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Factors Influencing Revitalization of Senior Citizen Centers in Goyang-si, Gyeonggi-do, South Korea*,**

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Abstract

This study explores the relationship between the number of users in senior citizens' centers, the neighboring walking environment, spatial differences in the number of users in senior citizens' centers, and sociodemographic factors in Goyang-si, Gyeonggi-do, South Korea. This study considers the number of users as the level of revitalization to the leisure welfare facilities for elderly persons. This study assumes that the better the walking environment for the elderly, the greater the number of users per senior citizens' center. This study also assumes differences in regional demand and demographics for the use of senior citizens' centers. The walking environment was measured by variables such as the number of CCTV and security lights, slope, area of green fields, urban parks, pedestrian roads, and major roads within 400m of the centers. In addition, this study used Getis–Ord Gi* to recognize the spatial difference in the number of users in senior citizens' centers. Sociodemographic variables such as the gender ratio, percentage of single-person households, and relative education levels of elderly persons were also considered. This study used ordinary least squared (OLS) regression as the statistical model. The results show that CCTV, the slope, the area of major roads, and spatially clustered areas in the number of users are statistically significant factors at $p<0.05$. In the neighboring walkable environment, CCTV, steeper slope, and larger major roads are associated with fewer users of senior citizens' centers. The study also shows that the demand for senior citizens' centers is higher in rural areas than in urban areas, but no demographic factors are statistically significant. This study provides data to help identify suitable locations to revitalize senior citizens' centers.

Keywords Age-friendly City, Senior Citizen Center, Elderly Walking Environment, Difference in Spatial Demand
주제어 고령친화도시, 경로당, 노인 보행환경, 공간적 수요의 차이

Ⅰ. Introduction

1. Background and Purpose of the Study

In South Korea, elderly population aged 65 or above took up 16.5% of the total population as of 2021 and is expected to increase to 20.3% by 2025, thus leading the nation to enter the stage of a super-aged society (Statistics Korea, 2021). Due to continued decreases in both birth rates and mortality rates, aging, together with low birth rates, has come to be considered the most serious social problem. With an increase in the percentage of the aged population in the total population due to aging, attention has been directed at plans to enhance senior citizens' quality of and satisfaction with life (Hong and Kim, 2016). Out of such plans, the importance of the elders' good use of leisure has been

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stressed, and, in order to achieve this, the need to secure spaces for hobbies and leisure activities has emerged. At present, from among senior citizen welfare facility operation projects implemented by the state and local governments, senior citizen centers play the roles of such leisure welfare facilities (Jeon et al., 2014).

Because short-distance activities increase in old age due to health and physical constraints, it is important to create a physical environment where exchange with neighbors and community activities in the local community are possible (Kim and Koo, 2016). In order to prepare a basis that will provide senior citizens with opportunities for social participation and enable them to enjoy active lifestyles, an age-friendly walking environment must be taken into consideration without fail (Oh et al., 2021). In addition, siting that meets senior citizens' demands must be performed in consideration of the local characteristics (Cho et al., 2010). In fact, one *Fact-finding Survey on the Status of Senior Citizens* (FSSSC; 2017) has confirmed great differences between urban and non-urban areas in the rates of using senior citizen centers. However, it is unclear as to how a walking environment taking the physical characteristics of the aged into consideration and differences in spatial demands affect the revitalization of senior citizen centers so that this study will analyze this problem through the case of Goyang-si (Goyang Special Case City) in Gyeonggi-do (Gyeonggi Province).

With the emergence of the problem of aging as a global demographic change, the World Health Organization (WHO) announced in 2007 the Global Age-friendly Cities Guide. A measure against the increase in aged population, they sought to create cities that, by providing diverse policies and services, would enable the aged to take part actively in the local community without inconvenience due to environmental changes. Accordingly, Gyeonggi-do legislated a related ordinance for active old age and joined the WHO's Global Network of Age-Friendly Cities & Communities (GNAFCC) in 2018, thus pursuing an age-friendly city so that not only the aged but also people in all age groups may live comfortably.

Out of municipalities in Gyeonggi-do, as for Goyang-si, the number of senior citizens aged 65 or above amounted to 160,146 as of the end of August 2022, thus taking up 14.9% of the total population. The aging rate is expected to reach 20.6% by 2028, and the number of senior citizens is expected to reach 300,000 (305,687; 26.7%) by 2035, respectively, so that the city is faced with its entry into the stage of a super-aged society. In addition, though the number of senior citizen centers per 1,000 senior citizens in Gyeonggi-do was 4.81 (Gyeonggi Data Dream, 2022; and Gyeonggi Provincial Government, 2022), the number of senior citizen centers per 1,000 senior citizens in Goyang-si was merely 3.65 (Gyeonggi Data Dream, 2022; and Gyeonggi Provincial Government, 2022). Consequently, the city urgently needs to prepare for both an aged society and a super-aged society and must expand support for the creation of an environment for the aged (Moon et al., 2020).

Consequently, this study will select Goyang-si as the object of a case study and explore plans to revitalize the use of senior citizen centers in terms of walking accessibility and the characteristics of both spatial demands for and users of senior citizen centers. In order to achieve this, this study will perform multiple regression analysis of the number of registered members of senior citizen centers, walking environments surrounding senior citizen centers, spatial differences in the number of users of senior citizen centers, and sociodemographic statistical values, all of which are senior citizen center revitalization indices.

