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Study on Spatial Characteristics of Common Space in Japanese Intensive Care Nursing Home from the Viewpoint of Resident's Occupancy

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Abstract

The common space in nursing home is an important place to enhance residents' social exchange, and to promote residents healthy and life satisfaction. However, investigation shows the occupancy of common space in Japanese nursing home is low.

This paper explores the association between space occupancy and space spatial configuration, aims to contribute to spatial design for better resident's social exchange. The factors of spatial configuration in this paper includes space geometric metrics like area size per residents, shape, distance to living space, and the spatial metrics which is measured by Space syntax theory.

Firstly, the common space area sizes and factors of spatial configuration form Space Syntax theory are analyzed and compared through the past 35 years nursing home samples for clarifying the spatial characteristics.

The investigation to nursing homes published in Japanese architecture magazines shows that the total area size of common space per resident was gradually increased since the 1980s from 3.2m^2 to 8.1m^2 in 2010-2015. In detail, the area size per resident for dining room, physical training room, multi-purpose room etc daily life category common space was increased from 2.1m^2 in 1980s to 6.5m^2 in 2010-2015, community space, meeting room etc common facilities was increased from 0.4m^2 in 1980s to 1.2m^2 in 2010-2015, the service facility common space like service station, beauty salon, shop etc were increased from 0.1m^2 in 1980s to 0.3m^2~0.5m^2 in 2010-2015. On the other hand, the area size of entrance hall, lobby and guest room, family room, day service etc remained less changes in the whole period. This reflects the tendency of increasing the dining room, physical training room, multi-purpose room etc daily life common facility and community space area size to enhance the residents' daily life and enrich social exchange in Japanese nursing homes.

The investigation of spatial configuration by Space syntax theory reveals the spatial centrality(space with the highest spatial integration value) in Japanese nursing home has been changed from the corridor in the 1980s to hall space in modern Japanese nursing homes. And, the community space, physical training room, service station, dining room, etc. common facilities were also started to be the spatial centrality in some of Japanese nursing homes after the 1995s.

About the overall changes of spatial configuration, the community space shows the increase in spatial integration and spatial connectivity in the past 35 years, from 0.78 in 1980s to 1.09 in 2010-2015, and from 2.0 in 1980s to 4.29 in 2010-2015; the physical training room shows small increase in spatial integration and spatial connectivity, from the 0.99 in 1980s to 1.02 in 2010-2015, and from 1.83 in 1980s to 3.13 in 2010-2015. Because both spatial integration and connectivity are the indicator of accessibility, this transition tells the tendency to allocate place with higher spatial centrality for community space and physical training room in Japanese nursing homes. On the other hand, the analysis also reveals that the service stations which were allocated in place with high spatial integration in classical large-scale care nursing homes are allocated to place with lower spatial integration in modern unit care nursing homes.

Then, the space occupancy were surveyed. The number of residents in eight common facilities at 12 nursing homes from 8:00am to 18:00pm were investigated.

Further, the space occupancy regression model with spatial configuration were performed. Based on the common characteristics in occupancy time and purpose in common facility, a general occupancy regression model for all common facilities, and specific regression model for common space exclude dining room were obtained.

The regression model for all common facilities as general common space are extracted with the spatial integration, area size per resident, and spatial connectivity as significant spatial configuration factors, which tells that generally the space occupancy(occupancy rate) can be increased by increase in spatial integration, per resident area size, and spatial connectivity.

This regression model basically applies to common facilities without considering the occupancy difference between dining room and others(for example, in the floor where there is dining room located).

And, when taken all common facilities except dining room as a common space, the space area size, and spatial connectivity are significant spatial configuration factors.

This regression model 2 applies to common facilities with considering the occupancy difference between dining room and others(for example, in the floor where there is no dining room located). Because only space area size and spatial connectivity are significant variables, this model is much easier to use in actual nursing home common space design practice.

As a conclusion, with certain range of spatial configuration and space occupancy within the 12 surveyed nursing homes, allocating common facility to place with higher spatial integration, more spatial connectivity with surroundings, and increasing the average space area size per resident are valid way to raise the space occupancy of common space in Japanese nursing homes.

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Chapter 1 Introduction

1.1 Background and Research objective

1.1.1 Importance of common space and occupancy in nursing home

The social integration and the strength of social ties are important predictors to the elderly healthy and longevity(Byoung-Suk, 1998), and it has profound effects on individuals' physical and mental well-being throughout the life(Antonucci T., 2009). This also applies to residents of nursing home: the resident-resident relationships influence their life satisfaction(Park, 2009), subjective well-being(Street, and Burge, 2012), and quality of life(Ball et al.,2004 ; Street D. et al., 2007; Candace L., 2012).

Moreover, the architecture spatial layout influences the resident's social life(Penn, 1999; Sailer and Penn, 2009; Sailer et al, 2013). The physical environment, specially the common space, can promote peoples' social integration(Byoung-Suk, 1998). The formation of social ties is substantially depended on the informal social contact which occurs in the common spaces(Frances E, 1998).

Research also shows same conclusion for common space in nursing home: it facilitates social interaction(Diane Y., 1993), and is conducive to resident interaction(Candace L., 2012), which in turn affects individual, group, organizational outcomes and quality of life(Keith D., 2012; Burton 2012; Calkins 2009; Ulrich et al. 2008; Renalds 2010).

