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Role of Social Infrastructure in Social Isolation within Urban Communities

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Abstract: Social isolation is a global problem with far-reaching consequences. Nevertheless, various solutions can address it. Building social infrastructure is important for preventing isolation. In this study, we aimed to understand the impact of urban infrastructure on social isolation using social surveys and statistical data from South Korea. A multilevel logistic model identified the infrastructure characteristics required to solve social isolation by adding regional-level data to individual-level data. The analysis showed that, at the individual level, gender, age, marital status, and household income were significant, whereas at the regional level, the ratio of single-person households, access to traditional markets, and the capital region status areas were significant. The findings suggest that social infrastructure can impact social isolation. Hence, it is important to plan urban spaces and design infrastructure to help alleviate social isolation.

Keywords: social isolation; multilevel logistic model; social infrastructure; urban community

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1. Introduction

As the number of people experiencing social isolation worldwide rises, so do the efforts of various governments. Unlike in the past, social isolation has been recognized as a crucial issue requiring policy intervention, with the UK and Japan appointing a Minister for Loneliness in 2018 and 2021, respectively. Given that social isolation can lead to poor health [1] and people dying alone (a phenomenon known as lonely deaths), it is important to explore interventions to address the risks deriving from social isolation.

On 1 April 2021, South Korea's Ministry of Government Legislation passed the Act on the Prevention and Management of Lonely Deaths. This legislation establishes an institutional basis for the systematic prevention and management of lonely deaths nationally. A basic preventive plan must be formulated and implemented every five years. The Act includes matters related to creating a social environment, such as a community's social network programs using libraries or community facilities. These policies are important because they recognize the influence of the social environment, rather than just individual factors, on social isolation, although their practical effects have not yet been seen. According to Carstensen et al. [2], organizing spaces with different functions and activities can help alleviate social and physical isolation among urbanites.

Social isolation is recognized as an urban problem, not just an individual problem. Most studies have aimed to identify individual characteristics associated with social isolation, focusing on specific age, gender, and class groups as units of analysis. However, individual behaviors associated with social isolation are influenced by urban environmental factors such as a lack of social networking space. To overcome the limitations of considering only 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. Zavaleta et al. [3] described social isolation as a state of deprivation of social connectedness, and, according to Mouratidis [4], social relationships are affected by the planning of urban environments.

Social isolation has gained increased attention as an important social issue since coronavirus disease 2019 (COVID-19) [5]. Social isolation is an individual phenomenon, but it interacts with environmental factors surrounding the individual. Individuals' social relationships are weakening, especially in urbanized environments. Face-to-face contact and forming social relationships between individuals can depend on the accessibility and type of space in which they engage in their daily activities [6]. Recent studies [7] discuss how certain neighborhoods have better social infrastructure conducive to forming social relationships, which may lead to health disparities between neighborhoods. While this study focuses on South Korea, which has a high rate of aging and suicide, the general relationship between individuals, their surroundings, and social infrastructure may also apply elsewhere.

This study aimed to combine individual- and regional-level factors affecting social isolation in a multilayered structure and determine how regional factors impact social isolation. We used a sample of 89,768 respondents from the 2020 Social Survey of South Korea, considering both individual factors that influence social isolation, as in previous studies, and regional factors in the 59 municipalities where the respondents lived.

This study is structured as follows. First, we examine the conceptual definition of social isolation and the theoretical background underlying personal and regional characteristics. Second, we describe how, based on the data, we used a multilevel logistic model to analyze social isolation, considering personal and regional factors. Third, we present the results of the analysis to identify personal and regional characteristics that influence social isolation. Fourth, we pinpoint the reasons for the significant factors in the analysis; we also derive implications from the findings.

2. Literature Reviews

2.1. Social Isolation

Social isolation is associated with loneliness and refers to a state in which an individual has minimal contact with others or has limited participation in community life [8], is deprived of social connectedness [3], and lacks personal relationships [9]. A concept similar to social isolation is social exclusion, which Bäckman and Nilsson [10] described as a situation or process in which individuals or groups cannot fully participate in society owing to factors such as unemployment, poverty, or poor health. Social exclusion refers to discrimination regarding social activities, such as financial poverty and labor market exclusion. In contrast, social isolation focuses on emotional isolation from family and friends within a social network. The social infrastructure of a city is related to social isolation because social infrastructure has attributes based on the social network.

