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A Study on Hierarchy Analysis of the Floor Compositions of Geriatric Hospital Treatment Wards

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Abstract: The effects of aging on society have led to various studies on professional services facilities for the elderly. Due to the specialty of Geriatrics hospitals concerning both the elderly and medical care, studies regarding Geriatrics hospitals are extremely lacking. In light of this, hierarchy analyses of the floor compositions of geriatric hospital treatment wards where elderly individuals reside were undertaken. Upon undertaking the analyses, the results were further applied for the purpose of establishing basic research materials used to design the treatment wards of Geriatrics hospitals. In doing so, the following conclusions were reached. The floor compositions of geriatric hospitals presented tree type and ring type structures in which shallow tree type and shallow ring type structures were presented, respectively. Connectivity of the treatment wards of Geriatrics hospitals each presented high connectivity in the hallways which was due to the characteristics of tree type and ring type structures. The integration levels of the nurses stations of Geriatrics hospital treatment wards presented a convex space indicative of high integration levels. This meant that the location of nurses stations can affect improvements in integration levels. The tree type floor composition structure of Geriatrics hospital treatment wards presented higher spatial structure intelligibility compared to ring type structures which indicated that such space could easily be used by the elderly.

Key words: Geriatrics hospital, treatment ward, spatial hierarchy, floor composition, space syntax, ring type structures

INTRODUCTION

Our society is currently facing a rapid rise in the population of the elderly who are 65 and older and resulting issues concerning the elderly have become widely recognized as social tasks that must be urgently addressed. According to reports from the US Census Bureau, the proportion of the elderly population in Korea is expected to rise to the 2nd highest levels in the world by 2050 and according to reports from the OECD published in 2015 estimating the outlook and trends regarding the costs of supporting the elderly, the ratio of the working age population to the elderly population is expected to reach 1.25 workers for every elderly individual by 2075. Such figures indicate that the toll of the effects of the aging of Korean society is expected to be profound. To resolve such issues regarding the elderly the Korean government has been attempting to embark on a number of policies and facility expansions.

Compared to average adults in the general population, the elderly are classified as being more physically, psychologically and socially, vulnerable. Although, such characteristics have led to increasing demands for specialized facilities for the elderly such facilities have only been established to the extent of meeting the bare minimum legal requirements and are largely lacking in substance or quality (Lee, 2014; Park *et al*., 2003). This has been the result of government policy being specifically focused on quantitatively expanding the number of elderly facilities to meet the demands of the growing elderly population. In light of this, necessary paradigm shifts and studies regarding the matter need to be undertaken. The number of Geriatrics

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hospitals, a type of specialized facility for the elderly has increased in line with increases in the elderly population. However, despite the fact that Geriatrics hospitals require a degree of specialty that enable them to respond to the special needs of the elderly, Geriatrics hospitals are typically being planned and constructed according to the standards of General hospital facilities and because of this, further studies regarding the matter need to be conducted.

Accordingly, this study sought to map the spatial floor compositions of the treatment wards of Geriatrics hospitals and further applied the floor compositions to quantitative analyses to study factors such as accessibility, level of perception and level of control for the purpose of establishing basic research material needed for the designing of Geriatrics hospitals.

Methods and scope of research: In this study in order to perform a hierarchy analysis of the floor plan of the treatment wards of Geriatrics hospitals, the following steps as shown in Fig. 1 were undertaken.

First, during the study of reference materials, the characteristics of the elderly and the concept and treatment ward composition of Geriatrics hospitals were studied. In addition as a means of carrying out a quantitative analysis of the floor compositions, the analytical methods and indexes used in Space Syntax were studied.

Second, cases of Geriatrics hospitals that were considered to have hallway type and circulating type floor compositions were selected for further analysis in this study. Before making final selections as mentioned earlier, the hospitals selected for analysis in this study were limited to Geriatrics hospitals located in Korea, a country where societal aging has been progressing at extremely fast speeds.

