). Multilevel Logistic Model is appropriate because the dependent variable in this study has a binary nature of 1 and 0, and the analysis aims to identify the characteristics of the social infrastructure in the region of residence that affect social isolation in addition to individual characteristics. The equation used in the study is as follows (Merlo et al., 2006).

Equation 1 : $log(p_i) = log\ odds = log\left(\frac{p_i}{1-p_i}\right) = M + E_A$

Equation 2 : $\mathrm{Logit}(p_i) = M + \beta_1 \mathrm{Sex}_i + \beta_2 \mathrm{Age}_i + \beta_3 \mathrm{Education}_i + \beta_4 \mathrm{Marriage}_i + \beta_5 \mathrm{Economic}_i + \beta_6 \mathrm{Income}_i + E_A$

Equation 3 : $\mathrm{Logit}(p_i) = M + \beta_1 \mathrm{Sex}_i + \beta_2 \mathrm{Age}_i + \beta_3 \mathrm{Education}_i + \beta_4 \mathrm{Marriage}_i + \beta_5 \mathrm{Economic}_i + \beta_6 \mathrm{Income}_i + \beta_7 \mathrm{Singleperson}_A + \beta_8 \mathrm{Religion}_A + \beta_9 \mathrm{Park}_A + \beta_{10} \mathrm{CulSpo}_A + \beta_{11} \mathrm{Welfare}_A + \beta_{12} \mathrm{Market}_A + \beta_{13} \mathrm{Apart}_A + \beta_{14} \mathrm{Capital}_A + E_A$

p_i: probability that a phenomenon occurs for the individual i

M : overall mean probability expressed on the logistic scale

E_A: The area level residual

i : individual level - individual

A : regional level - Municipality

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$: regression coefficients for the individual covariates

$\beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}$: regression coefficients for the area level variable

The Stata 16 programme was used for analyses. The analysis sequence was as follows: first, the basic statistical analysis of each variable was performed to identify the characteristics of the variables, and the Variance Inflation Factor (VIF) value was derived to check for multi-collinearity. Next, the intraclass correlation coefficient (ICC) was calculated to determine the explanatory power of the dependent variable at the regional level. After conducting the multilevel logistic model analysis, the ICC value was re-derived to determine the explanatory power of the regional-level variables, and finally, the marginal effects were obtained.

4. Findings

The VIF values for the variables were found to be a maximum of 3.48 for all variables, so there is no multicollinearity problem as values are not greater than 10.

Table 9. Basic Statistics

	Variable	Obs	Mean	Std.Dev.	Min	Max
Dependent variable	Social Isolation	89,768	0.176	0.381	0	1
Independent variables (Individual-level variables)	Sex	89,768	0.488	0.500	0	1
	Age	89,768	4.482	1.352	2	6
	Education	89,768	2.376	0.751	1	3
	Marital status (Marriage)	89,768	0.331	0.471	0	1
	Economic Activity (Economic)	89,768	0.376	0.484	0	1
	Average monthly household income (Income)	89,768	4.026	1.753	1	6
Independent variables (Regional-level variables)	The ratio of single-person households (singleperson)	59	0.327	0.058	0.234	0.497
	Park (per 10,000 people)	59	2.375	2.040	0	13.033
	Culture and sports Facilities (per 10,000 people)	59	0.121	0.147	0	1.195

	(CulSpo)					
	Welfare Facilities (per 10,000 people)	59	0.246	0.158	0	0.817
	Access to traditional markets (Market)	59	9.044	12.248	4.005	120
	Places of worship (per 10,000 people) (Religion)	59	4.145	2.727	1.225	17.994
	Capital area status	59	0.441	0.497	0	1
	The ratio of multifamily units (Apart)	59	0.835	0.124	0.246	0.970

The basic statistical analysis of the research data is shown in Table 2. The total number of respondents was 89,768, and their personal characteristics showed that women are 51.2%, and people aged 60 and over are 32.5%. In education, 54.1 % have a university degree or higher, and married people were 66.9%. The economic activity rate is 62.4% and the average monthly household income of more than 5 million won was 31.3%. In terms of regional characteristics, the ratio of single-person households was about 0.3, and parks were about 2.3 per 10,000 people, while cultural-sports and welfare facilities were 0.12 and 0.24 per 10,000 people, respectively. There were about 4 worship places per 10,000 people. In addition, there are 44.1 % of people living in non-capital areas, and on average, the multifamily ratio is 0.835.