Several studies have examined how social isolation can be measured and its associated factors. Chatters et al. [1] explored the frequency of contact with one's family and friends to gauge social isolation using the following questions: "How often do you see, write to, 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?" Prior studies have linked social isolation to loneliness and confirmed the former by measuring the latter. Gyasi et al. [11] suggested that social isolation can be measured by responding to questions such as "Do you feel left out?", "Do you feel isolated?", and "Do you feel that you lack friendships?" with responses of sometimes or often. Social isolation can be measured in two ways: (1) objectively by ascertaining whether a person is isolated from others based on measures such as contact and (2) by assessing whether the person perceives himself/herself as isolated.

Several personal characteristics influence social isolation. First, age is significant, with older people being particularly vulnerable, and their risk of social isolation increases as their opportunities to add new social relationships decrease [12]. However, a recent study found that younger people report twice as many lonely and isolated days, even with larger social networks [13], confirming that social isolation is a problem that can be experienced at any age. Gender and income are also significant factors. Generally, men are

more vulnerable to social isolation because they have fewer social resources and limited interactions with others compared to women. At the same time, higher income is associated with a lower likelihood of isolation from one's family [1].

Metropolitan areas are more vulnerable to social isolation. Warner and Andrews [14] found that as urban high-rise development increases and more parents and children live in urban centers, they experience physical and social barriers that prevent them from forming deeper social connections with their neighbors. Warner and Andrews [14] interviewed residents and found that the high density of high-rise living makes it difficult to visit acquaintances and maintain existing social ties owing 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. [15] also found in an interview study of social isolation among inner-city high-rise residents in Auckland, New Zealand, that 43% of respondents reported feeling isolated in the city center. 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 when we analyze social isolation.

2.2. Social Infrastructure

According to Popova [16], the concept of infrastructure is broadly divided into social infrastructure and economic and production infrastructure; social infrastructure consists of healthcare, education, culture, and tourism. Grum and Kobal Grum [17] defined social infrastructure as things that play an important role in people's daily lives; they are important elements that satisfy the needs and overall development of individuals and society alike and contribute to non-social interactions. Social infrastructure relates to various services, facilities, and public spaces for the community, relationships, and networks between community members, and creates opportunities for social integration and participation [6,18]. Smith et al. [19] suggested that because the COVID-19 pandemic required physical distancing, which has led to increased social isolation, remote services and programs should be developed to provide the infrastructure to prevent social isolation. Stender and Nordberg [5] emphasize the role of social networks in public spaces as social infrastructure, which they argue became even more prominent during the COVID-19 pandemic.

Social infrastructure that supports social interactions also reduces social isolation. Ward Thompson et al. [20] found that parks and open spaces offer support for neighborhood contact and the preservation of connections within communities, which in turn mitigates social isolation; Ward Thompson et al. [20] also revealed a link between the percentage of green space and reduced stress levels. Social infrastructure can contribute to forming social networks, mitigating social isolation, and positively impacting mental health by reducing stress. Johansson-Pajala et al. [21] 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 develop social networks that offer proper support. ICTs have been studied as a new type of infrastructure that helps resolve the issue of social isolation in modern society. Jiménez et al. [22] indicated that older adults who received face-to-face ICT training experienced reduced social isolation and loneliness, which increased their overall well-being. Therefore, considerations should be included to facilitate the implementation of ICT programs in community settings.

With the increasing awareness of the importance of social infrastructure, South Korea is trying to introduce infrastructure to improve livelihood. Currently, infrastructure is well distributed in South Korea. Still, there is a shortage of cultural, sports, and leisure facilities and a minimization of the importance of the distance between facilities and residences [23]. In South Korea, infrastructure includes traditional markets, which have long been central to the living environment; they serve various socioeconomic functions and influence small communities [11,24]. Cultural and sports centers, leisure facilities, and traditional markets are vital pieces of social infrastructure in South Korea.