1.1.2 Issues of common space and occupancy in Japanese nursing home

Because of the significance of common space in residents' social life in nursing home, it is important to promote its utilization. We have improvement history of system for resident's daily life on intensive care nursing home in Japan. The developing the unit care system is one of significant achievement for realizing familiar care with suitable space. Residents can share the unit living space for their daily life as smallest community space. However, the utilization of common space in Japanese nursing homes is low especially in the outside of units. Investigation shows residents spent about more than 90% of time a day within the care unit where they're living, the time staying in hall, lobby, community space, physical training room etc. common space was only about 4% to less than 10%(Kanki 2005a, Toyama 2002, Sannomiya 2004), for example,

According to Kanki Y. et al.(2005a, p66), Study on the residents' space-use and behavior at common spaces:
The percentage of time a day that resident staying in their own care unit: 89.0%
The percentage of time a day that resident staying in other care unit: 2.3%
The percentage of time a day that resident staying in common facilities: 4.5%
The percentage of time a day that resident staying out of side of nursing home: 4.2%

According to Toyama(2002), the stay rate of residents in private and semi-private area reaches 98%(Toyama 2002, p74):
The stay rate during day time at bed: 40.2%
The stay rate during day time inside private room and corridor: 7.5%
The stay rate during day time in toilet: 4.0%
The stay rate during day time in bathroom: 4.2%
The stay rate during day time in living space: 42.8%
The stay rate during day time in other place: 1.2%

According to Sannomiya M., the occupancy rate of each space in investigated nursing home(Sannomiya 2004, p137):
The occupancy rate of private room: 58.3%

The occupancy rate of living space: 35.8%
The occupancy rate of common space: 2.3%
The occupancy rate of corridor: 3.1%

And, based on the study done by Ishibashi, 87% of residents in unit care nursing homes uses living room for daily food service(Ishibashi 2015). The utilization of common space out of the unit where the residents belong to is low, which includes the community hall/community space, physical training room, multiple purpose room, lobby, lounge etc.

The longer staying time of residents in the care unit and lower occupancy of common space in Japanese nursing home brings the risk that the residents close themselves in the small unit, and affects their social life. In order to enhance residents social life, it is important to promote the use of common space outside of the unit(Kanki 2005b), like community space, physical training room, multiple purpose room etc. Therefore, there is the needs to find a means to promote common space utilization from the viewpoint of common space design.

However, what is an effective common space design in nursing home? So far there is no report about quantitative evaluation and proposal of common space design. Researchers in US argue and suggest the smaller space to facilitate the social interaction and conversation(Diane Y. 1993 p. 21, Lois J. 2006). But, it is not clear that it is applicable to nursing home in Japan, and what the spatial layout is.

On the other hand, there has been growing interests in applying Space Syntax(SS) theory to analyze the relationship between people's activity and the spatial structure in urban design and public buildings(Young 1999; Takano 2012), especially from the year of 2000, there are many successful examples in applying SS theory to commercial building facilities, libraries, and museums.

However, the elderly's movement and involvement in space in nursing homes are different from general people's space recognition and behavior in public facilities because of the slow space recognition of elderly and defined care service in the nursing home. The methodology and application of SS theory for general peoples' recognition and involvement in space may not be always applicable to elderly residents in nursing home.

For thinking the better communication in common space, the resident's occupancy in the common space is extracted as the specific aspect of resident's chance of communication from many factors of utilization. And a method for quantitative evaluation of the association between spatial configuration and occupancy should be considered for improving the better utilization of common space in nursing home design.

Therefore, in this article I specify the common space out of care unit like community space, physical training room, multiple purpose room, lounge, hall etc as research target, to verify the feasibility of applying SS theory to express elderly's involvement in these common space, to find the association between residents' space utilization and spatial configuration, and to explore a way in effective design of common space from the perspective of having higher efficiency common space utilization in Japanese nursing homes.

1.1.3 Research objectives

The objective of this research is to explores the association between space occupancy and spatial configuration in the common space of intensive care nursing home, for contribution to spatial design for better resident's social exchange. The factors of spatial configuration in this paper includes space geometric metrics such as area size per residents, shape, distance to living space, and the spatial metrics which is measured by Space syntax theory.

From the document survey, the following two topics will be discussed as basis for common space configuration evaluation.

1. The current state of area size of each common spaces and how it was transited from past in Japanese nursing home in consideration with Japanese regulations?

2. The current state of spatial configuration of common space, the types of spatial configuration of common space, and how it was transited from past in Japanese nursing home?

And from on-site field survey, the current occupancy data are collected and analyzed for clarifying the representing characteristics of resident's occupancy of common space.

Then, the association between resident's spatial occupancy and spatial configuration in nursing homes are analyzed on regression model. Finally The actual spatial configuration are considered from the view point of resident's better communication.

1.1.3.1 Research scope

In this research, the intensive care nursing home in Japan is the object of study. It is elderly care facility providing nursing care services to elderly people whose nursing care insurance is applied based on nursing care insurance law, and this is the main elderly care facility in Japan [Note 1)].

The common space in this research means the space of common facilities where the residents can share activity commonly, such as community center, community space, physical training room, club house, care and service station, and restaurant, dining room etc. space in nursing home.

The spatial configuration in this research means the space geometric metrics such as area size per residents, shape, distance to living space, and the spatial factor which is measured by Space syntax theory(spatial integration, depth, connectivity, access etc.). The space geometric is included because it was reported that area size influences the social interaction(Diane Y., 1993, p. 21; Ball et al., 2004; Eckert et al., 2001).

The space occupancy in this research is defined as the proportion of time that a common space is occupied during certain period a day, for indicating the residents' chance of communication in the common space.

1.1.3.2 Common space classification in Japanese nursing homes

With the introduction of regulation on unit care nursing home by Ministry of Health, Labor and Welfare in 2002 [Note 2)], Japanese nursing homes has been transited from classical large-scale nursing care to unit care. By this transition, the space structure including common space has also been changed, as shown in Fig. 1.1.

In the large-scale care nursing home, the common space is mainly concentrated in one location, where eating, recreation, and rehabilitation are taken place. On the other hand, in unit care style the dining room and day activity are separated, living space is designed and shared by several private rooms, and further, it connects to place with higher publicity.

The space in unit care nursing home is divided as shared space and personal space. The shared space is further divided into public space which is used for social community service, and the semi-Public space used by residents from different living units. The personal space is divided into semi-Private space such as living space, dining room, and the private space(private room) as shown in Table 1.1.