Table 310. Logit analysis results at the individual level

Individual	Variable	Coef.	Std. Err.	z	P>|z|	[95% CI]	
Independent variables	Sex	0.180	0.018	9.77	0.000	0.144	0.216
	Age	0.051	0.009	5.91	0.000	0.034	0.068
	Education	0.061	0.016	3.79	0.000	0.030	0.093
	Marital status (Marriage)	0.244	0.021	11.65	0.000	0.203	0.285
	Economic Activity	-0.020	0.020	-0.96	0.338	-0.059	0.020

	(Economic)						
	Average monthly household income (Income)	-0.092	0.006	-14.56	0.000	-0.104	-0.079
	Pseudo R_2 = 0.0084						

Table 411. Logit analysis results at the municipality level

Regional	Variable	Coef.	Std. Err.	t	P>|t|	[95% CI]	
Independent variables	Sex	-0.134	0.159	-0.85	0.401	-0.452	0.184
	Age	-0.005	0.060	-0.09	0.929	-0.125	0.114
	Education	0.091	0.108	0.85	0.400	-0.125	0.307
	Marital status (Marriage)	0.459	0.177	2.59	0.012	0.103	0.814
	Economic Activity (Economic)	-0.265	0.184	-1.44	0.157	-0.635	0.105
	Average monthly household income (Income)	-0.005	0.047	-0.11	0.913	-0.099	0.088
	R_2 = 0.3311 / Adj R_2 = 0.2540						

In Table 3, The logit analysis of the variables used at the individual level showed a small coefficient of determination of 0.0084, but this problem should be considered in light of previous research. The OLS regression model conducted in the study by Gyasi, R.M. et al. 2021, which considered variables such as age, gender, education level, and income level along with variables such as urban residence, chronic disease, physical activity, and social activity for social isolation, showed different coefficient values depending on gender and age. While the overall coefficient was 0.274, it was lower for men (0.279), women (0.137), the 50-64 age group (0.170), and the over 65 age group (0.185). The coefficient of determination of this study, using only basic variables, is inevitably low because social isolation cannot be fully explained even when multiple individual factors are taken into account. The regression analysis at the regional level in Table 4 also showed that the region has an impact on social isolation. As social isolation is a complex phenomenon that is affected not only by the individual level but also by the regional

level, it is necessary to analyse both factors together, so an analysis was performed using a multilevel logistic model.

Table 512. First-level individual factors and multilevel model analysis

	Variable	Coef.	Robust Std. Err.	z	P>|z|	[95% CI]	
Independent variables	Sex	0.237	0.034	6.96	0	0.171	0.304
	Age	0.051	0.019	2.63	0.009	0.013	0.089
	Education	-0.023	0.044	-0.53	0.598	-0.110	0.064
	Marital status (Marriage)	0.199	0.078	2.56	0.01	0.047	0.352
	Economic Activity (Economic)	0.012	0.041	0.29	0.775	-0.069	0.092
	Average monthly household income (Income)	-0.178	0.018	-9.81	0	-0.213	-0.142
Residual Intraclass Correlation	Level	ICC	Std. Err.			[95% CI]	
	By municipality	0.117	0.024			0.077	0.172

Since the multilevel model is analysed by determining whether the level 2 independent variables affect the dependent variable, it is necessary to check the intraclass correlation coefficient (ICC) value. A value close to 0 means that there is no difference between regions, and in Table 5, ICC = 0.117 for this study. This value means that region explains 11.7% of the variance in social isolation.

Table 613. Multilevel Logistic Model Results

	Variable	Coef.	Std. Err.	z	P>|z|	[95% CI]	
Independent variables (Individual-level variables)	Sex	0.238	0.034	6.98	0.000	0.171	0.305
	Age	0.051	0.019	2.64	0.008	0.013	0.090
	Education	-0.024	0.044	-0.55	0.584	-0.111	0.063
	Marital status (Marriage)	0.199	0.078	2.56	0.011	0.046	0.351
	Economic	0.012	0.041	0.29	0.775	-0.069	0.092