There are two main takeaways from the literature on social isolation and social infrastructure. First, the factors that influence social isolation can be divided into individual biological, behavioral, and socioeconomic factors, which work in combination. Urban environmental factors are important in shaping social relationships among socioeconomic factors. Urban environmental factors can be further categorized into residential and neighborhood factors, and even within the same urban environmental factors, there are differences in the degree of impact depending on the region and the area under study. Second, social infrastructure contributes to resolving social isolation. In traditional urban planning discussions, social infrastructure refers to physical facilities such as roads, railways, and schools. Still, recent discussions have emphasized the networked nature of social infrastructure, which can contribute to interactions between people. The role of infrastructure in influencing individual behavior and networks is based on this discussion. In this study, we investigated variables based on the influencing factors of social isolation discussed in the literature. We integrated two factors with different units of analysis into a single model to examine the relationship between them.

3. Materials and Methods

3.1. Data and Variables

The scope of the study included 59 municipalities in four cities—Seoul, Busan, Daegu, and Incheon—which are representative metropolitan areas in South Korea where people are at risk of social isolation. The social survey of Busan, Daegu, and Incheon used in this study identified social concerns, including social isolation, individual characteristics, and subjective perceptions of people related to quality of life. In the case of Seoul, a similar survey was conducted under the name of the Urban Policy Indicators Survey (Seoul Survey), which was used in the analysis.

The data and variables in Table 1 are organized as follows. We focused on adults aged 20 and older who responded to a social survey. They were divided into five age groups (20s, 30s, 40s, 50s, and over 60), by gender (women and men), and three educational levels (middle school or lower, high school or lower, and university or higher). The three educational levels were divided into graduated, attended, completed, dropped out, took leave of absence, and graduated from school. Economic activity was divided into those who were economically active and those who were not. In the case of Seoul, only the occupation category was available, so we classified unemployed, student, and housewife as non-economic activities. Housewives' domestic work can be considered labor. Still, as it does not trigger interaction with others, which is the core of social isolation research, we classified it as a non-economic activity.

We obtained data on regional influences from the Korean Statistical Information Service (KOSIS) [24–28]. 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 municipality and 0 for no facilities. The parks and welfare facilities variable was 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, data that separated each city and district's areas were unavailable; therefore, 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 regions, whereas Busan and Daegu were classified as non-capital regions.

Table 1. Data and variables.

Type	Variable (Name)	Definition	Source
Dependent	Social isolation	Do you have someone to help you in times of need? 1 = No (social isolation), 0 = Yes	Social Survey [25], Seoul Survey [26]
Independent (Individual Level)	Gender (*Gender*)	1 = Man, 0 = Woman	
	Age (*Age*)	2 = 20s, 3 = 30s, 4 = 40s, 5 = 50s, 6 = 60 and above	
	Education (*Education*)	1 = Middle school or lower, 2 = High school or lower, 3 = University or higher	
	Marital status (*Marriage*)	1 = Non-married, 0 = Married	
	Economic activity (*Economic*)	1 = No, 0 = Yes	
	Average monthly household income (*Income*)	1 = Less than KRW 1 million, 2 = KRW 1 million to less than KRW 2 million, 3 = KRW 2 million to less than KRW 3 million, 4 = KRW 3 million to less than KRW 4 million, 5 = KRW 4 million to less than KRW 5 million, 6 = More than KRW 5 million	
Independent (Regional Level)	Ratio of single-person households (*Singleperson*)	$\frac{Number\ of\ single-person\ households}{Total\ households}$	Population Census [27]
	Number of parks per 10,000 people (*Park*)	$\frac{Number\ of\ parks \times 10{,}000}{Total\ population}$	Urban planning statistics [28]
	Number of culture and sports facilities per 10,000 people (*CulSpo*)	$\frac{Number\ of\ culture\ and\ sports\ facilities \times 10{,}000}{Total\ population}$	Urban planning statistics [28]
	Number of welfare facilities per 10,000 people (*Welfare*)	$\frac{Number\ of\ welfare\ facilities \times 10{,}000}{Total\ population}$	Urban planning statistics [28]
	Access to traditional markets (*Market*)	Travel time (min) to traditional markets (average of car, public transit, and walking)	Transportation accessibility index [29]
	Number of places of worship per 10,000 people (*Religion*)	$\frac{Number\ of\ places\ of\ worship \times 10{,}000}{Total\ population}$	Building energy usage [30]
	Capital region status (*Capital*)	1 = No 0 = Yes (Seoul, Incheon, and Gyeonggi)	
	Ratio of multifamily units (*Apart*)	Total multifamily units divided by total housing units	Housing census [31]