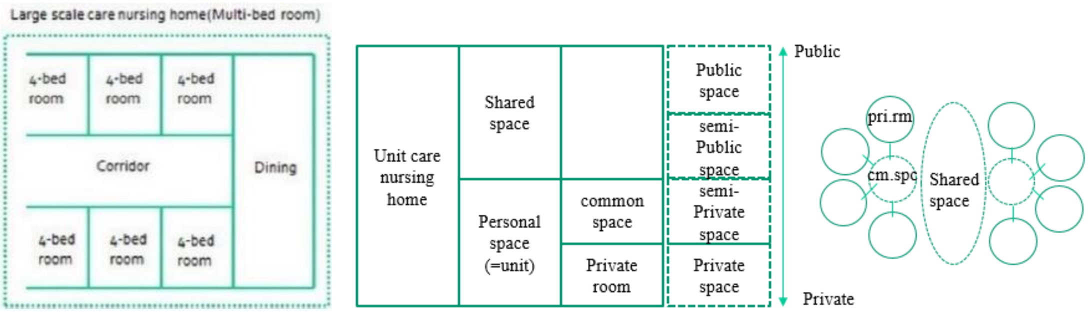

Fig. 1.1 Common space in Japanese classical large-scale care nursing home(left), unit-care nursing home(right)(Source: MHLW 2015(left), Mori 2003(right), translated by author)

Table 1.1 Space classification in nursing homes

Space	Large scale care nursing home	Unit care nursing home
Public space	Corridor, entrance hall, lobby	Community space, entrance hall, lobby, day service
Semi-public space	Dining room	Physical training room, club house, dining room
Semi-private space	Shared living room	Living space
Private space		Private room

The common space in this research covers the Public and Semi-public space which includes the community center/space, physical training facilities, club house, care and service station, restaurant, and dining room, as shown in Table 1.2.

Table 1.2 Common space in nursing homes

Common space	Public space	semi-Public space	semi-Private space	Private space
Entrance hall	O			
Dining room		O[1)]	X[2)]	
Physical training room		O		
Multiple purpose room		O		
Service station		O		
Community space	O			
Day service room	O		X	
Living space			X	

Note: 1)The dining room in classical large scale care nursing room servers all residents, belongs semi-Public space, or Public space.
2) The dining room in unit care nursing home, depends on location, can be semi-Public space serving residents from different units, or semi-Private space serving residents within same care unit.

1.2 Previous research

1.2.1 Study of spatial configuration and behavior in elderly facilities in Japan

Common space design is a study of concern in Japanese nursing home. There is much research reported so far to verify the utilization and importance of common space to resident social life by the observation of resident environment behavior or interview on resident daily activities. The researches done by Inoue(1990), Kato(2007), Mori S.(2004), Kozuma(2015), Toyoma(2002), Murakami(2011), and Mori K.(2014) are typical examples.

The resident environment behaviors observed in these investigations including conversation, idleness, wandering, planned activities, etc.

By analyzing the actual utilization status, Inoue put forward the topic of the necessity of having common facilities in the nursing home(Inoue, 1990), and based on environment behavior observation for over 50 residents in 3 nursing homes, Kato conducted a research on factors to improve residents living quality(Kato, 2007). Further, by the observation of actual care activities and people's movement in common space, Mori pointed out the problem in current nursing home common space designing that some of the care functions which should originally be performed in common space were actually packed into private room(Mori S., 2004), and Kozuma proposed a living space layout rearrangement to improve residents stay and routines of movement(Kozuma, 2015). Terabayashi(2015)'s research on common space shortage and future development based on 37 nursing homes in Kanto area.

Since the introduction of Space syntax theory by the University College London in 1980s(Hillier and Hanson 1984, Hiller 1990), there has been increased number of quantitative studies about human environment behavior and spatial configuration(Congsi 2015, Saif 2012, Teklenburg 1993, Peponis 1990, Pelin 2007). Among them, Penn's study on the effect of spatial configuration to communication patterns and people's movement was an typical example(Penn 1997). Besides, Turner et. al verified the importance of spatial features in people's use of space(Turner 2001), Dursun and Saglamer concluded that distinctive characteristics of societies exist within spatial systems, and association between social characteristics and space can be studied by Space syntax(Dursun and Saglamer, 2003).

The environmental behaviors and social characteristics investigated in these research includes(Congsi 2015):

Wandering – a waking activity without any particular purpose or destination.
Standing – standing at a particular place without clear purpose, or stops during wandering.
Socializing – talking to each other or gaining information by using verbal or non-verbal communication.
Wayfinding and movement(Saif 2012) – finding the way to destination and passing through.

The SS theory were also applied for nursing home spatial configuration quantitative analysis in Japan. Kang S. conducted spatial analysis for four nursing homes by using SS theory, and concluded to widen facility and front hall to secure communication within residents(Kang, 2012). Bai L. analyzed the changes of common space spatial configuration in the past 35 years, and concluded that compared with classical large-scale care nursing homes, the spatial integration of community space in modern unit care nursing homes is increased, but service station and dining room are reduced, and identified the importance of community space in modern nursing homes(Bai L., 2018).

However, so far the quantitative studies on nursing home spatial configuration is still very limited in Japan, and there is no report on the association of common space spatial configuration with residents' utilization in Japanese nursing home, and no report on common space design based on the quantitative relationship between spatial configuration and residents utilization of common space in Japanese nursing homes.

1.2.2 Study of spatial configuration and behavior in elderly facilities oversea

Hanson did the first study of applying Space syntax to nursing home in 2005. He investigated the relationship between perceived quality of life(QoL) and spatial layout in 36 senior homes in Engliand(Hanson and Zako, 2005; Saif H, 2012). In the study, he analyzed ten space syntax syntactic metrics, and their effects on residents' QoL score.

The QoL score is syntactic variables based on the proportion of time active during the observation, the frequency of enjoyable activity, the choice and control over the environment etc. The result shows that the SS spatial integration syntactic metric were significant associated with quality of life outcomes(Saif H, 2012).

Congsi H. studied the spatial syntactic metric of accessibility, the intelligibility and its relationship with resident's wandering, standing, and socializing behaviors in three day-care centers in Germany. The results show a positive correlation between spatial accessibility and frequencies of these activities(Congsi H. 2015).

