J. Integr. Sci. Technol. 2021, 9(1), 45-53 Article

Journal of Integrated
SCIENCE & TECHNOLOGY

Evaluation of spatial hierarchy in the Elderly Nursing facility according to the Circulating Flow system

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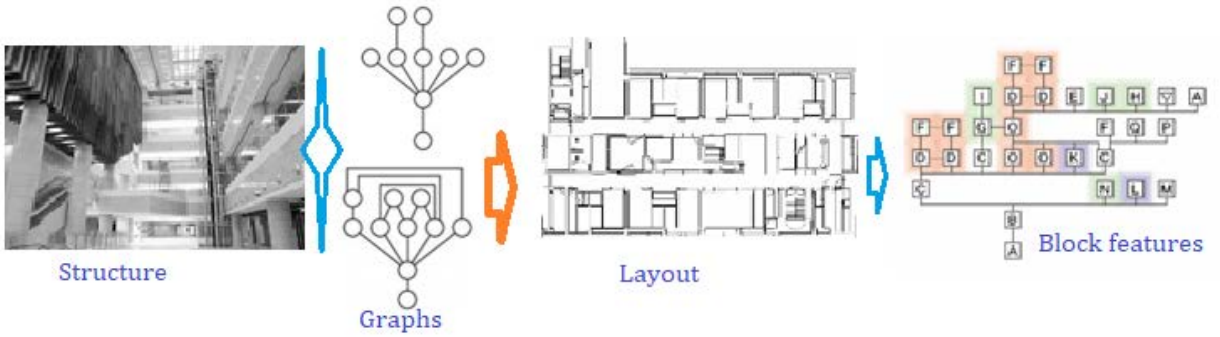
Received on: 07-Jan-2021, Accepted and Published on: 21-Aug-2021

ABSTRACT



Recently, various and diverse problems related to the elderly have emerged due to the rapid increase of the elderly population. Various studies have been conducted and various attempts are being made to solve these problems. As one of these attempts, the wards of elderly nursing homes are providing the elderly with sociality and autonomy through a circular movement system. This study is to build basic data that can be used to design the wards of elderly nursing homes by performing a quantitative analysis on the wards of elderly nursing homes which have a circular movement system. The analysis of this study results the J-Graph for the analysis target which shows a shallow annular J-graph type with a spatial depth of 7 or 8. This is because of the results of reflecting the design intention to increase the sociality and autonomy of the elderly by applying a circular movement system.

Keywords: Elderly Care Facility, Circulation, Space cognition, Space syntax, J-Graph

INTRODUCTION

1.1. Background and Purpose

Advances in medical technology and science have increased life expectancy, and as a result, aged population in society is increasing rapidly.[1,2] According to Statistics Korea, Korea entered an aged society in 2020 as the ratio of older adults was 15.8% of the total population, and is projected to become a super-aged society by 2026, when the elderly population will exceed 20% of the total population.[3] Therefore, the rapid growth of the aging population is becoming a significant social issue.[4] However, in recent years, the number of physically and mentally healthy seniors is increasing due to medical technology and improved cultural standards, and this population hopes to continue their social activities. As the older population continues to grow, and the most significant problems related to aging are divided into 4 areas: housing, leisure, home care facilities, and medical problems. However, the government is only focusing on solving medical problems by increasing health care facilities for the elderly to cope with the increasing demand without considering their re-entry into society.[5,6] As a result, the integrated development of elderly nursing facilities in Korea that consider housing, leisure, and home care facility problems is still in its early stage.[7] This reduces the effectiveness of managing geriatric patients and causes problems for elderly patients when they return to society after recovery. Also, the perception of the elderly has changed from those who need care or are maintaining their status quo to active seniors who receive rehabilitation treatment so they can return to society.[8] Therefore, ordinary general hospitals or basic nursing

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Cite as: *J. Integr. Sci. Technol., 2021, 9(1), 45-53.*