Third, Space Syntax was applied as a method of undertaking spatial hierarchy analyses of Geriatrics hospitals and upon doing so, the accessibility of public spaces, level of perception regarding indoor spaces and control levels of nurses stations were analyzed. By undertaking such measures, it was possible to establish basic research material and quantitative evaluations results regarding the floor compositions of Geriatrics hospitals.

However, as indicated in the procedural explanations above, the floor compositions of concern in this study were limited to hallway types and circulating types and the assessments of such floor compositions were based on the spatial analyses results of Space Syntax

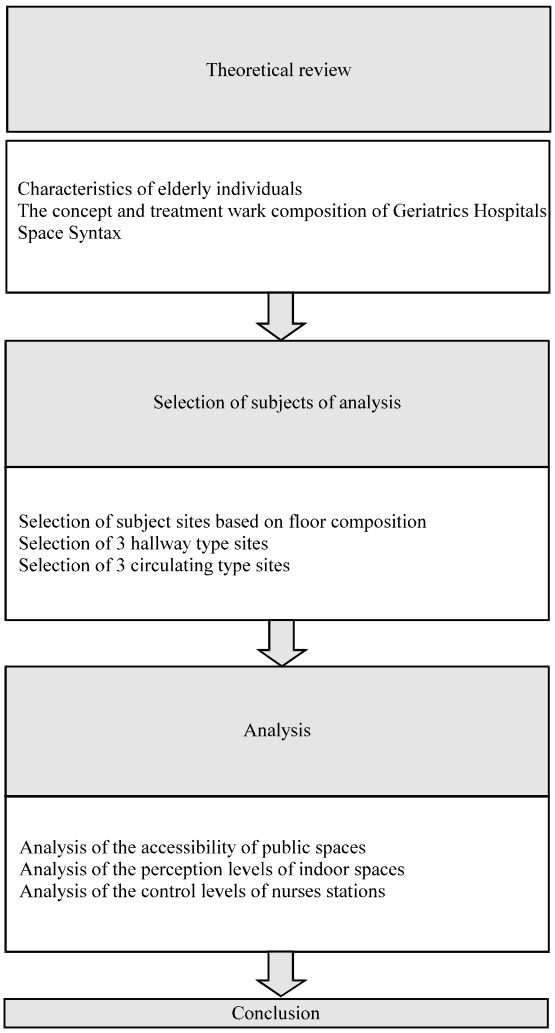


Fig. 1: Architecture of sensor node

and J-graph (Cho, 2010; Park and Lee, 2006; Shen *et al*., 2015). In addition, the Geriatrics hospitals selected for assessment in this study were limited to hospitals having 100 beds or more (Lee and Kim, 2009), a standard of classification for General hospitals and within the selected Geriatrics hospitals the analyses were limited to the floors of the treatment wards. In consideration of the needs associated with ease of control and access to patient rooms and common facilities by the nurses stations of each treatment ward, nurses stations were subjected to independent analyses.

Characteristics of elderly individuals: Despite the standards used to classify elderly individuals varying according to subjects and laws in general individuals at the age of 65 or more are regarded as elderly (Ryu and Lee, 2008). The definition of an elderly individual as set by the International Association of Gerontology and

Geriatrics is 'a person experiencing complex interactions between the physiological, psychological, environmental and behavioral changes associated with the aging process'. The definition also includes individuals, not necessarily defined to be of a certain age who are experiencing loss of social and economic status. The characteristics associated with the elderly concern physical characteristics, psychological characteristics and cognitive characteristics (Song and Choi, 2009; Kim *et al*., 2011). Details regarding these characteristics include the following; First, among the physical characteristics that manifest themselves as a result of the aging process, reduced mobility and impaired eyesight are two of the most prominent. Second, psychological characteristics that manifest themselves include lowered learning capacities, lowered memorization abilities and lowered problem-solving abilities. Reduced powers of memory often reveal themselves in the inability to retain information that was recently acquired (while memories from the distant past may remain intact) and this is known to negatively affect the psychology of elderly individuals using new spaces. Third, cognitive characteristics that manifest themselves among the elderly often include difficulties in perceiving compared to other members of the general population. Cognition involves the process of responding to and assessing large amounts of data collected from the surrounding environment and when considering the physical and psychological characteristics of the elderly, the elderly are only able to collect small amounts of information regarding their surrounding environment resulting in a narrow scope of cognition. Spaces for exclusive use by the elderly should be planned according to such characteristics of the elderly and should enable greater levels of spatial accessibility and cognition by the elderly.