II. Literature Review

1. Senior Citizen Centers as Senior Citizens' Leisure Welfare Facilities

With a continued increase in senior citizens' needs for leisure and social activities in a super-aged society, the preference for senior citizen welfare facilities has become stronger. South Korea's baby boom generation (born in 1955-1963) is equipped with high educational levels and a wealth of social experiences. Consequently, discussion is urgently needed on the roles of senior citizen leisure welfare facilities meeting current senior citizens' needs, which have become complex in contrast to those of senior citizens in the past (Lee and Yoon, 2018). According to Article 31 of the Welfare of Senior Citizens Act, senior citizen welfare facilities are divided into senior citizen residential welfare facilities, senior citizen medical welfare facilities, senior citizen leisure welfare facilities, and senior citizen protection agencies, and senior citizen leisure welfare facilities include the facilities of senior citizen

welfare centers, senior citizen centers, and senior citizen education courses. As of 2021, out of 68,823 senior citizen leisure welfare facilities nationwide, senior citizen centers amounted to 67,211, thus taking up the bulk of senior citizen leisure welfare facilities. When the Ministry of Health and Welfare's 2020 *Fact-finding Survey on the Status of Senior Citizens* (Ministry of Health and Welfare, 2020) is examined, 28.1% of the total senior citizens used senior citizen centers, which shows that senior citizen centers are representative senior citizen leisure welfare facilities used by senior citizens. In addition, through multiple regression analysis of factors affecting the quality of life of senior citizens aged 65 or above who used senior citizen centers in 25 gu (districts) in Seoul, Kang and Lee (2018) elucidated that satisfaction with life increased as satisfaction in the use of senior citizen centers increased. Interest in facilities for the good use of leisure in old age has thus increased with South Korea's entry into a super-aged society, and, as such spaces for the good use of leisure, senior citizen centers have the positive effects of providing senior citizens with opportunities for leisure activities and promoting social relationships within this population group so that their importance has increased day by day (Lee, 2019).

While senior citizen centers are highly important, as has been mentioned above, most earlier research was conducted with a focus on senior citizen welfare centers out of senior citizen leisure facilities, which are far lower in the frequency of facility siting than are senior citizen centers. Based on data from the Korean Social Life, Health and Aging Project (KSHAP), Park and Park (2021) analyzed factors affecting the use of senior citizen welfare centers by senior citizens aged 65 or above living in *K* gu of 25 administrative gu (25 districts) in Seoul in 2018, confirming that the use of such welfare centers was affected by gender, age, educational level, and income level. Lee and Yoon (2018) conducted a survey and logistic regression analysis of senior citizens living in five *eup* (towns), *myeon* (townships), and *dong* (neighborhoods) near senior citizen welfare centers in *N* si (city) in Gyeonggi-do, discovering that variables including gender, educational level, current housing (home ownership, *jeonse* (returnable key money-based rental), monthly rental, etc.), and income were influencing factors of the use of these facilities. In addition, Park and Choi (2017) conducted a study in order to present architectural planning guidelines reflecting both users' needs and geographical characteristics so as to revitalize senior citizen welfare centers in Chungcheongbuk-do (North Chungcheong Province), categorizing current status investigations and spatial compositions of senior citizen welfare centers.

In addition, as for senior citizen centers, research was conducted limited to satisfaction in using these facilities according to users' characteristics rather than the surrounding physical environments or to sociodemographic factors. Ko and Lee (2017) conducted a survey of senior citizens using senior citizen centers in *K* gu of 25 administrative gu (25 districts) in Seoul and, through the methods of t-test, correlation analysis, and multiple regression analysis, discovered that the quality of senior citizen centers' services, users' ages, and users' monthly incomes significantly affected satisfaction in using senior citizen centers in this order.

2. Senior Citizens' Walking Environment in Terms of Access to Facilities

The walking environment for senior citizens is very important for movement to destinations. The means of transportation most often used by senior citizens who are mobile in daily life are in the order of foot (74.0%), subway (17.0%), and bicycle (7.0%) (Noh and Yang, 2011). Most activities in old age thus rely much on foot, and a comfortable, safe, and pleasant environment is very important for senior citizens. A study by Park et al. (2017) positivistically analyzed senior citizens' walking behavior and elucidated that senior citizens' walking activities occurred mostly within neighborhoods and that streets with high walking frequency in age-friendly neighborhood environments were places where facilities and walking safety conducive to senior citizens' social activities had been secured. Consequently, because neighborhood living areas equipped with service facilities within walking distances play key roles in enhancing senior citizens' living standards and letting them break out of a state of social isolation, it is necessary to grasp both the types of major facilities needed by senior citizens and walking distances from neighborhood living facilities (Choi and Park, 2017).

Most existing research on senior citizens' walking environments consists of subjective surveys. Through multiple linear regression analysis based on surveys of senior citizens

in Seongnam-si (Seongnam City) aged 60 or above, Lee (2011) confirmed that physical environmental factors affecting walking satisfaction included the continuity of sidewalks, presence/absence of street lights, speed reduction facilities, and benches. A study by Oh et al. (2021) conducted a survey of senior citizens aged 65 or above in Busan-si (Busan Metropolitan City) on age-friendly walking environments in reference to the WHO's Checklist of Essential Features of Age-Friendly Cities. According to the results of analysis, satisfaction was high with pedestrian roads, pedestrian crosswalks, street shelters, and public toilets. Through a survey of senior citizens in areas in Daegu-si (Daegu Metropolitan City) with high concentrations of aged population on senior citizens' awareness of walking environments, Park and Lee (2022) confirmed high awareness of the state of pavement, continuity, and slope out of physical walking environments were high. Based on the 2017 Survey on Residential Conditions, Kwon and Choi (2021) elucidated that, for senior citizens and people with disabilities nationwide, who are mobility-disadvantaged, age, gender, urban parks and green fields, and public transportation accessibility were factors affecting walking satisfaction. Establishing as the independent variables sociodemographic factors collected through a survey and variables including walking environments, neighborhood facility accessibility, and use of senior citizen centers, Kim (2019) conducted research to verify the mediating effects of satisfaction with senior citizen centers on senior citizens' residential satisfaction. According to the results of the study, out of independent variables significantly affecting satisfaction with senior citizen centers, derived were the sociodemographic factors of gender, age, and family form and the walking environments and neighborhood facilities of sidewalk widths, safety evacuation facilities, traffic volume, pedestrian crosswalks, benches, parks, hospitals, and banks.

3. Spatial Biases in Demands for Senior Citizen Centers

Article 55(2) of the Regulations on Housing Construction Standards, etc., stipulates that, when residents' communal facilities are installed in a housing complex of 100 or more households, they must include senior citizen centers and children's playgrounds in the case of a housing complex of 150 or more households. From this, it is apparent that the installation of senior citizen centers focuses on population density rather than demands. If the supply of public facilities to cities centered on population density in the past, nowadays, a consideration of residents' actual activities is becoming important (Kim, 2021). Because an unequal distribution of public facilities among areas is linked to differences in the quality of life of service users, solutions must be prepared (Seoung, 2019). Consequently, in order to stop quantitative supply and to be able to supply public facilities appropriately to areas needing them, investigations of local demands and local characteristics are prerequisites (Jo and Nam, 2019).