 Published by: ScienceIN
JIST ISSN: 2321-4635 http://pubs.iscience.in/jis

facilities cannot meet the demands for these changes. Accordingly, the need for elderly care facilities that have the characteristics of providing both medical care and treatment will increase in the future. However, elderly care facilities are buildings that combine various spatial configurations and pedestrian circulation flows.[9,10] In this context, there are significant difficulties in the spatial planning of such facilities because the characteristics of the elderly must be reflected in the space. In addition, due to the rapidly aging society in Korea, there is a lack of research on elderly care facilities compared to other countries such as European nations and Japan. In the past, seniors were perceived as physically, socially, and psychologically weak, so many elderly care facilities used one-way circulation systems. However, more and more modern elderly nursing homes and facilities are adopting circulating flow systems or structures to maintain the sociality of seniors before they return to society.[11–13] Nevertheless, research should be conducted on these circulating flow systems because they may have negative effects on the use of space by the elderly.[14]

Therefore, this study performed a quantitative evaluation on the wards of elderly nursing facilities using circulating flow systems or structures to build basic data for planning these facilities in the future.

1.2. Method and Scope

This study was conducted in three stages, as shown in Figure 1. The first stage involved a literature review to derive the analysis method. The characteristics of the elderly were examined from a spatial aspect to derive the components of space, and the concept and components of elderly nursing homes were also investigated in this stage. In the second stage, J-Graphs of the analysis targets were derived based on the literature review to analyze the spatial composition characteristics and relationships. The third stage involved analysis and evaluation by applying space syntax based on the results above. The conclusions were drawn based on the results obtained through the process above.

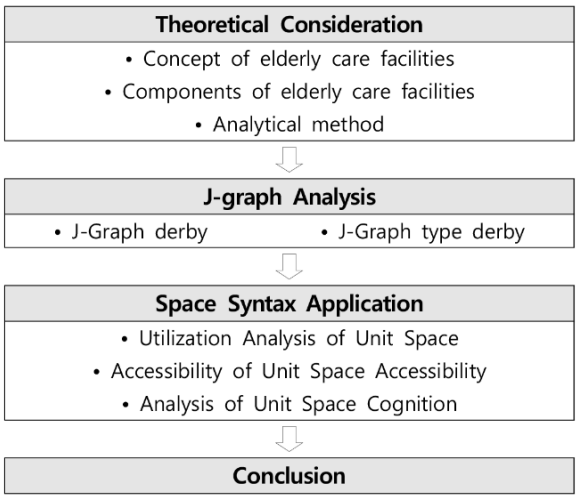


Figure 1. Space Syntax Deduction Method.

The targets or subjects selected for this study were limited to elderly nursing homes or care facilities in Korea with more than 100 beds. According to the Ministry of Health and Welfare, general hospitals must have more than 100 beds, so nursing homes or medical facilities larger than general hospitals will have all of the components of elderly care facilities required for this study.

Consideration of Elderly Care Facilities and Analysis Methods

2.1. The Characteristics of the Elderly in Terms of Space

This study classified the composition or spatial form of circulating flows in elderly care facilities by reflecting the characteristics of various seniors. That is, the characteristics of the elderly were classified only from a spatial perspective (physical, psychological, and cognitive characteristics).[15–17] The details are as follows. First, physical characteristics are the typical characteristics that seniors experience by aging. The factors related to spatial aspects are reduced mobility, less energy and physical strength, and reduced visual acuity. In general, seniors who use elderly facilities lack independent living skills and need help from other people. Second, psychological characteristics are the psychological changes that seniors experience as their adaptive and intellectual abilities to perceive environmental changes decrease as they undergo physical changes with age. That is, they express signs of depression, inferiority, and dissatisfaction as they feel psychological loneliness and alienation. Therefore, their behavior tends to be introverted and passive, and their area of activity decreases because of these psychological characteristics. Third, social characteristics refer to changes such as reduced or loss of income or social roles as older adults retire from their jobs. As mentioned above, the elderly experience social alienation or loneliness because of these changes, which reduces their psychological stability and causes emotional anxiety. Therefore, the elderly become introverted, passive, and tend to spend more time in specific and familiar spaces, so the indoor environment tends to become their main living area.