The concept and composition of Geriatrics hospitals: Geriatrics hospitals must be equipped with appropriate facilities and personnel as mandated by the stipulations of the Ministry of Health and Welfare and Geriatrics hospitals are defined as those facilities that provide medical services to the elderly. Geriatrics hospitals are operated, especially, for the purposes of providing treatment for Geriatrics illnesses, providing a place of recuperation and providing care for patients who are about to pass away. Based on such elements, Geriatrics hospitals can be regarded as being facilities in between general hospitals and recuperation facilities.

As shown in Table 1, Geriatrics hospitals consist of out-patient departments, central treatment departments, treatment wards, testing departments, management departments, supply departments and bereavement and condolences departments (Kim, 2002). Although, hospitals present some differences regarding the details regarding such spaces according to their sizes and specialties, hospitals are generally organized according to the classifications in Table 1. The treatment wards to be analyzed in this study specifically, refer to places where elderly patients can reside for certain periods, receive treatment and recuperate. In light of this, the space requires planning that is accommodative of the characteristics of the elderly. In addition, the treatment wards are areas used by patients and workers alike in which the traveling pathways of patients and staff members must be considered in the planning and the nurses stations located within the treatment ward must have high control over patient rooms and public spaces.

Table 1: Department of Geriatrics hospitals

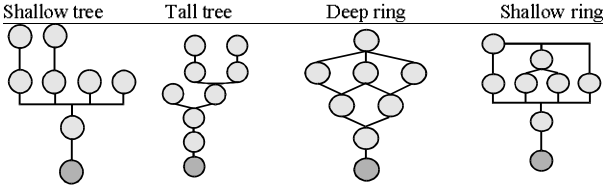
Department	Classification
Out-patient treatment	Out-patient, emergency treatment, daytime care, public space
Central exams and treatment	Clinical testing, radiology, rehabilitation treatment, public space
Treatment ward	Patient space, nurses space, public space
Management department	Director's office, administrative offices, medical records, public space
Supply department	Pharmacy, cafeteria, central supply, morgue, convenience facilities, public space

Spatial hierarchy analysis methodologies: The methodology used to analyze the floor compositions of Geriatrics hospitals and accordingly analyze the levels of accessibility, perception and control involved the use of J-graph and Space Syntax. The reasons why J-graph and Space Syntax were chosen as the methods of analysis for this study are explained as follows.

J-graph concerns a method of visualizing spatial compositions and the status of the connections found in a space. It is composed of unit spaces and nodes that connect such spaces. The unit spaces of J-graphs are based on convex spaces and convex spaces refer to open spaces that do not have any obstructions that deny or impede visual perception. In the case of blind spaces, convex spaces are divided into two or more spaces that are presented on the J-graph. Depending on the shapes of J-graphs, the shapes can be divided into tree type structures and ring type structures. Tree type structures are characterized as having high visibility. On the other hand, ring type structures are characterized as spaces that have high autonomy and social levels that require prior consideration of spatial perception (Jung *et al*., 2007). Such types of J-graphs are summarized in Table 2. These explanations outline the basis of the floor compositions of this study and this study sought to undertake analyses of floor plan compositions upon classifying the floor compositions into tree type and ring type structures.