Most existing studies on demands for senior citizen welfare facilities assume that these facilities must be sited in areas with high concentrations of senior citizens on the basis of the housing construction standards mentioned above. Establishing aging rates and proportions of super-aged senior citizens as senior citizen welfare demand variables and limiting the senior citizens welfare supply variable to the number of such facilities, Choi and Cho (2020) used the Coulter coefficient of inequality, location quotient (LQ), and Relative Concentration Index to analyze regional equity in the supply of senior citizen welfare facilities. A study by Jeon et al. (2019) derived areas concentrated with populations aged 65 or above in Cheongju-si (Cheongju City) on the level of aggregated *gu* and, through network analysis per city-based facility including senior citizen welfare facilities and convenience facilities, examined equity in services. In addition, in order to analyze the balanced arrangement of senior citizen centers in Buk-gu in Gwangju-si (Gwangju Metropolitan City) that took into consideration the scope of senior citizens' movements, Song et al. (2017) established a radius of 150 m as senior citizens' pedestrian space in areas concentrated with senior citizen centers in Buk-gu and elucidated that overlapping senior citizen centers must be relocated or combined. In order to explore spatial disagreement between the spatial distribution of facilities demanded by senior citizens in Seoul and senior citizens' actual residential distribution, Cho and Lee (2017) examined such spatial disagreement through both the spatial distribution of the six types of facilities of hospitals, traditional Korean medicine (TKM) hospitals, parks, senior citizen centers, senior citizen welfare centers, and traditional markets and the distribution of senior citizens' residential areas by using Moran's I technique.

4. Study Novelty

The uniqueness of this study is as follows. First, factors affecting the revitalization of the use of senior citizen centers will be analyzed by adding physical and spatial characteristics to sociodemographic characteristics. Sociodemographic characteristics such as users' genders and ages are major factors affecting the use of such facilities and were analyzed in earlier research as well, but the effects of physical environments surrounding the facilities failed to be sufficiently taken into consideration. This study will simultaneously examine the effects of both physical environments around senior citizen centers and differences in spatial needs, which were not examined in existing research.

Second, physical walking environments near senior citizen centers that make it possible to enhance senior citizens' access to these facilities will be measured to find out their effects. Existing studies (Lee, 2011; Oh et al., 2021; Park and Lee, 2022; Kwon and Choi, 2021; and Kim, 2019) showed that pedestrians' sociodemographic characteristics and physical environments subjectively perceived by pedestrians were important factors of walking activities. However, existing research based on surveys rely on pedestrians' perception. Evaluations through surveys can differ in satisfaction according to pedestrians' tendencies even in the same walking environment. In contrast, this study will explore differences in the number of senior citizen centers according to differences in physical walking environments objectified on the basis of digitized data.

Third, establishing the number of registered members of senior citizen centers as a measure of actual demands, this study will analyze spatial differences in demands for senior citizen centers and present a plan for revitalizing senior citizen centers. Research on senior citizen welfare facilities, which currently are installed according to the criterion of population density, mostly relies on the number of facilities installed, which is limited in failing to reflect actual demands. Indeed, though senior citizen centers so far have been supplied more in urban areas according to the criterion of population density, according to the Ministry of Health and Welfare's 2017 *Fact-finding Survey on the Status of Senior Citizens*, the rate of using senior citizen centers was higher in non-urban areas than in urban areas (Ministry of Health and Welfare, 2017). Consequently, finding out regional and spatial differences in demands for the use of senior citizen centers is important for the appropriate siting and revitalization of these facilities.

III. Materials and Methods

1. Study Area

As in <Figure 1>, the temporal and spatial scopes of this study were senior citizen centers in Goyang-si in 2018. Data on the zone boundaries of administrative *dong* and senior citizen centers in the city were acquired from both the Open Market on the Korea National Spatial Data Infrastructure Portal and the Gyeonggi Data Dream. In the case of senior citizen centers, data on addresses were converted into spatial data through Geocoding in/of ArcGIS Pro, as shown in <Figure 1>. While there were 560 senior citizen centers in Goyang-si as of 2018, 555 were constructed for this study, with the exclusion of five facilities with missing data. Senior citizen centers in the city were concentrated near Ilsan New Town and the Hwajeong housing site development district, both areas with relatively high population density.

2. Study Methods

1) Study Variables

Presuming that the revitalization of senior citizen centers is affected by walking environments around such facilities, demands for senior citizen centers, and sociodemographic differences, this study views the number of annually registered members of senior citizen centers, which is a dependent variable, as the level of the revitalization of these facili-

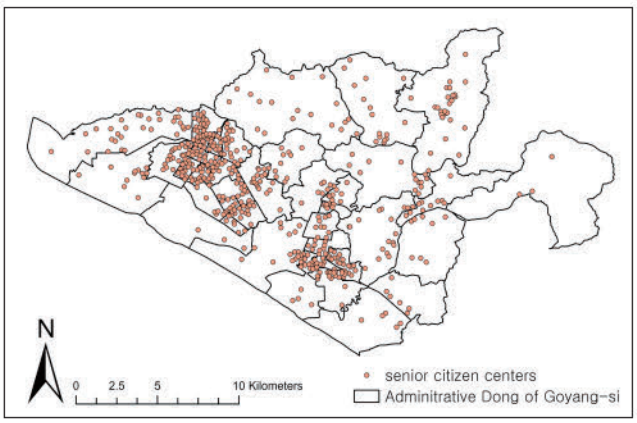

Figure 1. The study area in Goyang-si, South Korea and spatial distribution of senior citizen centers

ties. In other words, this means that the larger the number of annually registered members of a senior citizen center is, the higher is the level of the revitalization of this facility. On the basis of data on the locations of senior citizen centers constructed earlier, this study will examine the use of these facilities as well as walking environments around each senior citizen center, demands, and current sociodemographic conditions. <Table 1> summarizes a list of variables included in this study and the sources of data. Because data on the number of annually registered members of senior citizen centers in this study are from 2018, in order to unify the time frames, data from a time frame close to 2018, the standard, were constructed. However, because the time frames for data updates differed according to the organization providing the data, data from other years were inevitably used.