2.2. Concept and Components of Elderly Care Facilities

In Korea, elderly care facilities or nursing homes refer to facilities that can accommodate 30 or more patients where doctors provide medical care. According to the Medical Service Act, these facilities are medical institutions established mainly to provide long-term care for inpatients. In 1995, the Department of Welfare for the Elderly first introduced the term elderly care facility or nursing home through their guidelines on paid elderly welfare facility loan projects, and the first statutory provisions were created through revising the Elderly Welfare Act in 1999. According to the Act, geriatric hospitals are divided into elderly care facilities, special elderly care facilities, and elderly medical welfare facilities, and the annex specifies standards and regulations related to installation, staffing, and facilities.[18,19] There are three types of elderly care facilities depending on how they are established and operated: geriatric hospitals established with the support of paid elderly welfare facility loan funds, municipal/provincial dementia nursing hospitals, and general hospitals converted to geriatric hospitals, or general hospitals operating geriatric wards. These facilities are categorized somewhere in between elderly care facilities focusing on nursing and general hospitals focusing on medical care.

The components of elderly care facilities may be classified differently depending on the researcher, but they are usually divided into the outpatient, central care, ward, examination, management, supply, and mortuary departments, as shown in Table 1. The ward, which is the main focus in this study, consists of spaces for patients and nursing and a public space.[20]

Table 1. Composition and classification of elderly care facilities.

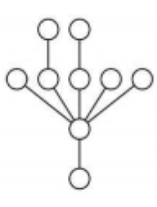
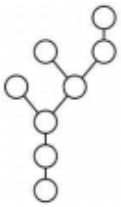
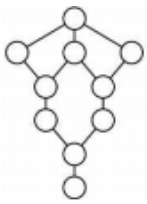
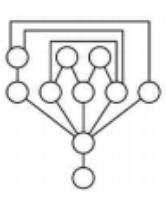
Department	Classification	Images
Outpatient	Outpatient care, emergency care, daycare center, public space	
Central care	Clinical examination, radiation, rehabilitation, public space	
Ward	Patient space, nursing space, public space	
Management	Director's office, office space, medical record room, public space	
Supply	Pharmaceutical, food service, central supply, laundry, mortuary, convenience facilities, public space	

2.3. The Concept and Types of J-Graphs

A J-Graph is a diagram that visually organizes the structural hierarchy of complex spaces and consists of nodes and links that connect them.[21,22] J-Graphs are derived by dividing spaces into convex and concave spaces. Convex spaces refer to open spaces where all of the points can be visually recognized, and concave spaces are spaces with curves and blind spots. Spatial analysis, such as Space Syntax, is performed by dividing a certain space into two or more convex spaces.[23,24]

J-Graphs are classified into tree and ring types, as shown in Table 2. Tree types have sequential structures with continuous properties, making them more visible than cognitive in terms of space. On the other hand, ring types show social characteristics and have highly autonomous spatial structures, so elements related to spatial recognition are more important than visible elements.

Table 2. Composition and classification of elderly care facilities

Tree type		Ring type	
Small bush	Tall tree	Deep ring	Shallow ring
			

2.4. Consideration of Quantitative Spatial Hierarchy Analysis Methodology

This study evaluated the accessibility and recognition of indoor spaces by spatial hierarchy analysis according to the circulating flow systems of wards in elderly care facilities. Space syntax is a set of techniques to investigate spatial layouts and hierarchy by analyzing configurative spatial relationships. Space syntax was selected as the analysis methodology of this study because it quantitatively analyzes the usage, accessibility, and recognition through connections between unit spaces. The main indicators of space syntax are as follows.

First, connectivity measures the number of spaces immediately connected to a space of origin. So, spaces with high connectivity are located at the center of the circulation or traffic flow or are frequently used.

Second, the control level is a regional variable like connectivity and also an extended variable that includes connected spaces and spaces that affect their surroundings. This acts as an indicator for users to determine accessibility.

Third, global integration is a measure of integration, measured throughout the spatial configuration, while local integration refers to the local availability of space considering only a few spatial depths. According to previous studies, people only recognize up to three spatial depths, but different depths may be applied depending on the characteristics or circumstances of the subject. Generally, the higher the degree of local integration, the higher the awareness of the space.

Overview of Analysis Targets and Analysis Results

3.1. Selection and Overview of Analysis Targets

This study limited the scope of research to analysis targets in Korea, which entered an aged society due to its rapid increase in the elderly population. The targets were then narrowed down to elderly care facilities with more than 100 beds due to the characteristics of space syntax analysis. In particular, this study limited the analysis targets to six elderly care or nursing facilities with circulating structures, as shown in Table 3 below, to conduct a quantitative hierarchical analysis of wards that have circulating flow systems.