3.2. Multilevel Logistic Model

As a measure of the dependent variable—social isolation—we used the response to the question "Is there anyone you can turn to for help in times of need?" from the social survey. The response was presented as a binary variable—yes or no— with yes indicating that the respondent was not socially isolated. The independent variables were divided into individual and regional.

Previous studies on individual variables have used age, gender, residence, marital status, educational level, employment status, and monthly income level as covariates that may affect social isolation [11]. Similarly, age, gender, race/ethnicity, family income, educational level, marital status, and household status have been used as socioeconomic variables [32]. In addition, social infrastructure based on social networks is discussed as a regional-level variable that can influence social isolation [5,6,33]. Based on previous research, we used age, gender, household income, educational level, marital status, and economic activity as variables that could be obtained from social survey data. For the regional variables, we used the social infrastructure elements of time to reach a traditional market and the number of parks, cultural/sports facilities, welfare facilities, and places of worship per 10,000 people in the municipality. Additionally, we used the ratios of multifamily units, single-person households, and the capital region status.

We employed a multilevel logistic model for the analysis (Figure 1). The goal of logistic regression is to predict the probability of a phenomenon occurring in an individual based on the value of a certain binary dependent variable. A multilevel logistic model considers the statistical dependence of an individual's probability on their region of residence [32]. Such a model is appropriate because the dependent variable in this study had a binary nature of 1 and 0, and we aimed to identify the characteristics of the social infrastructure in the region of residence that affected social isolation in addition to individual characteristics. The equations used in this study are as follows:

$$log(p_i) = logodds = log\left(\frac{p_i}{1-p_i}\right) = M + E_r \tag{1}$$

$$Logit(p_i) = M + \beta_1 Gender_i + \beta_2 Age_i + \beta_3 Education_i + \beta_4 Marriage_i + \beta_5 Economic_i + \beta_6 Income_i + E_r \tag{2}$$

$$\begin{aligned} Logit(p_i) = M + \quad & \beta_1 Gender_i + \beta_2 Age_i + \beta_3 Education_i + \beta_4 Marriage_i \\ & + \beta_5 Economic_i + \beta_6 Income_i + \beta_7 Singleperson_r + \beta_8 Park_r \\ & + \beta_9 CulSpo_r + \beta_{10} Wlfare_r + \beta_{11} Markt_r + \beta_{12} Religion_r \\ & + \beta_{13} Capital_r + \beta_{14} Apart_r + E_r \end{aligned} \tag{3}$$

p_i : probability that a phenomenon occurs for individual i
M : overall mean probability expressed on the logistic scale
E_r : regional level residual
i : individual level
r : regional level (municipality)
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$: regression coefficients (individual level)
$\beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}$: regression coefficients (regional level)

We used Stata 16 (StataCorp., College Station, TX, USA) software for all analyses. The analysis sequence was as follows. First, we performed basic statistical analysis of each variable to identify its characteristics, and we derived the variance inflation factor to check for multicollinearity. We calculated the intraclass correlation coefficient (ICC) to determine the dependent variable's explanatory power at the regional level. After conducting a multilevel logistic model analysis, we re-derived the ICC value to determine the explanatory power of the regional-level variables. Finally, we obtained the marginal effects.