In order to construct surrounding walking environment variables, it is necessary first to define the scope of senior citizens' pedestrian spaces. Kim and Ahn (2012) investigated the threshold distance to major facilities used by senior citizens, which was approximately 350-450 m according to the results. In the case of senior citizen centers, the scope of use for senior citizens was derived as 398 m. As for the aged with three or more physical constraints, the threshold distance was formed around 400 m, thus being shorter than the general pedestrian space of 500 m. In order to achieve this, this study will define senior citizens' pedestrian space as 400 m on the basis of Kim and Ahn's (2012) research.

Next, as for independent variables, safety from crimes, topographic conditions, and street environment will be selected as factors linked to the walking environment on the basis of earlier research and as shown in <Table 1>. Variables linked to safety from crimes will be divided into the number of closed-circuit televisions (CCTVs) and the number of security lights in a pedestrian space. This study will presume that when many CCTVs and security lights are installed around senior citizen centers, the degree of safety from daytime/nighttime crimes in that pedestrian space rises, through which the walking accessibility of senior citizens in surrounding areas to senior citizen centers is enhanced so that the rate of using these facilities will increase. Goyang-si's 2018 data on CCTVs classify CCTVs per the purpose of installation, into everyday crime prevention, traffic crime

Table 1. Variable description

Variable			Description	Data source
Dependent variable		The number of registered members	current status of senior citizen centers in 2018 (No.)	Gyeonggi Data Dream (2018)
Walking environment	Safety	CCTV	the number of CCTV in 2018 (No.)	Gyeonggi Data Dream (2018)
		Security light	the number of security lights in 2019 (No.)	Gyeonggi Data Dream (2019)
	Topography	Slope	mean slope (degree)	Spatial Information Portal (2015)
	Street	Green area	green area (km^2)	EGIS (2021)
		Urban park	urban park area in 2018 (km^2)	Public Data Portal (2018)
		Pedestrian road	pedestrian road area in 2022 (km^2)	Spatial Information Portal (2022)
		Major road	major road area in 2022 (km^2)	Spatial Information Portal (2022)
Spatial Cluster of registration (Getis-Ord's Gi*)		Hotspot	Yes=1, No=0 (95% significance level)	
		Coldspot	Yes=1, No=0 (95% significance level)	
Sociodemographics		Elderly population	percentage of over 60s to the total population in 2019	KOSIS (2019)
		Gender ratio	the gender ratio over 60s in 2019	KOSIS (2019)
		Single-person household	percentage of single-person households over 60s in 2019	KOSIS (2019)
		The level of education	percentage of education levels over 60s in 2020 (elementary / middle / high / over university / none)	KOSIS (2020)

prevention, and vehicle control. Because CCTVs installed in residential areas, around schools, and at entries to roads for everyday crime prevention will be linked more directly to pedestrians' safety in walking environments than will be those for traffic crime prevention and vehicle control, this study considered the number of CCTVs for everyday crime prevention. In addition, this study considered security lights rather than street lights because whereas the latter are lighting installed by roads for vehicles, the former are lighting installed by sidewalks for pedestrians. As for topographic conditions, by using the digital elevation model (DEM) in the Open Market on the Korea National Spatial Data Infrastructure Portal, taken into consideration on ArcGIS Pro is the mean slope processed as a grid with the size of 50 m x 50 m. Because slopes can be hindrances due to physical constraints special to senior citizens, the mean slope is included in topographic factors. As for the street environment, data on green fields, urban parks, pedestrian roads, and major roads provided by the Environmental Geographic Information Service (EGIS), Gyeonggi Data Dream, and Open Market on the Korea National Spatial Data Infrastructure Portal are used to calculate the area of each facility in a pedestrian space. High percentages of green fields in surrounding parks enhance pedestrians' quality of life and increase cities' pleasantness, thus making it possible to create a pedestrian-friendly environment (Kim and Kim, 2011). In addition, in terms of walking, increases in the areas of pedestrian roads will create pedestrian-friendly environment, and, in contrast, increases in the areas of major roads will cause rupture in walking, thus negatively affecting walking.

This study will take into consideration sociodemographic variables in addition to walking environments around senior citizen centers, which are physical environments. An earlier study mentioned above (Ko and Lee, 2017) showed that aged people's satisfaction with the walking environment changed according to sociodemographic characteristics. Consequently, in reference to items in earlier research, the percentage of senior citizens aged 60 or above in the total population, senior citizens' gender ratio, percentage of single-person households, and percentage of educational level will be selected as the sociodemographic variables of administrative *dong* in which senior citizen centers are sited. Though users of senior citizen centers are aged 65 or above, this study will use statistical values for people aged 60 or above per administrative *dong* provided by Statistics Korea. As for the gender ratio, the percentage of males will be used. In the case of educational levels, with university or higher as the standard, percentages of other educational levels will be used.

2) Descriptive Statistics

As shown in <Table 2>, as for the number of registered members of senior citizen centers, which was a dependent variable, the following values were derived: 10 (minimum), 137 (maximum), and approximately 35 (mean). Out of the physical walking environment, which was an independent variable, within a radius of 400 m from all senior citizen centers in Goyang-si, the number of CCTVs for everyday crime prevention, which are a measure of safety, was 0 at a minimum and 98 at a maximum, and the number of security lights was 0 at a minimum and 191 at a maximum, respectively. The standard deviation was 23.35 for the former and 40.02 for the latter, respectively, exhibiting a deviation in the numbers of these devices installed in pedestrian space per senior citizen center. Next, in terms of slope, which is a topographic factor out of the physical walking environment, according to research analyzing slope for an age-friendly walking environment, for the aged to walk safely and comfortably, a slope must measure less than 7° (Roh and Park, 2018). As for senior citizen centers in Goyang-si, the steepest place had a slope of approximately 14°, but the mean slope was approximately 2°; thus, the city generally is level topographically. Consequently, Goyang-si can be seen as an age-friendly walking environment in terms of slopes. In addition, out of street environment factors, the area of naturally green fields was 0.047 km^2 (mean) and 0.396 km^2 (maximum), and the area of urban parks was 0.026 km^2 (mean) and 0.238 km^2 (maximum), respectively. The area of major roads was 0.035 km^2 (mean) and 0.279 km^2 (maximum), and the area of pedestrian roads was 0.112 km^2 (mean) and 0.520 km^2 (maximum), respectively. Derived in this study through Getis-Ord Gi*, hotspots and coldspots took up 14.4% and 53.0%, respectively. These indicate the spatial distribution of senior citizen centers in Goyang-si in consideration of demands, and areas corresponding to coldspots seem to be so due to the installation of senior citizen centers according to the criterion of population density despite relatively small demands for these facilities. In addition, by using sociodemographic statistics collected on the