Keith performed similar study. He did behavioral observations for 150 residents in three care facilities in German. By using the SS visibility and proximity syntactic metrics, he identified its relation with the locations of various social activities occurrences, and confirmed the influence of spatial configuration on social interaction(Keith D 2012). The further research done by Ferdous also support this result(Ferdous F., 2015).

The environment behaviors in Keith D's observation includes movement, light conversation, physical interaction, prolonged conversation etc(Keith D 2012).

Gesine M investigated the residents' activities of daily living(ADL), and its association with spatial configuration for 82 participants in a dementia care facility in Germany, confirmed the correlation between spatial convexity(ratio of the number of all convex spaces to the number of functional rooms) and the ADLs(Gesine M, 2011).

Campos examined the relationship between spatial configuration and patterns of space use in social welfare buildings and two day-care centers. He analyzed the space visibility graph, people's movement flows, staff and users' interaction, and concluded that the ability to provide social services is significantly affected by the spatial layout(Campos et al., 2007).

Lee J investigated the spatial and social properties in elderly care facilities, and suggested that social and cultural factors may shape the design of elderly care settings(Lee J., 2017).

Joseph analyzed the relation between physical environmental factors and walking behavior of residents in 3 US elderly facilities, concluded that space configuration and settlement relates to patterns of walk routine selection and movement(Joseph 2006).

The similar researches were also done on the wayfinding performance of visitors and patients, and on nurses' movement in hospitals(Khan N., 2012; Seo H. B., 2010; Haq S. et al. 2005; Hendrich et al., 2009). The result shows the strong correlation between spatial syntactic metrics and observed nurses' behaviors(Cai H., 2012). In addition, in Haq and Luo's comprehensive literature review, they concluded that SS theory is able to successfully perform quantitative spatial data analysis for hospital space(Haq and Luo, 2012).

However, the targeted spaces in above studies were day-care centers(ADCs), hospitals, and US elderly facilities. By considering the specialty of Japanese nursing home spatial structure(like unit care nursing home), and the difference in culture and environmental behavior in Japan, these study results are referenceable but it's not unclear whether they are applicable or not to nursing homes in Japan

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In short, the studies done so far in care facilities, hospitals, nursing homes by SS theory includes the space SS spatial metrics like integration, accessibility, visibility, convexity, intelligibility, local integration etc., and the environment behaviors investigated includes the residents' or peoples' wandering, standing, socializing, wayfinding and movement, active time, conversation etc. These studies reveal that correlation exists between space SS spatial metrics and environment behavior.

However, the targeted spaces in above studies were day-care centers(ADCs), hospitals, and US elderly facilities. By considering the specialty of Japanese nursing home spatial structure(like unit care nursing home), and the difference in culture and environmental behavior in Japan, these study results are referenceable but it's not unclear whether they are applicable or not to nursing homes in Japan.

1.2.3 Previous Research Summary

In summary, the studies on nursing home spatial configuration is still very limited in Japan, and there is no report on the association of common space spatial configuration with residents' utilization in Japanese nursing home.

There were many researchers oversea of implementing space syntax to healthcare facilities including nursing homes to examine the effect of spatial configuration on resident's environmental behaviors. The human and environment behaviors investigated covers wandering, standing, idleness, wayfinding and movement, active time, conversation and socializing etc various activities. These research disclosed the correlation exists between SS spatial metrics and these human environment behaviors in common space.

However, these study targets, the spatial structure, and social culture and behaviors of people are different with Japan. But it reminds me the needs of study to explore the association between spatial metrics and residents' behavior, or at least, the total stay time for all kinds of behaviors in Japanese nursing home common space, so as to provide a method for common space effective design from the perspective of having higher efficiency utilization in Japanese nursing homes.

1.3 Methodology

1.3.1 Factors affect common space utilization

There are a number factors which may affect the occupancy of common space. These factors can be human administrative, external changeable factors and the space internal inherent characteristics.

The human administrative factors include the planned, and organized group activities like festival events, welcome party etc.

Besides, the external factors like the equipment deployed on-purpose, air conditioner, the equipped sofa/chair, table, and decorations can also affect residents' common space utilization. These factors are easily changeable after common space is designed and created.

However, in this research we focus on the space inherent spatial characteristics, includes spatial metrics like the accessibility, connectivity with surroundings, and geometric metrics like the area size, shape, distance etc. These spatial characteristics can't be changed as long as the space is designed and created. The administrative factors such as special event will be carefully excluded through the onsite observation, and the external factor such as temperature will be checked so as to have similar temperature condition.

For the space accessibility and connectivity with surroundings, the spatial metrics measured by Space syntax theory is selected because researches confirmed SS theory is a valid tool to quantitatively evaluate the spatial configuration(Hillier and Hanson 1984, Hiller 1990).

In short, the factors of spatial configuration considered in this research includes:

- The spatial geometric metrics like:
  - o Space area size
  - o Space shape: circle, square, rectangle, triangle, etc
  - o The proximity(distance between each other)
- The Space syntax syntactic spatial metrics:
  - o Spatial connectivity
  - o Spatial depth
  - o Spatial integration

1.3.2 Common space occupancy

As mentioned before, the space occupancy in this research means the proportion of time that a common space is occupied during certain period a day.

The on-site survey and interview of nursing home care staff of resident's occupancy of common space is performed. Here the occupancy of a common space is defined as the percentage of time averagely one resident spent at a common space to the total observation duration(8:00am ~ 18:00pm). The number of residents stay in common space is recorded in each 30 mins time interval, which leads the occupancy as:

$$\text{OCP} = \frac{\sum(NUM*TIM)}{Total\ observed\ residents *DUR(mins)} \qquad (1)$$

Where the NUM is the number of residents staying in common facility observed; TIM is the observation time interval, 30 mins; DUR is observation period, 600 mins from 8:00am to 18:00pm.

It is assumed that the opportunity of communication would increase when people stay in common space longer. Compared to the specific behavior like chatting, playing, reading, meditating the stay time is more fundamental and is only considered in this research.