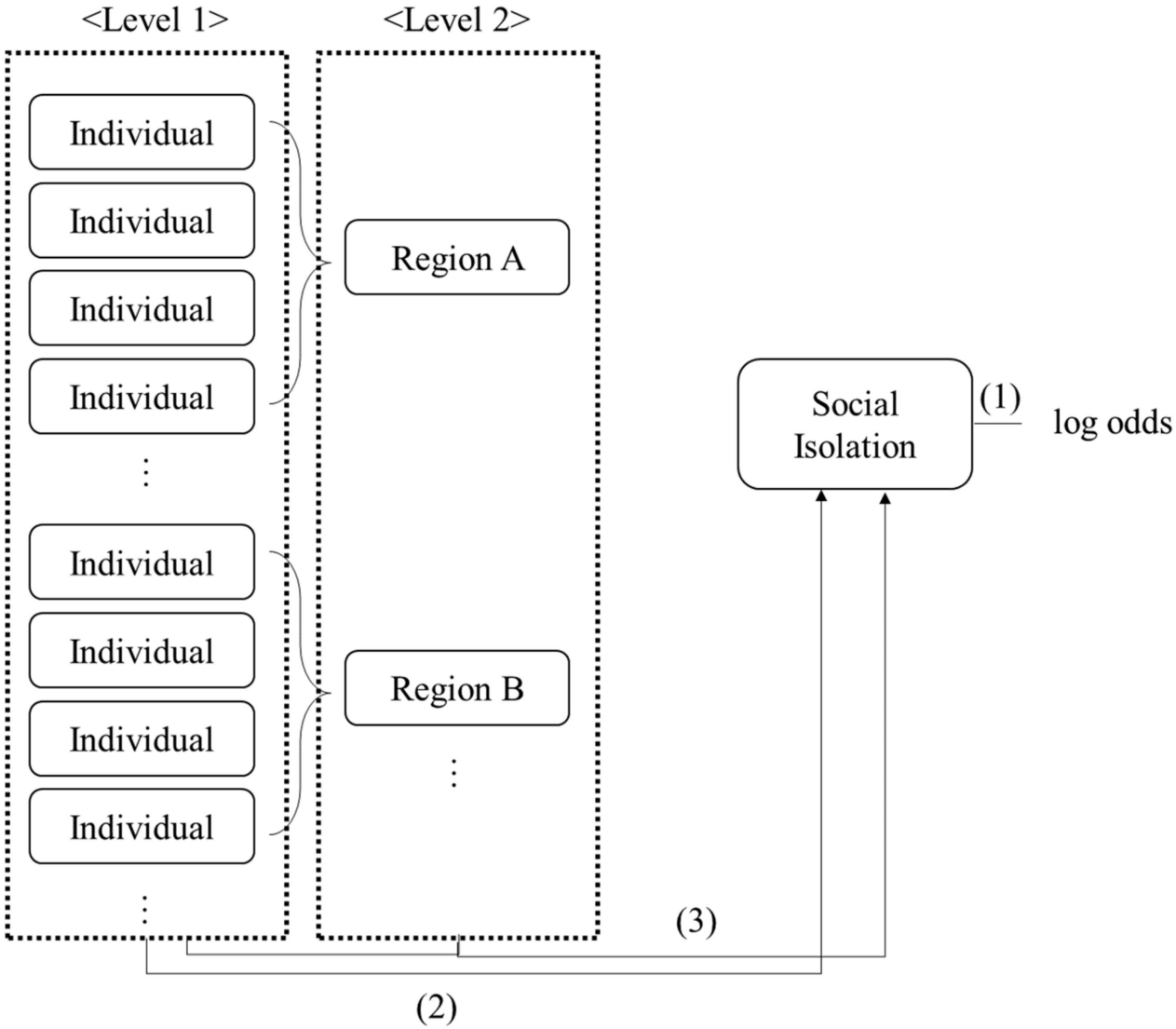

Figure 1. Analytic model flow. Note: Parentheses indicate the number of equation.

4. Results

We found the variance inflation factor values to be a maximum of 3.48 for all variables; as the values were not greater than 10, there was no multicollinearity problem.