Table 3. Overview of analysis targets

Hospital	Opened in	Location	Number of beds	Number of foors
Daegu Siji Geriatric Hospital	2002	Daegu, Korea	160	7
Yeoju Elderly Care Facility	2002	Gyeonggi, Korea	198	3
Gimhae Geriatric Hospital	2005	Gyeongnam, Korea	180	4
Seoul North Municipal Hospital	2006	Seoul, Korea	200	6
Bobath Memorial Hospital	2006	Gyeonggi, Korea	400	7
Tongyeong Geriatric Hospital	2007	Gyeongnam, Korea	155	5

3.2. Analysis Method

The research was conducted in the following method to analyze the hierarchy of circulating flow systems of wards in elderly care facilities. First, as shown in Figure 2, the sub-spaces of each component were zoned based on the floor plan of the analysis target to divide them into convex spaces. However, the analysis was performed by adding the following contents from traditional concepts to divide the convex spaces.[25] The nurse stations in the wards were divided into separate unit spaces, and the same spaces, except for corridors, were considered as one unit space (convex space) even if some parts were visually blocked. Then, J-Graphs were created by considering convex spaces as unit spaces. The types and spatial depths were derived based on these J-Graphs. Second, this study conducted a quantitative analysis of the usage, accessibility, and recognition of the unit spaces using space syntax based on the divided unit spaces. For the analysis, the S3 Convex program developed by Seoul National University (Korea) was used.

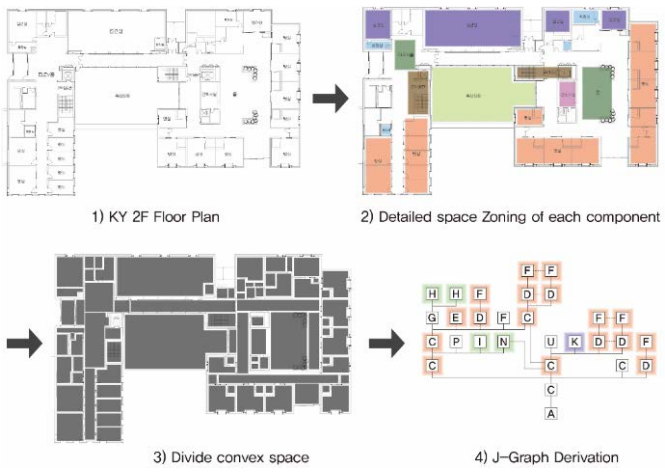


Figure 2. J-Graph derivation method

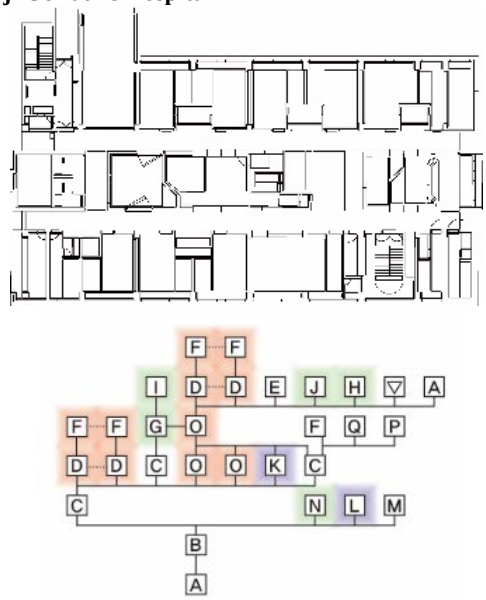
3.3. Analysis Results and Discussion

This study quantitatively analyzed the wards of elderly care facilities with circulating flow systems, and the results are as follows.

First, J-Graphs were derived from the selected facilities, as shown in Table 4. The results showed shallow ring-type J-Graphs with a spatial depth of 7 or 8. These structures increase the sociality and autonomy of the elderly due to using circulating flow systems, and limiting the spatial depth minimizes the difficulties of using these spaces for the elderly.