	Activity (Economic)						
	Average monthly household income (Income)	-0.179	0.018	-9.86	0.000	-0.214	-0.143
Independent variables (Regional-level variables)	The ratio of single-person households	3.163	1.403	2.25	0.024	0.414	5.913
	Park (per 10,000 people)	0.043	0.025	1.73	0.084	-0.006	0.091
	Culture and sports Facilities (per 10,000 people) (CulSpo)	-0.371	0.597	-0.62	0.534	-1.542	0.800
	Welfare Facilities (per 10,000 people)	-0.353	0.644	-0.55	0.584	-1.614	0.909
	Access to traditional markets (Market)	-0.022	0.005	-4.44	0.000	-0.032	-0.012
	Places of worship (per 10,000 people) (Religion)	-0.015	0.023	-0.65	0.518	-0.059	0.030
	Capital area status	-0.602	0.116	-5.19	0.000	-0.829	-0.374
	The ratio of multifamily units (Apart)	0.840	0.836	1.01	0.315	-0.798	2.478
	Prob > chi2 = 0.0000						

Residual Intraclass Correlation	Level	ICC	Std. Err.			[95% CI]	
	By municipality	0.059	0.018			0.033	0.104

Table 714. Multilevel Logistic Model Marginal Effects Analysis Results

	Variable	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% CI]	
Independent variables (Individual-level variables)	Sex	0.033	0.005	7.15	0.000	0.024	0.041
	Age	0.007	0.003	2.61	0.009	0.002	0.012
	Education	-0.003	0.006	-0.55	0.582	-0.015	0.009
	Marital status (Marriage)	0.027	0.010	2.6	0.009	0.007	0.048
	Economic Activity (Economic)	0.002	0.006	0.29	0.774	-0.009	0.013
	Average monthly household income (Income)	-0.024	0.003	-9.59	0.000	-0.029	-0.019
Independent variables (Regional-level variables)	The ratio of single-person households (singleperson)	0.433	0.188	2.31	0.021	0.065	0.801
	Park (per 10,000 people)	0.006	0.003	1.73	0.084	-0.001	0.012
	Culture and sports Facilities (per 10,000 people) (CulSpo)	-0.051	0.081	-0.62	0.532	-0.210	0.109
	Welfare Facilities (per 10,000 people)	-0.048	0.088	-0.55	0.582	-0.220	0.124

	Access to traditional markets (Market)	-0.003	0.001	-4.53	0.000	-0.004	-0.002
	Places of worship (per 10,000 people) (Religion)	-0.002	0.003	-0.64	0.52	-0.008	0.004
	Capital area status	-0.082	0.016	-5.09	0.000	-0.114	-0.051
	The ratio of multifamily units (Apart)	0.115	0.114	1.01	0.315	-0.109	0.339

The ICC value found after performing the multilevel logistic model as shown in Table 6 is 0.059, which means that the regional factors used in this study explain about 5.8% of the previous 11.7%, and about 5.9% remains, which means that the regional variables in this study explain about half of the regional level influence of social isolation, so the variables are set appropriately. In addition, the analysis of the marginal effects is necessary for the interpretation of the multilevel logistic model, so the marginal effects in Table 7 are derived, and the results are as follows.

The first level of individual variables shows that gender, age, marital status, and average monthly household income are significant. Men were 3.3% more likely to be socially isolated than women (Coef. = 0.238, P>|z|= 0.000, [95% CI]=[0.171, 0.305], dy/dx= 0.033). Increasing age was associated with a 0.7 % higher odds of being socially isolated (Coef. = 0.051, P>|z|= 0.008, [95% CI]=[0.013, 0.090], dy/dx= 0.007) Being non-married compared to married was associated with a 2.7% greater likelihood of being socially isolated. (Coef. = 0.199, P>|z|= 0.011, [95% CI]=[0.046, 0.351], dy/dx= 0.027) Finally, an increase in income was associated with a 2.4% decrease in the odds of being socially isolated. (Coef. = -0.179, P>|z|= 0.000, [95% CI] = [-0.214, -0.143], dy/dx=-0.024).

At the regional level, the ratio of single-person households, access to traditional markets, and capital city status were significant. In the case of the ratio of single-person households, an increase in the ratio of single-person households was associated with a 43% increase in the risk of social isolation. (Coef. = 3.163, P>|z|= 0.024, [95% CI]=[0.414, 5.913], dy/dx= 0.433) In the case of access to traditional markets, a 0.3 % reduction in the probability of being socially isolated was found for each additional hour of travel time. (Coef. = -0.022, P>|z|= 0.000, [95% CI]=[-0.032, -0.012], dy/dx=-0.003) Finally,

capital status is associated with an 8.2 % decrease in the probability of being socially isolated in a non-capital city compared to a capital city. (Coef. = -0.602, P>|z|= 0.000, [95% CI]=[-0.829, -0.374], dy/dx=-0.082).