Table 2 presents the basic statistical analysis. The total number of respondents was 89,768; women comprised 51.2% of the sample, and people aged 60 and above amounted to 32.5%. Regarding educational level, 54.1% of the respondents had a university degree or higher, and married people composed 66.9% of the sample. The economic activity rate was 62.4%, and the proportion of an average monthly household income of more than KRW 5 million was 31.3%. As for regional characteristics, the ratio of single-person households was about 0.3, and there were 2.3 parks per 10,000 people, while there were 0.12 cultural/sports facilities and 0.24 welfare facilities per 10,000 people, respectively. There were about four places of worship per 10,000 people. In addition, 44.1% of the respondents lived in the non-capital region. On average, the multifamily ratio was 0.835.

As the multilevel model was analyzed by determining whether the Level 2 independent variables (this study's regional variable) affected the dependent variable, it was necessary to check the ICC value using first-level individual factors (Table 3). A value close to 0 indicated no difference between regions. In this study, the ICC value is 0.117. This means that the region explained 11.7% of the variance in social isolation.

Table 2. Basic statistics.

Type	Variables	Obs.	Mean	Std. Dev.	Min	Max
Dependent	Social isolation	89,768	0.176	0.381	0	1
Independent (Individual Level)	*Gender*	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
	Marriage	89,768	0.331	0.471	0	1
	Economic	89,768	0.376	0.484	0	1
	Income	89,768	4.026	1.753	1	6
Independent (Regional Level)	*Singleperson*	59	0.327	0.058	0.234	0.497
	Park	59	2.375	2.040	0	13.033
	CulSpo	59	0.121	0.147	0	1.195
	Welfare	59	0.246	0.158	0	0.817
	Market	59	9.044	12.248	4.005	120
	Religion	59	4.145	2.727	1.225	17.994
	capital	59	0.441	0.497	0	1
	Apart	59	0.835	0.124	0.246	0.970

Table 3. First-level individual factors and multilevel model analysis.

Variables	Coef.	Robust Std. Err.	z	P > |z|	[95% Confidence Interval]	
Gender	0.237	0.034	6.96	0	0.171	0.304
Age	0.051	0.019	2.63	0.009	0.013	0.089
Educational level	−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

Note: residual intraclass correlation (ICC) at the regional level is 0.117 with 0.024 standard error. Pseudo R^2 is 0.3311 in the individual level model.

The ICC value after constructing the multilevel logistic model, as depicted in Table 4, was 0.059, which means that the regional factors explained about 5.8% of the previous 11.7%, and approximately 5.9% remained; this implies that the regional variables explained around half of the regional influence of social isolation, so the variables were set appropriately. Also, it was necessary to examine the marginal effects to interpret the multilevel logistic model; therefore, we derived the marginal effects (Table 5). The results are as follows.

The first level of the individual variables showed that gender, age, marital status, and average monthly household income were significant. Men were 3.3% more likely to be socially isolated than women (Coef. = 0.238, P > |z| = 0.000, [95% confidence interval (CI)] = [0.171, 0.305], dy/dx = 0.033). Increased age was associated with 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).

Table 4. Multilevel logistic model results.

Variables		Coef.	Robust Std. Err.	z	P > |z|	[95% Confidence Interval]	
Individual Level	*Gender*	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
	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
	Income	−0.179	0.018	−9.86	0.000	−0.214	−0.143
Regional Level	*Singleperson*	3.163	1.403	2.25	0.024	0.414	5.913
	Park	0.043	0.025	1.73	0.084	−0.006	0.091
	CulSpo	−0.371	0.597	−0.62	0.534	−1.542	0.800
	Welfare	−0.353	0.644	−0.55	0.584	−1.614	0.909
	Market	−0.022	0.005	−4.44	0.000	−0.032	−0.012
	Religion	−0.015	0.023	−0.65	0.518	−0.059	0.030
	Capital	−0.602	0.116	−5.19	0.000	−0.829	−0.374
	Apart	0.840	0.836	1.01	0.315	−0.798	2.478
Prob > chi^2 = 0.0000							

Note: residual intraclass correlation (ICC) at the regional level is 0.059 with 0.018 standard error.

Table 5. Multilevel logistic model's marginal effects.