Table 2. Descriptive statistics

Variables				Mean	Min.	Max.	S.D.
Dependent variable		The number of registered members		35.324	10.000	137.000	14.676
Walking environment	Safety	CCTV		26.816	0.000	98.000	19.515
		Security light		38.913	0.000	191.000	40.021
	Topography	Slope		1.892	0.000	13.909	2.003
	Street	Green area (km^2)		0.047	0.000	0.396	0.071
		Urban park (km^2)		0.026	0.000	0.238	0.033
		Major road (km^2)		0.035	0.000	0.279	0.026
		Pedestrian road (km^2)		0.112	0.000	0.520	0.111
Spatial cluster of registration (Getis-Ord's Gi*)		Dummy variable (0, 1)	Hotspot	0.144	0.000	1.000	0.352
			Coldspot	0.530	0.000	1.000	0.500
Sociodemographics		Elderly population (%)		21.249	14.491	34.026	42.062.
		Gender	Male (%)	45.320	42.151	52.586	1.540
			Female (%)	54.681	47.414	57.849	1.540
		Single-person household (%)		30.190	18.900	47.000	5.304
		The level of education	Elementary school (%)	16.348	9.224	28.353	4.223
			Middle school (%)	15.010	8.338	26.267	3.380
			High school (%)	38.441	31.591	43.711	2.810
			Higher than high school (%)	25.510	10.393	44.816	8.361
			None (%)	4.690	2.206	9.093	1.882

level of administrative *dong*, indicated were the gender ratios, percentages of single-person households, and percentages of educational levels for people aged 65 or above in administrative *dong* equipped with these facilities. The mean value of the percentage of senior citizens aged 60 or above in administrative *dong* in Goyang-si was 21.3%, showing that the city had entered the stage of an aged society according to UN standards. In addition, the mean value of the percentage of males aged 60 or above was 45.3% and of females was 54.7%, with the latter taking up a relatively larger share. Out of households with members aged 60 or above, the mean value of the percentage of single-person households was 30.2%. Among people aged 60 or above, the mean value for those whose educational level was elementary school amounted to 16.3%, middle school amounted to 15.0%, high school amounted to 38.4%, university or higher amounted to 25.5%, and uneducated amounted to 0.47%, respectively, showing that, in relative terms, the educational level of high school took up the largest share for people aged 60 or above in Goyang-si (Table 2).

3) Spatial Clustering of Number of Registered Members of Senior Citizen Centers

This study assumes that there will be differences in demands for senior citizen centers according to spatial characteristics. It signifies the existence of spatial biases in the number of registered members. In order to confirm this, the Getis-Ord Gi* spatial statistical technique on ArcGIS Pro will be used to analyze the spatial clustering of the number of registered members of senior citizen centers in Goyang-si.

With the Getis-Ord Gi* technique, value Z of units of analysis in the total areas is calculated through Equation (1), and the degree to which high and low values with statistic significance are concentrated is indicated. If value Z is high and the p-value is equal to or below the significance level, the null hypothesis is rejected, and if value Z is positive (+), spatial clustering is judged to have occurred. This has the advantage of being able to determine statistically the forma-

tion of hotspots and coldspots in the areas covered and to diagrammatize it in terms of the units of analysis (Getis and Ord, 1992; and Ord and Getis, 1995). In this study, grasped are areas that are relatively high or low in the value of the degree of concentration of the number of registered members of senior citizen centers at the reliability of 95% or above, with the former being hotspots and the latter being coldspots. After such clustering is confirmed, hotspots and coldspots are each established as dummy variables (hotspots: 0 or 1; coldspots: 0 or 1) in order to perform regression analysis.

$$G_i^*(d) = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{SD\sqrt{\frac{[n\sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=1}^{n} w_{i,j})^2]}{n-1}}}, all\ j; \quad (1)$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}, SD = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\overline{X})^2}$$

i, j : Units of analysis
x_i, x_j : Attribute data for area i or j
$w_{i,j}$: Spatial weight between areas i and j
n : No. of units of analysis

4) Multiple Linear Regression Analysis

This study performs multiple regression analysis of the number of registered members of senior citizen centers, walking environment variables, sociodemographic variables, and senior citizen center users' spatial clustering variables constructed earlier. In order to achieve this, this study will use ver. 4.2.1 of R, a statistical analysis program, to construct a multiple regression model (ordinary least square regression). Out of regression analysis methods, which are statistical techniques for grasping functional relations between dependent and independent variables, multiple regression analysis uses Equation (2) to express functionally the relationship between or among two or more independent and dependent variables (Han et al., 2017). Such multiple regression models are linear models, and explore whether linear relationships exist between dependent variables and each independent variables. In this study, three different models will be constructed and compared in order to find the optimized model. These three models are divided into: Model 1, into which physical walking environment variables and registered members' spatial clustering are entered; Model 2, into which walking environment and sociodemographic variables are entered; and, finally, Model 3, into which walking environment, spatial clustering, and sociodemographic variables are entered.

$$y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \epsilon_i,\ i = 1, 2, \cdots, n \quad (2)$$

y_i : Dependent variable
α : Intercept
x_{1i}, x_{2i}, x_{3i} : Independent variables
$\beta_1, \beta_2, \beta_3$: Regression coefficients of each independent variable
ϵ_i : Error term

Regression analysis involves many hypotheses. Out of them, homoscedasticity, in which the variance of the error term is consistent regardless of independent variable levels, is one of the important hypotheses. If and when the hypothesis that the error term is homoscedastic does not hold so that the problem of heteroscedasticity arises, either optimal values cannot be derived from the model's estimates or inaccurate results are yielded in tests (Seo and Yoon, 2016). Out of verification methods for resolving the problem of heteroscedasticity, White the White test rejects the null hypothesis that the error term is homoscedastic when chi-squared test is performed and the results are equal to or below the significance level of 5%. Consequently, this is confirmed to determine the presence or absence of heteroscedasticity (White, 1980). When the hypothesis of homoscedasticity is violated, in order to resolve this, the robust standard error value is estimated. Also called Huber-White standard errors, robust standard errors are adjusted into standard errors, where errors are robustly broadened through the use of the empirical fluctuation of the regression analysis model's residuals and on the basis of the model (Mansournia et al., 2021). Consequently, in this study, the White test will be performed in order to verify whether or not the error term satisfies the conditions of homoscedasticity after the performance of multiple regression analysis.