5. Discussions

The analysis found that the risk of social isolation increased for older people, men, non-married people, and people with low incomes. Similar to previous studies, this study found that men were more likely to be socially isolated than women and that older people were more likely to be socially isolated. This may be because social isolation in older adults can be prevented by promoting communication and mutual help among neighbours (Kono et al., 2012), and according to Chatters et al. (2018), women are more invested in and connected to social networks, including family and friends, which can prevent social isolation even in old age. In contrast, it has been suggested that older men may be vulnerable to social isolation because they have fewer social resources and limited social interaction with others (Chatters et al., 2018). Health factors such as physical discomfort may contribute to limited social interaction, as well as reduced income and anxiety in retirement. As an older society, there will be more seniors who may be at risk of social isolation, so municipal governments need to expand their welfare workforce and foster related industries to provide a variety of services.

The study also found an increased risk of social isolation for unmarried people compared to married people because, unlike married people, they are unable to form new social networks with their spouse and any children they may have, as well as their spouse's family and friends. However, Sarkisian and Gerstel (2016) have shown that being unmarried has a positive impact on social connectedness, with more frequent contact with parents, siblings, neighbours and friends for support and increased social connectedness than being married. So, it is likely that in a modern society with a growing unmarried population, there are more social connections between unmarried people than in the past when married people were the norm. Therefore, rather than simply being unmarried increasing the risk of social isolation, it is likely that other factors have a greater impact on social isolation. Therefore, it is necessary to identify the status and actual situation of the unmarried population to distinguish between people who are actually at risk of social isolation and people who are not, and to establish social isolation reduction strategies tailored to their situation.

When household income is low, the lack of resources to undertake a range of social activities to build social connections limits choices and participation. As a result of these difficulties, their social network of relationships shrinks, increasing the risk of social isolation. Urban planning should endeavour to provide facilities that are accessible to all, so that people with low incomes can naturally form social networks in the city, even if

they do not participate in separate activities. For example, when installing facilities such as libraries, it is necessary to maximise the community element, and when organising operational programs, it is necessary to support things such as discussion groups and reading clubs that allow various people to mingle and talk together.

At the regional level, the variables of parks, culture and sports facilities, welfare facilities, and worship places, which are generally considered to be social infrastructure and contribute to community building, and the ratio of multifamily units were not significant, while the variables of the ratio of single-person households, access to traditional markets, and capital city status were significant. First, this study found that the risk of social isolation increases with a higher proportion of single-person households. In line with the fact that family and friends are the most important primary groups in any society and are expected to fulfil most of the belonging and social needs (Chatters et al., 2018), this research means that single-person households are relatively isolated from their most important social network of family and friends, increasing the risk of social isolation. To counteract this problem, it is important to create a network of interactive relationships among single-person households. This requires organising the social infrastructure of cities in a way that increases opportunities for natural contact and provides spaces for dialogue at the level of the urban areas in which they live.

Shorter travel times to traditional markets were associated with greater social isolation. The formation of traditional markets involves a long historical process, which makes markets more likely to be located in older, less developed areas. On the other hand, the newly formed areas do not have a traditional market, and large-scale commercial facilities are built, distancing them from the existing traditional market. Older neighbourhoods are more likely to be inhabited by socially vulnerable groups such as the elderly living alone, increasing the risk of social isolation. This issue leads to a higher risk of social isolation when there is good access to traditional markets, as in this study. In this respect, the role of traditional markets as a key part of social infrastructure can be reconfigured to maximise their effectiveness. Rather than creating communities by building new facilities in areas of existing deterioration, the use of existing markets can contribute to reducing social isolation by revitalising existing small communities and promoting social interaction.

In terms of capital cities, the results show that capital cities are more prone to social isolation than non-capital cities. Result can be attributed to overcrowding, increased competition, and a decline in quality of life due to increased commuting distances. Overcrowding, caused by increased migration from non-capital cities to capital cities, has led to increased competition in all aspects of life, including education, employment, and income. Those who fall behind in the competition are pushed to the outskirts of the capital city and face longer commutes, which adversely affects their time, reducing the

amount of time they have to engage in social interactions. This problem is also linked to a decline in quality of life, contributing to the overall problem of social isolation. In order to solve the fundamental problem, it is necessary to realise regional balanced development in non-capital areas, so that the population of the capital city can be dispersed to non-capital areas. When the population is dispersed and competition is reduced, more people can have physical and mental space, and space can help to alleviate social isolation by increasing social interaction.