Variables		dy/dx	Delta-Method Std. Err.	z	P > |z|	[95% Confidence Interval]	
Individual Level	*Gender*	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
	Marriage	0.027	0.010	2.6	0.009	0.007	0.048
	Economic	0.002	0.006	0.29	0.774	−0.009	0.013
	Income	−0.024	0.003	−9.59	0.000	−0.029	−0.019
Regional Level	*Singleperson*	0.433	0.188	2.31	0.021	0.065	0.801
	Park	0.006	0.003	1.73	0.084	−0.001	0.012
	CulSpo	−0.051	0.081	−0.62	0.532	−0.210	0.109
	Welfare	−0.048	0.088	−0.55	0.582	−0.220	0.124
	Market	−0.003	0.001	−4.53	0.000	−0.004	−0.002
	Religion	−0.002	0.003	−0.64	0.52	−0.008	0.004
	Capital	−0.082	0.016	−5.09	0.000	−0.114	−0.051
	Apart	0.115	0.114	1.01	0.315	−0.109	0.339

At the regional level, the ratios of single-person households, access to traditional markets, and the capital region status were significant. 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, regarding the capital region status, there was an 8.2% decrease in the probability of being socially isolated in the non-capital region compared to the capital region (Coef. = −0.602, P > |z| = 0.000, [95% CI] = [−0.829, −0.374], dy/dx = −0.082).

5. Discussion

The analysis revealed that the risk of social isolation increased for older people, men, unmarried people, and low-income individuals. Like previous studies, we found that men were more likely to be socially isolated than women and that older people were more likely to be socially isolated. However, social isolation in older adults can be prevented by pro-

moting communication and mutual help among neighbors [34]. Chatters et al. [1] found that 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, older men may be more vulnerable to social isolation because they have fewer social resources and limited social interactions [1]. Health factors such as physical discomfort, as well as reduced income and anxiety in retirement, may contribute to limited social interaction. As an older society will have more seniors who may be at risk of social isolation, local governments need to expand their welfare workforce and foster related industries to provide a variety of services.

We also observed an increased risk of social isolation for unmarried individuals because, unlike married people, they are unable to form new social networks through their spouses and children, as well as through their spouses' families and friends. Notwithstanding, Sarkisian and Gerstel [35] indicated that being unmarried has a positive impact, with more frequent contact with parents, siblings, neighbors, and friends for support and increased social connectedness versus being married. Hence, 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 being married was the norm. As such, rather than simply being unmarried increasing the risk of social isolation, other factors are likely to have a greater impact on this phenomenon. Therefore, it is necessary to identify the status and situation of the unmarried population to distinguish between those who are at risk of social isolation and those who are not and to develop strategies to reduce social isolation tailored to their unique circumstances.

When household income is low, a lack of resources to undertake a range of social activities to build social connections limits choices and participation. As a result, one's social network of relationships shrinks, increasing the risk of social isolation. Urban planning should endeavor to provide facilities that are accessible to all so that low-income people can naturally form social networks in the city, even if they do not participate in activities specifically for this purpose. For example, when installing facilities such as libraries, it is necessary to maximize the community element, and when organizing operational programs, it is necessary to support activities such as discussion groups and reading clubs that allow various people to mingle.

At the regional level, parks, culture and sports facilities, welfare facilities, and places of worship (generally considered elements of social infrastructure that contribute to community building), as well as the ratio of multifamily units, were not significant. In contrast, the ratio of single-person households, access to traditional markets, and the status of the capital region were significant. The risk of social isolation increased 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 fulfill people's social needs and sense of belonging [1], single-person households are distant from their most important social networks, thus increasing the risk of social isolation. Therefore, creating a network of interactive ties among single-person households is important. This requires organizing the social infrastructure of cities to increase opportunities for natural contact and provide spaces for dialogue at the urban level.