Table 2: Type of J-graph

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



Space Syntax refers to a type of technology used to conduct quantitative analyses of spatial arrangement relationships. Using Space Syntax, it is possible to analyze the frequency of use, accessibility and level of perception based on the analysis of the connections between unit spaces. Space Syntax also sets its basic unit space as convex spaces for the undertaking of spatial analyses and in this sense is similar to J-graph. The assessment indexes and details of the indexes developed through Space Syntax are outlined in the following manner.

First, connectivity refers to the number of connections a certain unit of space has with nearby unit spaces. High connectivity entails a spatial characteristic regarding a high frequency of use. In light of this, spaces having high connectivity can also be regarded as spaces subject to congestion and can also signify the importance of the location of a space along pathways.

Second, general integration refers to the relative spatial depth required to access a nearby unit space from a certain unit space. A unit space having high levels of integration refers to a unit space having high accessibility to other spaces. However, general integration is an index that numerically represents the relations of a certain space to all spaces. In the case of nurses stations, considering that a nurses station must be capable of easily managing the entire treatment ward it is situated in the station is required to have a high level of local integration.

Third, local integration refers to the accessibility of a certain unit space that is numerically represented. In general, local integration is developed at a spatial depth of 3 which is in consideration of the fact that humans in general perceive spaces by perceiving three convex spaces (Kim, 2002). In other words, if general integration refers to the accessibility of a unit space to an entire space, local integration differs to this in the sense that it regards the accessibility to a certain unit space in consideration of human abilities of perception.

Fourth, spatial structure intelligibility refers to the correlation between general integration and local integration (Lee and Kim, 2001) in which the higher the correlation between two indexes the higher the levels of spatial perception of a space. Geriatrics hospitals serving elderly individuals need to have high levels of spatial structure intelligibility.

MATERIALS AND METHODS

Spatial structure and hierarchy analysis of Geriatrics hospital treatment wards

Method of analysis: The following methods were used to undertake spatial hierarchy analysis according to the floor composition structures of the treatment wards of Geriatrics hospitals.

First, to select the Geriatrics hospitals subject for analysis in this study, hospitals which presented tree type and ring type structures using J-graph were selected. A total of 6 hospitals were selected as subjects, 3 hospitals with tree type structures and 3 hospitals with ring type structures.

Second, forfurther performance analyses, the treatment wards of Geriatrics hospitals were divided into convex spaces and the following content was additionally applied to the process of division into convex spaces. The process of dividing spaces into convex spaces involved a division of spaces into unit spaces in so far as the functions of spaces were similar, even for cases of 'scythe shaped' blind areas. In addition, nurses stations were considered as independent unit spaces during the analysis. This was due to the fact that nurses stations need to be located in positions that are easily accessible to all areas of a space.

Third, this study conducted a Space Syntax analysis using S3 convex analyze (Park *et al*., 2011; Lee *et al*., 2015; Oh *et al*., 2015) and was undertaken based on convex spaces that indicated high values in each index.

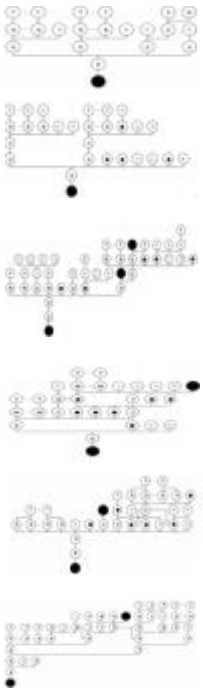
Selection of subjects: As indicated in Table 3 and 4 mentioned earlier, the Geriatrics hospitals subject for analysis in this study were limited to hospitals having 100 beds or more and also those hospitals that were opened after the year 2000.

The J-graphs of the selected Geriatrics hospitals to be analyzed with regard to their floor compositions via hierarchy analysis in this study are shown in Table 5. The floor compositions of the selected geriatric hospitals presented tree type and ring type structures in which shallow tree type and shallow ring type structures were presented, respectively.