1.3.3 Common space area size

The area size calculation tool in AutoCAD is used to measure the space area size.

The workflow of common space area size analysis is shown in Fig. 1.2.

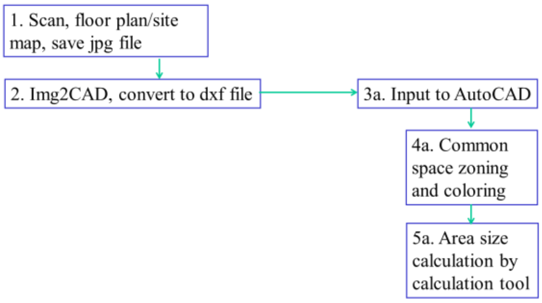

Fig. 1.2 Common space area size analysis workflow(Source: created by author)

1.3.4 Spatial metrics measured by Space syntax

SS theory provides a number of spatial synthetic metrics to depict spatial configuration(Hillier 1996). Among them, the depth measures the topological steps(turnings) from one space to another(Klarqvist B, 1993); the connectivity specifies the number of units directly connected to a space; the integration expresses the relative depth of a space from the others, it is fundamental indicator of spatial centrality: the higher integration of a space, the higher centrality of this space within the space system(Dettlaff, 2014). This is the main metric to describe the spatial configuration in this research.

In this research, these spatial metrics will be used to describe the common space spatial configuration, the detail of space syntax theory and workflow is mentioned in Chapter 3.

1.3.5 Regression analysis of common space occupancy and spatial configuration

The multiple linear regression analysis between space occupancy and spatial characteristics is performed to find the significant spatial factors. The multiple linear regression model is selected is because it attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data, and fits the need to find the significance of each explanatory variables(spatial configuration in this research) to response variable.

This is done by using IBM SPSS data analysis tool[Note3)], the detail is mentioned in Chapter 5.

1.4 Research procedure

This research intends to clarify the spatial characteristics of common space and its association with resident's use in Japanese intensive care nursing home, aims to contribute to spatial design for better resident's social exchange.

The procedure of whole research is shown in Fig. 1.3.

Chapter 1 clarifies the background, purpose, objective and significance of this study includes the previous literature review.

This chapter also introduces the research methodology. A simple introduction of SS theory, the spatial metrics, analysis workflow, common space occupancy survey, and the multiple linear regression mode are included.

Chapter 2 studies the transition of common space area size in Japanese nursing homes from past 35 years. Totally 79 nursing homes with floorplan available from Japanese architecture publication were selected, the common space area size within it is analyzed by using AutoCAD tool, which will be used for common space occupancy regression model analysis in Chapter 5.

Chapter 3 analyzes the common space spatial metrics in Japanese nursing homes and how it was transited from past. The spatial structure, especially the common space from totally 62 nursing homes were analyzed. The changes of SS spatial characteristics of common space from classical large-scale care type nursing home to unit care type are summarized. The result from this chapter will also be used for common space occupancy regression analysis in Chapter 5.

Chapter 4 details the common space occupancy survey in nursing homes, covers the survey scope, the selection of survey site, the questionnaire data collected, and occupancy survey data result.

Chapter 5 proposes the multiple linear regression model for common space occupancy in nursing homes. This chapter also introduces the use cases of common space spatial design based on the derived regression model.

Finally, the Chapter 6 summarizes what we learned from this study, and the perspective for future research.