Short travel times to traditional markets were associated with greater social isolation. The formation of traditional markets has generally involved a long historical process, making them more likely to be in older, less-developed areas. Newly formed areas do not have a traditional market, and large-scale commercial facilities are built, distancing people from existing traditional markets. Older neighborhoods are more likely to be inhabited by socially vulnerable groups, such as older adults living alone, at greater risk of social isolation. This leads to a higher risk of social isolation when there is good access to traditional markets, as demonstrated in this study. In this regard, the role of traditional markets as a key part of the social infrastructure can be reconfigured to maximize their effectiveness. Rather than creating communities by building new facilities in deteriorating areas, using existing markets can help reduce social isolation by revitalizing small communities and promoting social interaction.

In terms of the capital region, the results showed that their residents were more prone to social isolation than residents of the non-capital region. This outcome can be attributed to overcrowding, increased competition, and declining quality of life due to increased commuting distances. Overcrowding caused by increased migration from the non-capital region to the capital region has increased competition in all aspects of life, including education, employment, and income. Those who fall behind are pushed to the outskirts of the capital region and face longer commutes, which reduces the time they must engage in social interaction. This problem is also linked to a decline in quality of life, contributing to the overall issue of social isolation. To solve this fundamental problem, it is necessary to realize balanced regional development in the non-capital regions so that the populations of the capital region can be dispersed to the non-capital regions. When the population is dispersed, and competition is reduced, people have more physical and mental space, which can help alleviate social isolation by increasing social interaction.

Finally, although we thought having many multifamily housing units would bring more people together and allow for social interaction, this was not the case. This was also observed by Kang et al. [36], who indicated that apartments—the main type of housing in South Korea—are isolated from the rest of the external environment, strengthening the internal community but isolating individuals from the outside world. Kang et al. [36] also revealed that social capital (such as cooperation with one's neighbors) decreases when apartment complexes increase in scale. As a result, people living in apartments are isolated from the surrounding community by not using the external social infrastructure, and their relationships with their neighbors deteriorate as the size of the complex increases, leading to social isolation. Urban planning policies should ensure the openness of apartments to solve these problems. First, it is necessary to widen public pathways to provide spaces for apartment residents and outsiders to have natural contact. Second, they must ensure they do not duplicate the surrounding infrastructure when installing community facilities inside apartments. This would allow apartment residents to actively engage in community activities with the outside world, reducing social isolation risk.

Owing to the social survey used in this study, the questions differed by the local government of the metropolitan city; we did not select the metropolitan cities of Ulsan, Daejeon, or Gwangju. Another limitation is that more control variables could not be used for the target sample. As social isolation has been linked to physical and mental health conditions [11], it is necessary to control for these variables; however, we could not do so because the social survey in all target cities did not include this question. In addition, although we used the municipality as the regional level of analysis, a smaller level may have been more appropriate because people tend to use nearby facilities. Nevertheless, owing to the data collection limitations, we could not conduct neighborhood-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, we 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. As for regional characteristics, the impact of social infrastructure was greater in areas with more single-person households and better access to traditional markets. In contrast, the presence of parks, cultural/sports facilities, social welfare facilities, and multifamily housing was not significantly associated with social isolation.

Our findings have several implications for future research. First, previous studies have mostly considered social isolation and individual or regional characteristics separately based on multinomial models; however, this study is significant in that it reflects the complex interactions of diverse factors affecting social isolation by simultaneously considering each sample and the region where the respondents lived. Moreover, this study suggests ways to improve the social infrastructure in South Korea. Parks, cultural/sports facilities,

welfare facilities, and places of worship are typical elements of social infrastructure that should promote cohesive local communities and reduce social isolation; however, we did not find the presence of these facilities significant. These results confirm the inadequacy of the current configuration of facilities and indicate the need to plan and establish future social infrastructure to increase social interaction among local communities.

Finally, we propose urban planning implications for mitigating social isolation in cities. For urban planning to help alleviate the social isolation of citizens in cities, it is necessary to change the focus of social infrastructure provision in cities. This means shifting the focus from quantitative expansion to considering the networked nature of social infrastructure. The networked nature of social infrastructure requires increasing access to facilities and ensuring that the programs and content of the facilities are designed to increase interaction between people. Such a city's social infrastructure can function as a universal facility for all citizens and improve the health of its inhabitants.

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