Table 3: Otline of analysis target

Name of hospital	Image (treatment ward)	Year of opening/ No. of beds
Tree type		
Hyoja Geriatrics Hospital (YH)		2000/292
Jeonju City Hospital for the Elderly (JH)		2000/199
Bobath Memorial Hospital (BH)		2006/400
Ring type		
Daegu Siji Geriatrics Hospital (DH)		2002/198
Kimhae Sanitorium Hospital (KH)		2005/180
Seoul NMH (SH)		2006/400

Table 4: Derive J-graph

Tree types	Images	Name of hospitals
Ring types		YH JH BH DH KH SH

●: Core section, E: Elevator hall, C: Hallway, W: Treatment Ward, I: Intensive Care Patient Units, T: Restrooms, H: Hospice, N: Nurses station, ♦: Public space, ◊: Treatment, v: Supply, □: Managemen

Table 5: Connectivity analysis

Name of hospital	Floor composition	Connectivity priority value
YH	Tree type	Left ward hallway (12), right ward hallway (10), central elevator hall (4), hall lower area hallway (4)
JH		Right ward hallway (8), left ward hallway (7), hall lower area hallway (3), hall upper area hallway (3)
BH		Upper ward hallway (26), lower ward hallway (19), lower area elevator hall (6), upper area elevator hall (6)
DH	Ring type	Lower ward hallway (18), upper ward hallway (16), left ward hallway (5), right ward hallway (4)
KH		Upper ward hallway (18), lower ward hallway (16), left ward hallway (4), right ward hallway (4)
SH		Upper ward hallway (15), right ward hallway (16), lower ward hallway (7), left ward hallway (7)

RESULTS AND DISCUSSION

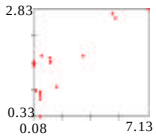
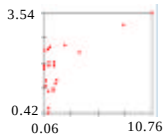
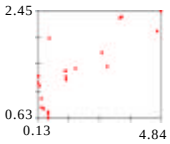
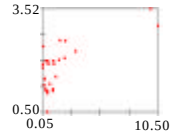
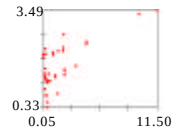
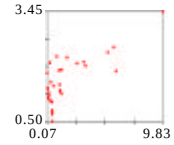
The analysis results developed in this study are as follows. First, the analysis results based on connectivity are as shown in Table 5 and the contents are as follows. Geriatrics hospital treatment wards presenting tree type floor compositions presented high connectivity in the convex spaces of hallways in between patient rooms compared to other convex spaces. Geriatrics hospital treatment wards presenting ring type floor compositions presented high connectivity in circulating hallways. This indicated that the 2 hallway convex spaces serving as axial points of tree type structures were at important locations along pathways and that the 4 hallway convex spaces used for circulation in the ring type structures were at important locations along pathways. However, it was noted that the concentration of activity in relation to certain convex spaces of the hallways of treatment wards could result in congestion and spatial plans to distribute such concentrations are considered to be needed.

Second, the analysis results based on integration are as shown in Table 6 and the contents are as follows. The convex space presenting high levels of integration were the nurses stations and this was due to the fact that they required high levels of access and control among all unit spaces. The local integration of nurses stations did not present tree type or ring type spatial structures. However, when directly connected to hallways having high local integration, the nurses stations were found to present high local integration. This indicated that to raise the integration levels of the nurses stations, it is recommended that the nurses stations be placed adjacent to convex spaces presenting high levels of local integration.