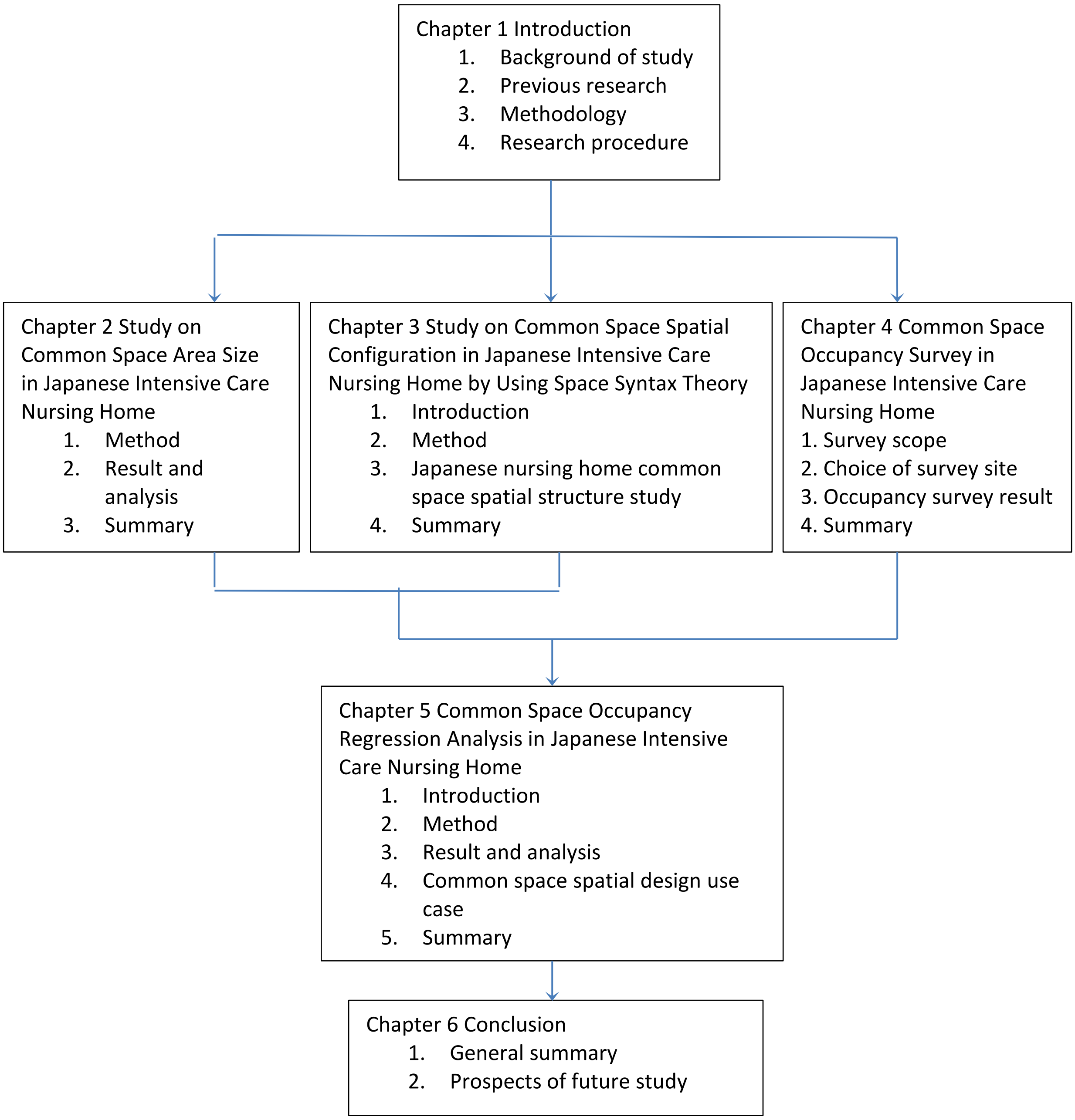

Fig. 1.3 Research procedure(Source: created by author)

Note:

1) Long-term care old-welfare institution. https://ja.wikipedia.org/wiki/%E4%BB%8B%E8%AD%B7%E8%80%81%E4%BA%BA%E7%A6%8F%E7%A5%89%E6%96%BD%E8%A8%AD (Accessed Oct.1, 2017)
2) Ministry of Health, Labor and Welfare(Sep. 28,2009), http://www.mhlw.go.jp/topics/kaigo/kaigi/010928/siryo5-1.html (accessed May 25, 2018).
3) IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.

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Chapter 2 Study on Common Space Area Size in Japanese Intensive Care Nursing Home

2.1 Introduction

This chapter studies the common space area size in Japanese nursing home, to clarify the current common space area size and how it was transited from the past. Knowing the common space area size transition and tendency is helpful to common space design in future and it is also the basis of occupancy analysis of common space in Japanese nursing home.

2.2 Method

2.2.1 The classification on common space

In this research, we aim to explore the common space where residents can share activity commonly, the spaces used by facility staffs is out of scope.

Based on the floorplan, the common space matching the definition in this classification were zoned. And, because investigation shows residents spent more than 90% time inside nursing home(Kanki 2005, Tachibana 2002, Tanaka 2000, Toyama 2002, Sannomiya 2004, Ishibashi 2015), we focus the analysis to common space inside nursing home.

For this consideration, following common facilities in public and semi-public regions are subjects of analysis in this research. Further, based on the features and functionality of each common facility, we also classify these common facilities to different category for the understanding the affect to resident daily life by different common space categories.

The considered common facilities and category is listed in Table 2.1.

1. Entrance and entrance hall surrounding space where people can stay and perform communication activity.
2. Living space, restaurant, cafeteria, tea ceremony, physical training room etc space.
3. Hobby room, entertainment room, multiple purpose room.
4. Beauty salons, convenience shops, vending machines etc. service enhance facilities.
5. Community space, gathering room etc community activity space.
6. Guest room, day service etc temporary occupancy space.

Table 2.1 The common facilities and category of indoor common space

Symbol	Category	Public or Semi-public space	Example	Example Abbreviation
ICS1	Hall	Public	Entrance halls, front hall and lobbies etc.	ENH
ICS2	Daily life	Semi-public	Dining room, tea room, coffee corner, rehabilitation room, physical training room, lounge etc.	DRM, PTR
ICS3	Hobby	Semi-public	Classroom, library, handicrafts room, hobby room, recreation room, multi-purpose room etc.	MPR
ICS4	Service facility	Semi-public	Beauty salon, shop, vending machine, telephone booth, service station etc.	SST
ICS5	Community facility	Public	Community space, meeting room, conversation room etc.	CMS
ICS6	External use	Public	Guest room, family room, day service center, volunteer room etc.	DSR

2.2.2 Selection of research objects

In this research, as a representative sample of nursing homes, the design data summarized for each facility and published in "New Architecture(Shinkenchiku)", a journal that has continuously posted architectural works in Japan, and special edition of elderly housing published in "Architectural

Design", and special edition of "Senior Life Care" of "Modern Architecture" were selected as research targets.

Add, it is considered that the care service and relationship with local community in Japanese nursing homes was strengthened around 1977 ~ 1979 for following reasons. Therefore, the nursing home built in 1978 to 2015 is selected as research target in this study.

According to the investigation of National Social Security and Population Research Institute the intensive nursing home in Japan has two changes in 1977 ~ 1979 [Note 1)]. First, the National council for social welfare recognized the necessity of new regional features providing short stay service, day home service, bathing service, meal service in nursing home as a countermeasure for at-home care in the "Research on the Improvement of Urban-type Special Nursing Home for the Elderly" in Aug. 1977.

Second, the "Central Social Welfare Council/Elderly Welfare Specialized Subcommittee" has recommended the necessity of opening nursing home for local community in 1977, and established the subsidize policy for nursing home to provide short-term stay(1978) and day service(1979).

Moreover, based on the scale of nursing care conducted, the selected nursing homes are divided to classical large-scale care type and unit care type(Ohara K, 2002) [Note2)].

There might be the concern that the nursing homes in publish magazines tend to be advanced designed compared with most ordinary nursing homes, because the data about designing, site condition, floorplan, and architecture features were sufficiently posted in magazine, these data can be helpful to clarify the common space, so the object selection is helpful in this research.

The totally 79 nursing homes from above publications are shown in Table 2.2, where the classical care type is 50, and unit care nursing home is 29. Fig. 2.1 shows the average number of floors and average ratio of floor-to-site area size in each five year for these nursing homes.