IV. Results and Discussion

1. Spatial Clustering of Registered Members of Senior Citizen Centers

<Figure 2> shows the results of the spatial clustering of the number of registered members of senior citizen centers derived through Getis-Ord Gi*, and the clusters thus formed exhibit spatial slanting. When the spatial clusters derived are interpreted with respect to the boundaries of administrative *dong* in Goyang-si, coldspots are Ilsan New Town, Hwajeong district, and Haengsin district including Juyeop-dong, Daehwa-dong, Madu-dong, Jeongbalsan-dong, Janghang-dong, and Haengsin-dong, all of which are housing site development districts where urbanization has proceeded. Areas where hotspots are located correspond to those with high percentages of non-urban areas such as Gobong-dong and Gwansan-dong. This is interpreted to signify that because there are many other leisure spaces that can be chosen according to one's tastes and preferences, senior citizens in urban areas use senior citizen centers relatively less. As for senior citizens living in non-urban areas, because leisure spaces are limited to senior citizen centers, spatial slanting seems to arise in the rate of utilization. This is supported by the 2017 *Fact-finding Survey on the Status of Senior Citizens* announced by the Ministry of Health and Welfare, according to which, the percentage of senior citizens using senior citizen centers was 11.5% in urban areas and 48.5% in non-urban areas, respectively (Ministry of Health and Welfare, 2017). Indeed, when the sites of senior citizen leisure welfare facilities were analyzed on the basis of data on senior citizen leisure welfare facilities as of 2018 provided by the Goyang City Government, urban areas in the city had many leisure facilities besides senior citizen centers including seven educational courses for senior citizens (two in Daehwa-dong, one in Janghang-dong, two in Hwajeong-dong, and two in Haengsin-dong), three senior citizen welfare centers (one in Daehwa-dong, one in Janghang-dong, and one in Hwajeong-dong). In contrast, non-urban areas had one educational course for senior citizens (one in Gobong-dong) and no senior citizen welfare centers, thus showing relative and regional differences in the number of leisure facilities.

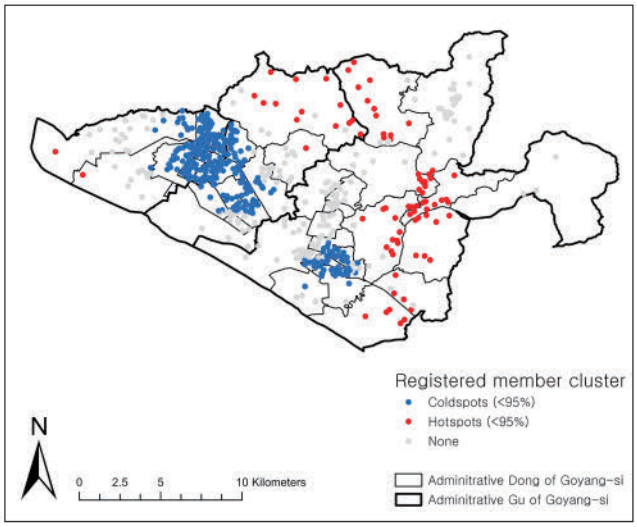

Figure 2. Spatial distribution of Hotspot/Coldspot in the number of Registered member

2. Multiple Linear Regression Analysis

Before explaining the results of regression analysis, this study diagnosed the homoscedasticity of the residuals of the regression analysis models. If and when the homoscedasticity hypothesis, a basic hypothesis of regression analysis that variances of the residuals are identical, is violated, the results of the regression models can no longer be trusted (Breusch and Pagan, 1979). Consequently, in order to verify whether or not the regression analysis models in this study satisfied homoscedasticity, the White test was performed. According to the results of White test, significance levels were equal to or greater than 5% for two of the models (p-value = 0.121 (Model 2), 0.12 (Model 3)). However, because the significance level was equal to or less than 5% (p-value = 0.016) for Model 1, heteroscedasticity was shown to exist. In order to resolve problems due to heteroscedasticity, the values of robust standard errors, which adjust standard errors in the results of regression analysis, were derived and a multiple regression analysis model was constructed.

As shown in <Table 3>, out of the results of multiple regression analysis, value R^2 was 0.207 for Model 1, 0.158 for Model 2, and 0.205 for Model 3, respectively. This indicates the explanatory power of independent variables of each model with respect to the number of registered members of senior citizen centers, which is a dependent variable. In other words, it means that the explanatory power is 20.7% for Model 1, 15.8% for Model 2, and 20.5% for Model 3, respectively. Next, multicollinearity (i. e., variance inflation factors (VIFs)) in multiple regression analysis of the three