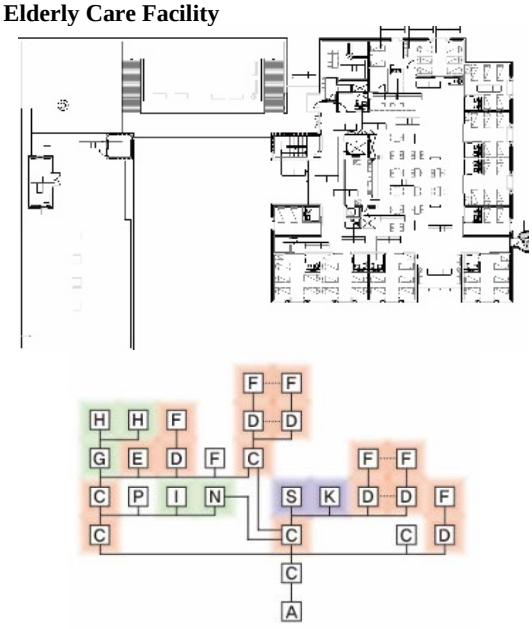
Table 4. Analysis of J-Graphs

Daegu Siji Geriatric Hospital



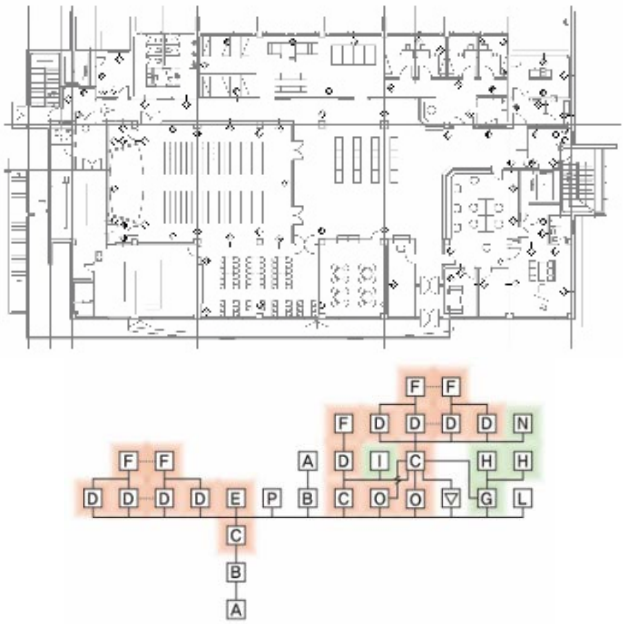
J-Graph type: Shallow ring, Spatial depth: 7