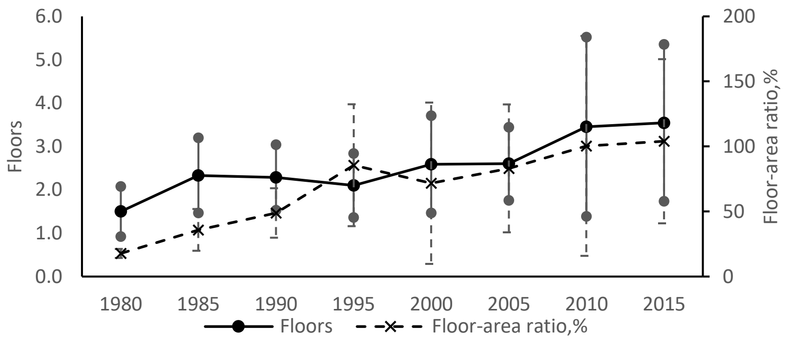

Fig. 2.1 Average floors and average floor-area ratio per 5 year interval (source: created by author)

Table 2.2 The list of selected nursing home and common facility inside

	Year of complete	Nursing home name	Site area, ㎡	Floor area, ㎡	Capacity	Stories	Publication	ICS1*	ICS2	ICS3	ICS4	ICS5	ICS6	Type**
1	1978.5	Wajunsou	7506	1381	50	2F	Arch. design, Vol.3	○	○		○			C
2	1979.7	Nanai	7506	1266	50	2F	Shinkenchiku. Vol.3,1980	○	○			○		C
3	1979.8	Cyouwaen	13946	3077	100	1F	Arch. design, Vol.3	○	○		○			C
4	1979.8	Komono Seijuji-no-ie	26316	3606	120	1F	Arch. design, Vol.3	○	○		○			C
5	1980.3	Shoujuen	5782	2165	75	2F	Arch. design, Vol.3	○	○		○			C
6	1980.9	Manseikeirouen	21205	4526	200	3F	Arch. design, Vol.3	○	○					C
7	1981.3	New Fuji home	21205	3225	100	3F	Arch. design, Vol.3	○	○					C
8	1982.11	Seimeien Kotobukiso	4717	3175	100	2F	Arch. design, Vol.3	○	○	○	○	○		C
9	1982.11	Yamayuri home	7416	3563	88	B1F+2F	Arch. design, Vol.3	○	○	○	○		○	C
10	1982.4	Nanjuen	6603	2723	85	2F	Shinkenchiku. Vol.6,1983	○	○	○	○	○		C
11	1982.3	Yasuragien	8330	1667	54	1F	Shinkenchiku. Vol.12,1982	○	○					C
12	1983.7	Kamigoen	10339	3646	104	2F	Arch. design, Vol.34	○	○	○				C
13	1984.3	Tokyo Kousaien	16606	6150	150	4F	Arch. design, Vol.34	○	○	○	○	○	○	C