Table 3. Results of regression analysis

Independent Variable			Model 1				Model 2				Model 3			
			B	Robust S.E.	p	VIF	B	Robust S.E.	p	VIF	B	Robust S.E.	p	VIF
Walking environment	Safety	CCTV	-0.118	0.047	0.012*	2.086	-0.147	0.046	0.002**	2.208	-0.113	0.049	0.021*	2.257
		Security light	0.033	0.022	0.133	1.919	0.025	0.026	0.325	2.345	0.034	0.023	0.148	2.345
	Topography	Slope	-0.706	0.349	0.044*	1.566	-0.748	0.362	0.039*	1.603	-0.706	0.351	0.045*	1.597
	Street (km^2)	Green area	17.362	13.508	0.199	2.187	24.606	14.871	0.099	2.418	18.200	14.658	0.215	2.484
		Urban park	1.952	21.996	0.929	1.246	0.208	21.833	0.992	1.330	-4.914	22.088	0.824	1.321
		Major road	-65.568	19.936	0.001**	1.134	-91.465	20.251	0.000***	1.132	-71.437	19.920	0.000***	1.201
		Pedestrian road	-9.916	5.259	0.060	2.169	-20.462	5.636	0.000***	2.065	-10.808	5.740	0.060	2.482
Spatial Cluster of registration (Getis-Ord Gi*)	Hotspot		8.245	2.631	0.002**	1.342					8.333	2.905	0.004**	1.601
	Coldspot		-4.469	1.598	0.005**	2.026					-4.798	1.724	0.005**	2.140
Socio-demographics (%)	Elderly population						0.109	0.192	0.569	1.893	0.182	0.189	0.334	1.936
	Gender	Male					1.235	0.532	0.021*	2.503	0.175	0.563	0.756	2.359
	Single-person household						0.311	0.138	0.024*	1.684	0.124	0.130	0.340	1.683
	The level of education	Elementary					0.155	0.256	0.544	4.247	-0.040	0.280	0.886	3.618
		Middle					-0.187	0.365	0.610	3.072	-0.305	0.342	0.372	3.089
		Over university					-0.068	0.266	0.799	1.286	-0.283	0.272	0.299	1.241
		None					0.129	0.363	0.772	1.678	0.182	0.189	0..299	1.936
Adjusted R^2						0.207				0.158				0.205

***, **, * is significant at 1%, 5%, 10% significance level, respectively.
S.E.: Standard Error

models above with respect to independent variables was reviewed, the results of which derived VIF values of 5 or less for all variables so that there was no problem with multicollinearity.

When Model 3, which, out of the three models, includes all variables, is examined first, the number of CCTVs, mean slope, areas of major roads, and hotspots and coldspots with concentrated numbers of registered members of senior citizen centers were derived as significant variables from among independent variables at significance levels within 95%. Identically to results derived in earlier research that used surveys on senior citizens' walking environments (Lee, 2011; and Park and Lee, 2022), the slope and the areas of major roads (continuity of sidewalks) were derived as significant variables. In addition, hotspots and coldspots, which involve the degree of concentration of the number of registered members of senior citizen centers and were used to find out spatial differences in demands for these facilities, were statistically significant factors in this study. When, out of physical walking environment variables, CCTVs in pedestrian space around senior citizen centers (400 m) increased by one, the number of registered members of senior citizen centers decreased by 0.113. When the mean slope increased by 1°, the number of registered members decreased by 0.706. When the area of major roads increased by 1 km^2, the number of registered members decreased by 71.437. In addition, as for senior citizen centers' spatial bias variables, hotspots had 8.333 more annually registered members of senior citizen centers than did other areas, and coldspots had 4.798 fewer annually registered members of these facilities than did other areas.

However, in Model 3 in this study, all sociodemographic

variables were statistically insignificant, unlike in earlier research. This is clear (Table 3) from the results of Model 2, with the exception of the spatial clustering variable. With the spatial clustering variable excluded, Model 2 derived areas of pedestrian roads, percentage of males, and percentage of single-person households as significant variables. In Model 3, which included spatial clusters, significance was revealed not in the variables above but in the spatial clustering variable. Because spatial clusters may have influencing relationships with the variables of areas of pedestrian roads, percentage of males, and percentage of single-person households, sociodemographic variables in this model seem to have lost significance. As for areas of pedestrian roads, the mean value (3.1 km^2) in urban centers (coldspots) was higher than the mean value (0.3 km^2) in non-urban areas (hotspots). As for the percentage of single-person (aged) households, the man value was 37.7% in urban centers and 34.6% in non-urban areas, respectively, with the former surpassing the latter in the percentage of single-person households. Consequently, areas of pedestrian roads and the percentage of single-person households can be interpreted as variables indicating urban centers. As for the percentage of males, the mean value in non-urban areas (43.0%) was greater than that in urban centers (40.7%). Because variables that were thus significant in Model 2 exhibited patterns similar to those of the spatial clustering variable, when they are taken into consideration together with the latter variable, significance levels can be low. In order to explore such differences more clearly, however, additional positivistic research is necessary. In addition, such differences in data can be the causes of distorted results because this study was constructed in terms not of pedestrian space but of units of administrative *dong* due to limitations in collecting data in the construction of sociodemographic variables. In other words, such results must be taken into consideration as variables that are important for revitalizing senior citizen centers even though walking environment variables including areas of pedestrian roads and sociodemographic variables including the percentages of males and single-person households were statistically insignificant in Model 3. This point agrees with the results of earlier research as well.

According to the results of analysis in this study, in consideration of physical walking environments, senior citizen centers' spatial characteristics, and sociodemographic characteristics, the number of CCTVs within a radius of 400 m from senior citizen centers had a negative (−) relationship with the number of registered members of senior citizen centers, thus exhibiting results differing from the hypothesis established in this study. As for CCTVs, this study failed to take into consideration the time gap between the time frame of installation and the time frame of the perception of pedestrian safety after installation. For these reasons, the following interpretation is possible. Crime prevention effects did not arise because many CCTVs were installed. Rather, the places where these devices were installed originally were environments with poor crime prevention so that the number of CCTVs was increased, without changes in pedestrians' perceptions such as subjectively felt safety and the mitigation of fear. According to Baek et al. (2018), residents tend to perceive areas installed with CCTVs as crime-ridden areas. Pedestrian safety can increase when, after the installation of CCTVs, residents perceive the installation these devices and feel safe. Consequently, it can be interpreted that the relationship was derived as a negative (−) one due to the occurrence of a time gap between the time frame of installing CCTVs and the time frame of perceiving pedestrian safety. As for other interpretations of the relationship between the number of CCTVs and the number of registered members, the matter can be examined in terms of places where CCTVs are installed. In order reasonably to install CCTVs in places where pedestrians' safety can be guaranteed, local governments have established the goal of installing public CCTVs at points with high crime rates. However, there is no clear standard on CCTV installation so that, with police cooperation regarding criminal data difficult to expect, local residents' opinions must be relied on to a considerable extent (Han et al., 2018). For this reason, even when there are many CCTVs around senior citizen centers, positive effects on pedestrians' safety may be difficult to expect.