Table 6: Local integration analysis

Name of hospital	Floor composition	Local integration max value/Nurses Station local integration value	Existence of direct connection between convex space presenting highest local integration with nurses station
YH	Tree type	7.125 (Left ward hallway)/0.125	×
JH		4.642 (Right ward hallway)/0.142	×
BH		11.500 (Upper ward hallway)/2.047	○
DH	Ring type	9.975 (Lower ward hallway)/0.618	×
KH		10.500 (Lower ward hallway)/2.118	○
SH		9.625 (Upper ward hallway)/0.125	×

Table 7: Intelligibility analysis

Floor composition: Tree	Floor composition: Ring
	
YH: 0.514	DH: 0.333
	
JH : 0.603	KH : 0.366
	
BH: 0.564	SH : 0.466

Third, spatial structure intelligibility was analyzed by analyzing the correlation between integration and local integration and the results are as shown in Table 7. Geriatrics hospital treatment wards presenting tree type spatial structures presented higher spatial structure intelligibility compared to ring type structure Geriatrics hospital treatment wards which indicated that the tree type spatial structures were more easily perceived by elderly individuals. However, in light of the fact that the ring type structured Geriatrics hospital treatment wards presented greater autonomy with regards to movement along pathways and were more social compared to simple structured tree type structures, the ring type structured wards were considered to possess the advantage of providing greater chances of adaptation by elderly individuals being discharged from a hospital. In light of this when planning the spaces of treatment wards of Geriatrics hospitals, it is considered appropriate that the nature of the Geriatrics hospital and the characteristics of its patients be further reviewed before selecting certain spatial structures. This analysis results indicated that an appropriate mix of tree type and ring type structures would provide psychological stability to the elderly while also better preparing them for leaving the hospital and going out into society again.

CONCLUSION

This study undertook analyses regarding the hierarchies and perceptions of different floor compositions of Geriatrics hospital treatment wards. In doing, so, methods of spatial hierarchy analysis based on J-graph and Space Syntax were adopted for the purpose of establishing basic research material to be further applied to improve the design of Geriatrics hospital treatment wards in the future. In doing, so, the following conclusions were reached.

First, the floor compositions of Geriatrics hospitals were found to present tree type and ring type structures in which shallow tree and shallow ring type structures were presented, respectively. These structures were considered as being floor compositions that considered the physical, psychological and cognitive characteristics of elderly individuals.

Second, the treatment wards of Geriatrics hospitals each presented high connectivity in hallways which was due to the characteristics of tree type and ring type structures. Connectivity was especially, found to be high in the case of ring type structures with regards to their connected hallways.

Third, the nurses stations of the treatment wards of Geriatrics hospitals require high levels of control over the entire treatment ward and thus, need high levels of integration. However, the results of analyzing the integration levels of the treatment wards of Geriatrics hospitals indicated an absence of nurses station integration values according to tree type and ring type characteristics. However, the placement of nurses stations adjacent to convex spaces presenting high integration was found to raise the integration levels of the nurses stations. In light of this, it is recommended that the nurses stations in the treatment wards of Geriatrics hospitals be placed adjacent to areas analyzed to present high levels of integration as presented by the convex spaces.

Fourth, the tree type floor composition structure of Geriatrics hospital treatment wards presented higher spatial structure intelligibility compared to ring type structures which indicated that such spaces could easily be used by the elderly. However, in the case of the ring type structure, it was found that the structure presented some advantages associated with greater opportunities for social activity and greater autonomy to select pathways among elderly patients that may result in easier adaptability among the patients upon their discharge. Based on these findings, it was determined that the designing of Geriatrics hospital treatment wards must entail appropriate selections of floor compositions that consider the nature of the Geriatrics hospitals and the characteristics of its patients. In addition to this an appropriate mix of tree and ring type structures is believed to result in providing elderly individuals with a range of benefits.

LIMITATIONS

Despite this study having significance in that it undertook an analysis of spatial hierarchy and levels of perception according to the floor compositions of Geriatrics hospitals, there is a limitation in that the floors of 3 dimensional spaces were only considered.

RECOMMENDATIONS

In addition in light of the fact that the analysis methods of this study used convex spaces as its unit space that did not involve factors associated with the size and length of spaces, further studies in the future that improve upon such limitations are considered to be needed.

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