Yeoju Elderly Care Facility



J-Graph type: Shallow ring, Spatial depth: 7

Gimhae Geriatric Hospital

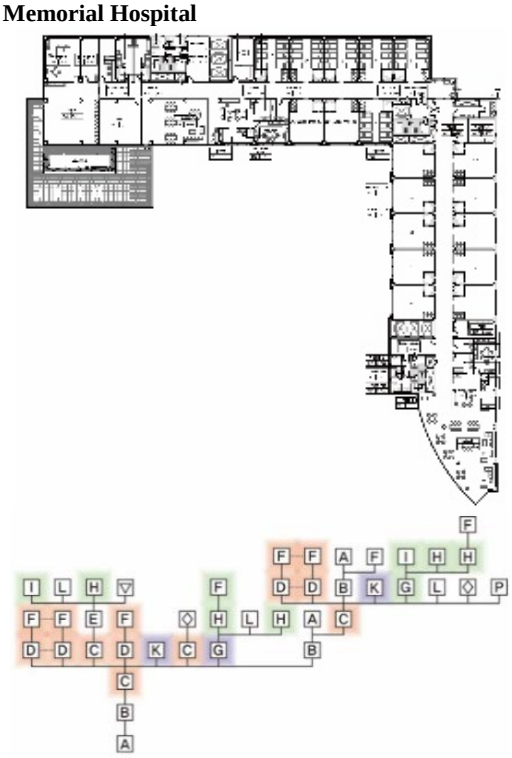


J-Graph type: Shallow ring, Spatial depth: 7

Seoul North Municipal Hospital

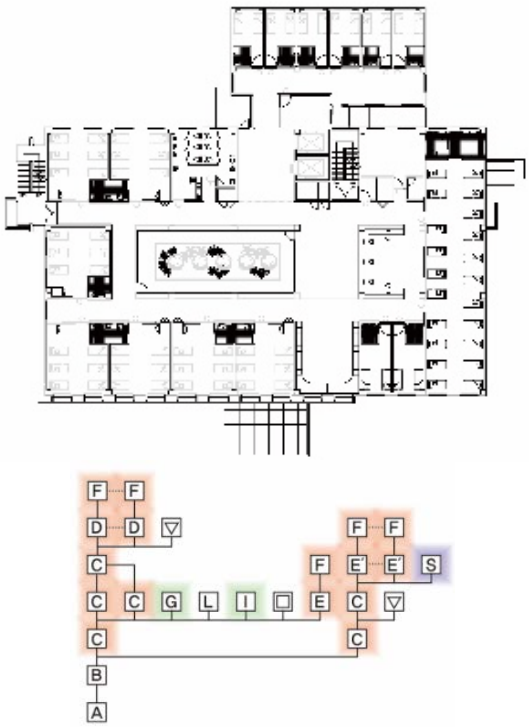
J-Graph type: Shallow ring, Spatial depth: 8

Bobath Memorial Hospital



J-Graph type: Shallow ring, Spatial depth: 8

Tongyeong Geriatric Hospital



J-Graph type: Shallow ring. Spatial depth: 7

: Patient space, : nursing space, : public space

Second, the connectivity was concentrated around the main corridors, as shown in Tables 5 and 6. These structures did not take advantage of the characteristics of circulating flow systems. In

particular, the connectivity of the public spaces where seniors were thought to communicate and socialize the most is lower than the average, so the elderly may use these spaces less often. The low connectivity of these spaces also means that they are not located in major positions in the circulating flow. This is another result of not taking advantage of the characteristics of circulating flow systems.

Table 5. Connectivity analysis results

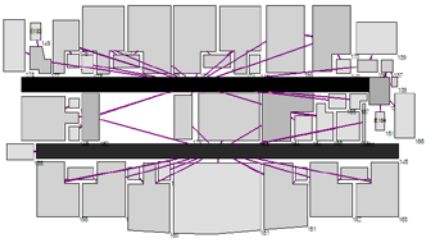
Elderly care facility	Min.	Max.	Avg.	Avg. of Public Space
Daegu Siji Geriatric Hospital	1	18	2.425	1
Yeoju Elderly Care Facility	1	10	2.087	1.5
Gimhae Geriatric Hospital	1	18	2.367	1.24
Seoul North Municipal Hospital	1	15	2.089	1.8
Bobath Memorial Hospital	1	21	2.097	1.84
Tongyeong Geriatric Hospital	1	17	2.250	1.358