Next, the mean slope has a negative (−) relationship with the number of registered members of senior citizen centers. As for Goyang-si, though the mean slope is approximately 2° so that relatively level land is formed, it shows that differences in slopes affect walking environments even in such a level region. Even in a level topographic environment, the steeper slopes are, the more difficult it becomes for senior citizens to maintain a balance due to reduced physical functions, thus increasing the risk of accidents such as slipping

and injuries from falls (Roh and Park, 2018). Consequently, increases in the mean slope cannot create walking environments that are conducive to senior citizens' access to facilities. The areas of major roads likewise have a negative (−) relationship with the number of registered members of senior citizen centers. It seems to be because when the area of major roads increases, the number of severed pedestrian roads increases, and when traffic volume in and widths of major roads increase, the frequency of accidents increases (Park and Lee, 2016), thus creating a walking environment that is vulnerable in terms of traffic safety and poor in terms of safety and negatively affecting the use of senior citizen centers sited in the area. In addition, according to the results of this study, hotspots, which are concentrated areas with a large number of registered members of senior citizen centers, have a positive (+) relationship while coldspots, which are concentrated areas with a small number of registered members of senior citizen centers, have a negative (−) relationship. Such results statistically show that, in a situation with other walking environments controlled, there are absolute spatial differences in the number of users of senior citizen centers. As shown in <Figure 2>, senior citizen centers in Goyang-si that were concentrated in urban areas such as new towns and housing site development districts but exhibiting low rates of utilization were coldspots. Distributed on the outskirts was a relatively small number of senior citizen centers, which exhibited high rates of utilizations so that they were derived as hotspots. In other words, the results agreed with the hypothesis established in this study: demands for senior citizen centers are greater in urban outskirts and non-urban areas, which are not equipped with diverse cultural infrastructures, than in urban centers, which are equipped with such infrastructures. This shows the need for installation criteria that take into consideration differences in geographical and spatial demands together with installation according to population density, or the existing senior citizen center installation criterion.

Some variables out of the physical walking environment variables established in this study were statistically insignificant. As for major roads in pedestrian space, increases in their areas alone increased the number of vehicles and therefore were directly linked to ruptures in walking so that qualitative levels may not have had significant effects. In contrast, because green fields and urban parks, which can significantly affect pedestrians in walking environments on qualitative levels, were taken into consideration in terms only of the areas of housing complexes, statistically insignificant results were derived. For senior citizens, sidewalk pavement materials, shades of street trees, degree of cleanliness, and benches providing rest during walks can affect the qualitative levels of the walking environment rather than areas. In addition, insignificant results may be characteristics only of Goyang-si, the object of this study. In the results of a survey of residents of the city by Yoon and Lee (2021), the factor most strongly affecting the walking environment was illegal parking/stopping of vehicles. In addition, reflecting the necessity to take into consideration not only hardware aspects but also software factors such as sidewalk pavement materials, degree of cleanliness, cooperation in land use, and citizen-centeredness (community spaces), it is possible to present the interpretation that factors other than the physical walking environment can be significant to pedestrians in Goyang-si.

V. Conclusions

This study explored factors affecting the number of registered members of senior citizen centers in Goyang-si as of 2018. It demonstrated that, out of such factors, both walking environments within 400 m from senior citizen centers and demand-based spatial characteristics of these facilities played important roles. The results of this study will be used as basic data in preparing both plans for the enhancement of senior citizens' walking environments and policies on installation and operation for the revitalization of the use of senior citizen centers. Findings derived from the results of this study are as follows.

First, through the results of this study, physical walking environment factors affecting the use of senior citizen centers were the number of CCTVs in pedestrian spaces (400 m) surrounding senior citizen centers, mean slope, and areas of major roads. Such results show that physical walking environments surrounding senior citizen centers are very closely linked to the revitalization of senior citizen centers. Increases in both slopes and areas of major roads create poor walking environments for senior citizens, and senior citizen centers located in such walking environments show the

negative (−) effects of these factors on senior citizen use.

Second, differences were examined in spatial demands between senior citizen centers located in administrative *dong* with high proportions of urban areas and those in administrative *dong* with high proportions of non-urban areas in Goyang-si. First, in non-urban areas, senior citizen centers were small in number but had large numbers of registered members, thus tending to enjoy high demands. In contrast, results were derived from urban areas where senior citizen centers were large in number but did not enjoy high demands. Demands for senior citizen centers are greater in non-urban areas than in urban areas, presumably because non-urban areas are relatively insufficient in cultural infrastructures and leisure spaces. This shows that the existing population density-based senior citizen center installation criterion fails to reflect actual demands for such facilities and that it is necessary to revise the existing senior citizen center installation criterion, which has been uniformly applied to urban and non-urban areas.

However, this study has several limitations. First, due to its use of data on the level of administrative *dong* in sociodemographic statistical values, this study failed to construct spatial data on people living near actual senior citizen centers. Due to such a limitation, the study may not have been able to derive the exact relationship between factors affecting walking and sociodemographic variables. Second, this study was limited in data acquisition so that it failed simultaneously to take into consideration physical walking environment data presented by earlier research such as sidewalk widths, pedestrian crosswalks, and benches. Future research needs to take into consideration the effects of additional walking environment factors. Third, this study failed to unify the time frames of the dependent variables and those of the independent variables. Because the time frames for data updates differed according to the organization providing the data, variables were constructed according to the time frame of the dependent variables (2018). Nevertheless, variables from disparate time frames can affect the results of research. Fourth, though the results of this study may be reflected in areas with changes in aged population similar to those in Goyang-si, the study is limited to the city as of 2018 so that it cannot be generalized for and applied to all areas. In addition, analysis was conducted from a viewpoint fixed on 2018 so that changes in time failed to be observed. Consequently, necessary is additional research based on spatial panel data that will apply diverse year variables together with various sample areas in order to find out time series changes. Finally, this study took into consideration only walking environments and spatial differences in demands as variables linked to the revitalization of senior citizen centers. In other words, this study failed to take into consideration qualitative levels such as the sizes of and programs at senior citizen centers. However, the qualitative levels of actual cultural facilities can considerably affect the revitalization of these facilities. It will be necessary in the future to research the limitations mitigating this study.

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