However, in this study, the proportions of parks, culture and sports facilities, welfare facilities, worship places, and multi-family units were not significant. This result may be due to the fact that previous studies have not yet fully considered the distance between facilities and residences when providing facilities in Korea (Kim et al., 2020), so urban residents may not be able to use these facilities due to their inaccessibility, and therefore facilities may not have a significant impact on reducing social isolation. Accessibility is a challenge that needs to be addressed in urban planning, first of all, in order to enhance accessibility, small-scale facilities should be located near the living areas of urban residents. Because smaller facilities in the immediate neighbourhood allow urbanites to have frequent contact with their neighbours and are less intimidating to visit, as opposed to larger facilities located further away. In addition, programmes to promote digital literacy should be included in the provision of various programmes to enable people to take advantage of the new social infrastructure of digital technology. Jiménez et al. (2021) found that face-to-face training was more effective for older people with low digital literacy as ICTs can alleviate social isolation among urbanites, so programmes should be designed to reflect this fact.

Lastly, despite the fact that we thought that having a large number of multifamily housing units would bring more people together and allow for social interaction, it seemed to be a factor that hindered communication and was not significant in resolving social isolation, as in previous studies. This fact was also found in a study by Kang et al. (2022) who found that apartments, the main type of housing in South Korea, are isolated from the rest of the external environment, which strengthens the internal community but isolates it from the outside world. Kang et al. (2022) also found that when apartment complexes increase in scale, social capital, such as cooperation with neighbours, decreases. As a result of this phenomenon, people living in apartments are isolated from the surrounding community by not using external social infrastructure, and their relationship with their neighbours deteriorates as the size of the complex increases, leading to social isolation. To solve these problems, urban planning policies should ensure the openness of apartments. First of all, it is necessary to open up public pathways to provide a space where apartment residents and outsiders can have natural contact. In addition, when installing community facilities inside the apartment, it is necessary to check that they do not duplicate the surrounding infrastructure. This will

allow apartment residents to engage in active community activities with the outside world, reducing the risk of social isolation.

Due to the nature of the social survey used in this study, the questions differed by city, and Ulsan Metropolitan City, Daejeon Metropolitan City, and Gwangju Metropolitan City were not selected as research subjects due to inadequate questions and lack of data. Also, it is a limitation that more control variables could not be used for the target sample. Social isolation has been linked to physical and mental health conditions (Gyasi et al., 2021), so it is necessary to control for these variables, but this study was not possible because the question was not asked in all target cities. In addition, although the municipal ward level was used as the regional level of analysis, a smaller ward level may be more appropriate for the analysis because people tend to use nearby facilities. However, due to the limitations of data collection, it was not possible to conduct a neighbourhood-level analysis, and it is necessary to explore ways to solve this problem in future research.

6. Conclusions

To examine the impact of social infrastructure on the social isolation of urban residents, this study used a multilevel logistic model with individual characteristics as the first level and the region they live in as the second level. The results showed that being male, older, unmarried, and having a lower income increased the risk of social isolation. In terms of regional characteristics, the impact of social infrastructure was found to be greater in areas with more single-person households and better access to traditional markets. In contrast, the presence of parks, culture and sports facilities, social welfare facilities, and multi-family housing were not significantly associated with social isolation.

Findings have several implications. First, this study examined the effects of both factors simultaneously by considering the individual level and the regional level together in a multi-level structure on the issue of social isolation. Previous studies have mainly looked at social isolation and individual or regional characteristics separately based on multinomial models, but this study is significant in that model reflects the complex interaction of various factors affecting social isolation by considering each individual sample and the region where they live simultaneously. Also, the study suggests ways to improve the social infrastructure that exists in South Korea. Parks, cultural and sports facilities, welfare facilities, and worship places are typical social infrastructure that should promote local community and contribute to reducing social isolation, but facilities were not found to be significant. These findings confirm the inadequacy of the current configuration of facilities and indicate the need to plan and lay out future social infrastructure in a way that increases social interaction with local communities.

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