Table 6. Connectivity analysis results: Analysis images

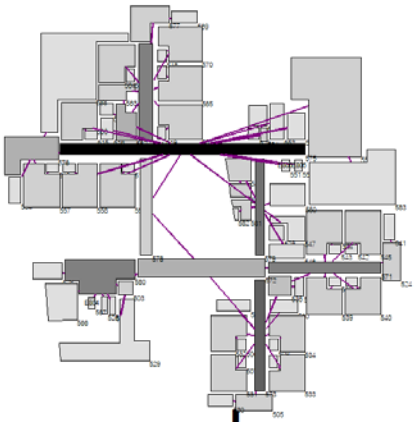
Daegu Siji Geriatric Hospital

Yeoju Elderly Care Facility

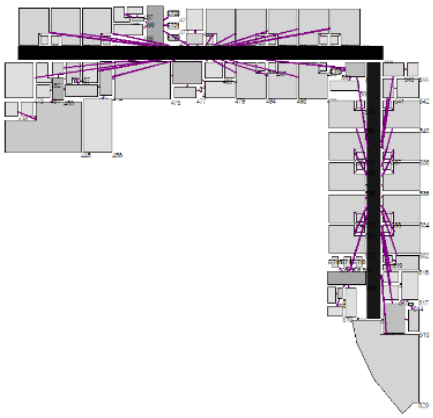
Gimhae Geriatric Hospital



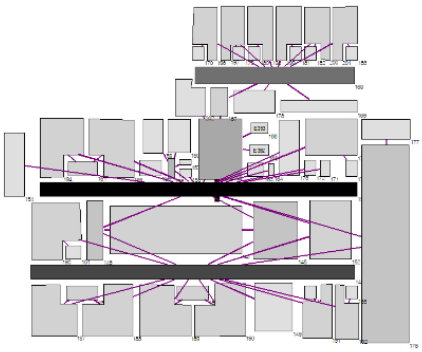
Seoul North Municipal Hospital



Bobath Memorial Hospital



Tongyeong Geriatric Hospital



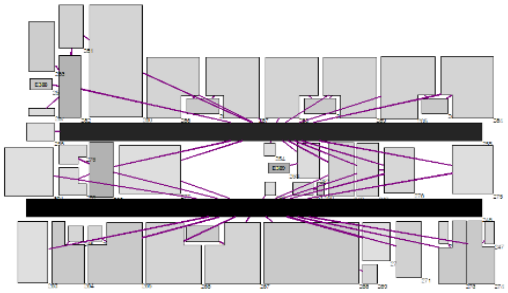
Third, Tables 7 and 8 show the results of analyzing the control level of the facilities, and the results are as follows. The control level indicates the accessibility of a specific unit space, so the control level of public spaces and nurse stations should be high. However, the control levels of public spaces and nurse stations in Daegu Siji Geriatric Hospital, Yeoju Elderly Care Facility, and Gimhae Geriatric Hospital are below average and may cause accessibility problems. On the other hand, the control levels of public spaces in Seoul North Municipal Hospital, Bobath Memorial Hospital, and Tongyeong Geriatric Hospital are above average. These differences are caused by whether the main corridors with a high level of control are directly connected to the unit spaces corresponding to the nurse stations and public spaces. Locating these spaces near the main corridor will increase their accessibility in the wards of elderly care facilities in the future.

Table 7. Control analysis results

Elderly care facility	Min.	Max.	Avg.	Public space	Nurse station
Daegu Siji Geriatric Hospital	0.055	10.750	1.027	0.395	0.618
Yeoju Elderly Care Facility	8.333	0.100	1.027	0.758	0.142
Gimhae Geriatric Hospital	0.055	9.866	1.029	0.872	0.122
Seoul North Municipal Hospital	0.066	9.625	1.034	5.75	0.111
Bobath Memorial Hospital	0.047	11.500	1.062	2.047	2.047
Tongyeong Geriatric Hospital	0.058	11.450	1.028	3.558	0.642

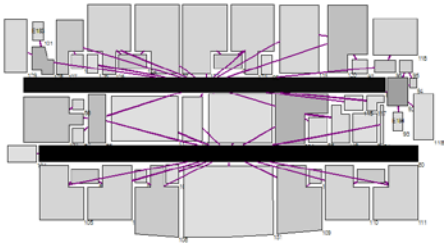
Table 8. Control analysis results: Analysis images

Daegu Siji Geriatric Hospital

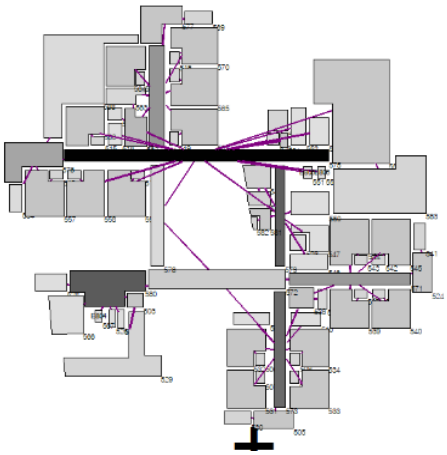


Yeoju Elderly Care Facility

Gimhae Geriatric Hospital

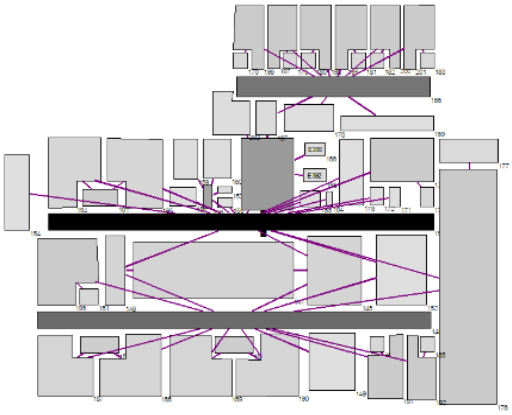


Seoul North Municipal Hospital



Bobath Memorial Hospital

Tongyeong Geriatric Hospital



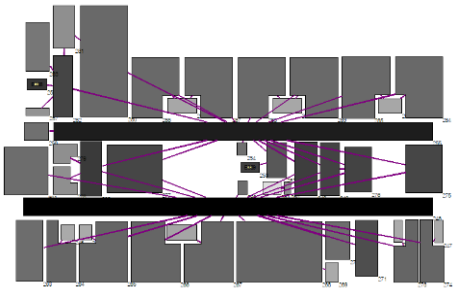
Fourth, Tables 9 and 10 show the results of analyzing the local integration of the facilities. The average local integrations of the convex spaces corresponding to public spaces are below the average value of all convex spaces. This is not suitable for the elderly with low cognitive awareness.[26] These results may have been caused by the lack of consideration in the initial design process of these facilities.

Table 9. Local integration analysis results

Elderly care facility	Min.	Max.	Avg.	Public space
Daegu Siji Geriatric Hospital	0.422	3.540	1.759	1.3
Yeoju Elderly Care Facility	0.422	2.693	1.225	0.457
Gimhae Geriatric Hospital	0.498	3.585	1.734	1.122
Seoul North Municipal Hospital	0.498	3.452	1.348	1.096
Bobath Memorial Hospital	0.333	3.492	1.585	1.25
Tongyeong Geriatric Hospital	0.780	3.637	1.585	0.981

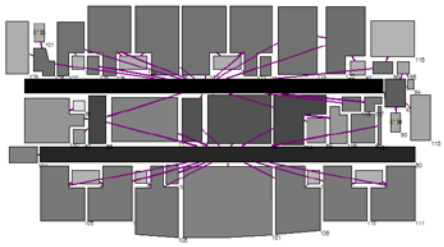
Table 10. Local integration analysis results: Analysis images

Daegu Siji Geriatric Hospital

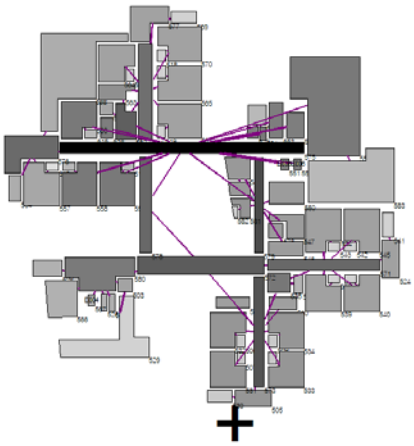


Yeoju Elderly Care Facility

Gimhae Geriatric Hospital

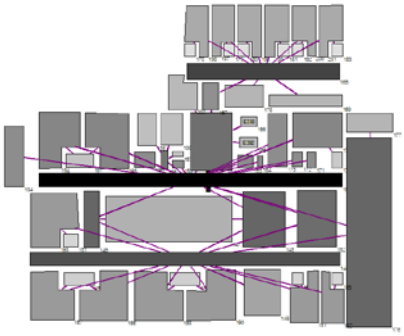


Seoul North Municipal Hospital



Bobath Memorial Hospital

Tongyeong Geriatric Hospital



In summary, wards with circulating flow systems may provide autonomy and sociality to the elderly in choosing their movements but may also cause problems because the design of public spaces has low accessibility and recognition.[27]

CONCLUSIONS

This study conducted a quantitative analysis on the wards of elderly care facilities with circulating flow systems to enhance the sociality of the elderly. The main findings are as follows.

First, as a result of deriving the J-Graphs for the analysis targets, the facilities in this study showed shallow ring-type J-Graphs with a spatial depth of 7 or 8. This reflects the design intention to

increase the sociality and autonomy of the elderly due to adopting circulating flow structures.

Second, the results of connectivity analysis showed to be concentrated or biased toward the main corridors. Consequently, the structures fail or do not take advantage of the characteristics of a circulating flow system. In particular, the public spaces where seniors were expected to communicate and socialize the most show values lower than the average connectivity, so the elderly may use these spaces less often.

Third, as a result of analyzing the control level, the accessibility of public spaces and nurse stations can be improved by allocating them near main corridors with high control levels. This arrangement should be applied in the design of elderly care facilities. Fourth, the local integration of public spaces intended to increase the sociality of the elderly was also low, which can lower the recognition of these spaces and their usage.

This study is effective in analyzing the accessibility and recognition of indoor spaces in the wards of elderly nursing homes with circulating flow systems designed to enhance sociality. However, the limitation of this study is that space syntax does not reflect the physical size of unit spaces. Therefore, future research should consider and use more diverse methodologies.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A5A8040240).

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