	Year of complete	Nursing home name	Site area, m²	Floor area, m²	Capacity	Stories	Publication	ICS1*	ICS2	ICS3	ICS4	ICS5	ICS6	Type**
14	1985.4	Seibo-no-sono	11790	4989	120	2F	Arch. design, Vol.34	○	○	○	○	○		C
15	1987.3	Taiyou-no-kuni	4498	3314	88	3F	Arch. design, Vol.34	○	○	○	○			C
16	1987.3	Kotouen	6693	3904	180	3F	Arch. design, Vol.34	○	○	○	○	○	○	C
17	1987.3	Basyoen	2844	1939	54	2F	Arch. design, Vol.34	○	○				○	C
18	1987.4	Yuwaen	8079	2904	80	B1F+1F	Arch. design, Vol.34	○	○	○				C
19	1988.3	Miyama Taiju-no-sono	20886	4088	110	3F	Arch. design, Vol.34	○	○		○			C
20	1989.6	Meiwaen	4836	2138	55	2F	Arch. design, Vol.34		○	○	○			C
21	1990.8	Kousyun-no-sato	6820	4674	120	2F	Arch. design, Vol.34	○	○	○	○	○	○	C
22	1990.3	Nakameguro home	2098	2973	58	B2F+2F	Arch. design, Vol.34	○	○	○				C
23	1990.4	Akaneen	2200	3288	66	B1F+3F	Arch. design, Vol.34	○	○		○		○	C
24	1990.5	Azariia home	3190	2705	70	2F	Arch. design, Vol.34	○	○	○			○	C
25	1991.3	Aichi Taiyonosya	9500	3477	100	2F	Arch. design, Vol.34	○	○	○		○	○	C
26	1992.2	Ikoni-no-sato	10285	3452	90	1F	Arch. design, Vol.34	○	○				○	C
27	1993.5	Asahien	4603	6636	110	B1F+3F	Arch. design, Vol.71	○	○		○	○	○	C
28	1994.4	Rapport Fujisawa	3305	2837	70	3F	Arch. design, Vol.71	○	○		○			C
29	1994.6	Orahausu Unazuki	17375	4322	60	1F	Arch. design, Vol.71	○	○	○	○		○	C
30	1994.11	Kichijouji-home	9441	8145	180	B1F+2F	Arch. design, Vol.71	○	○	○		○	○	C
31	1995.3	Roka home	4373	9443	120	B1F+4F	Arch. design, Vol.71	○	○	○	○	○	○	C
32	1995.3	Arupenhaitsu	4993	3298	60	2F	Arch. design, Vol.71	○	○		○			C
33	1995.3	Sakurajimaen	18431	2992	62	1F	Arch. design, Vol.71	○	○				○	C
34	1996.3	Ogura Mena	9264	3414	80	2F	Arch. design, Vol.71	○	○		○	○	○	C
35	1996.3	Sunshine Minoshirakawa	9812	3316	70	2F	Arch. design, Vol.71	○	○				○	C
36	1997.2	Inasa Aikoen	17376	3610	70	1F	Arch. design, Vol.71		○			○	○	C
37	1997.10	Tokami Kyouseien	15045	5518	100	2F	Arch. design, Vol.71	○	○	○	○	○	○	C
38	1997.3	Daini Seifuuen	9890	6328	130	B1F+3F	Arch. design, Vol.71	○	○	○	○	○	○	C
39	1997.3	Karitasu21	4057	4245	70	3F	Arch. design, Vol.71	○	○		○	○		C
40	1998.4	Suzuura-home	2579	4980	107	B1F+5F	Arch. design, Vol.71	○	○		○	○	○	C
41	1998.3	Popuranoki	4776	2748	60	3F	Arch. design, Vol.71	○	○	○			○	C
42	1998.3	Well port Kashimanosato	11004	4018	60	2F	Arch. design, Vol.71		○		○		○	C
43	1998.12	Toriasu	3411	3733	92	3F	Arch. design, Vol.71	○	○		○		○	C
44	1998.3	Kagobo-no-sato	35875	2999	70	1F	Arch. design, Vol.71	○	○					C
45	1999.2	Betania-home	3895	5517	88	4F	Arch. design, Vol.71	○	○	○	○	○	○	C
46	1999.2	Wagou Aikouen	32970	4339	70	3F	Arch. design, Vol.71	○	○	○		○	○	C
47	1999.12	Kazenomura	5683	3684	57	3F	Arch. design, Vol.103	○	○		○	○	○	C
48	2001.12	Komae Shokichien	5991	3531	60	3F	Arch. design, Vol.103	○	○		○	○	○	C
49	2001.3	Kema Kirakuen	2077	3779	70	B1F+3F	Arch. design, Vol.103	○	○				○	C
50	2001.1	KatsushikaYasuraginosato	2670	4036	111	3F	Shinkenchiku. Vol.6,2001	○	○	○		○	○	C
51	2003.9	Nozomi	3306	3260	60	B1F、	Arch. design, Vol.103	○	○		○	○		U
52	2003.3	Yuraku	15378	6558	100	3F	Arch. design, Vol.103	○	○	○	○	○		U
53	2003.2	Sakuranosato	10666	3416	50	1F	Shinkenchiku. Vol.4,2004	○	○		○	○	○	U
54	2004.8	Sawayaka-Nursing-Mitake	6741	5383	100	B1F+2F	Arch. design, Vol.103	○	○		○		○	U
55	2004.3	Residence Hana	7027	5176	120	4F	Arch. design, Vol.103	○	○		○	○		U
56	2004.11	Kuniyasuen	18382	6797	100	2F	Arch. design, Vol.103	○	○	○	○	○		U
57	2004.3	Hikarinosono	10187	7728	170	3F	Arch. design, Vol.103	○	○			○	○	U
58	2005.6	Daini Tangoen	30492	3137	60	3F	Arch. design, Vol.103	○	○					U
59	2005.10	Nanafukujin	6794	3579	80	2F	Modern archi.Vol.3,2006	○	○			○	○	U
60	2005.9	Hadano Syojuen	5360	6541	130	5F	Modern archi.Vol.3,2006	○	○					U
61	2005.3	Minamikaze	5478	5197	100	B1F+2F	Arch. design, Vol.103	○	○	○	○		○	U
62	2005.7	Sannoen	7749	5636	85	3F	Modern archi.Vol.3,2006	○	○		○	○		U
63	2005.9	Mitakenooka-Shibuya	4000	13383	215	9F	Modern archi.Vol.3,2006	○	○	○		○		U
64	2005.7	Soleil	5890	4614	105	2F	Modern archi.Vol.3,2006	○	○			○	○	U
65	2005.2	Ferichu Uehara	8616	4268	100	2F	Modern archi.Vol.3,2006	○	○			○	○	U
66	2005.5	Shinonome-no oka	12547	8102	112	3F	Modern archi.Vol.3,2006	○	○	○		○		U
67	2006.1	Mirai	4925	4969	90	3F	Modern archi.Vol.3,2006	○	○				○	U
68	2007.1	Shukutoku kyoseien	6143	7647	100	4F	Modern archi.Vol.3,2006	○	○			○	○	U
69	2010.10	Kokoro	6547	5650	135	3F	Modern archi.Vol.2,2014	○	○		○	○		U
70	2010.12	Aichitaiyonosha	7791	1442	40	3F	Shinkenchiku. Vol.10,2011	○	○			○		U
71	2012.3	Machida Shokichien	2545	4877	90	5F	Shinkenchiku. Vol.10,2012	○	○	○		○	○	U
72	2012.6	Kobaiso	12660	3285	96	1F	Shinkenchiku. Vol.10,2012		○					U
73	2012.3	Rihabiri-shirotori	2231	1913	54	2F	Shinkenchiku. Vol.10,2012	○	○	○			○	U
74	2012.12	Otakenosato	4006	7989	140	5F	Modern archi.Vol.2,2014	○	○			○		U
75	2012.3	Ragaru	4621	5566	130	3F	Modern archi.Vol.2,2014	○	○	○	○			U
76	2013.3	Mezurasyo	9786	9265	138	6F	Modern archi.Vol.2,2014	○	○					U

	Year of complete	Nursing home name	Site area, ㎡	Floor area, ㎡	Capacity	Stories	Publication	ICS1*	ICS2	ICS3	ICS4	ICS5	ICS6	Type**
77	2013.1	Koujuen	3576	4442	80	4F	Modern archi.Vol.2,2014	○	○		○			U
78	2013.1	Jurakuen	3503	5692	100	6F	Modern archi.Vol.2,2014	○	○		○			U
79	2014.4	Clair estate Yuraku	7297	2536	39	1F	Shinkenchiku. Vol.12,2014	○	○			○		U

* ICS1~ICS6：Category of indoor common space ○：Deployed; **Type: C-classical care, U-unit care.

2.3 Result and Analysis

2.3.1 Changes in each common space category

(1) The total area size

Table 2.3 and Fig. 2.2 are the result of total ICS area size per resident and ratio of ICS to total floor area size. The average ICS per resident is 7.05 m^2, maximum is 18.79 m^2, minimum is 1.20 m^2. And, the averaged ratio of ICS to total floor area is 14.46%.

Table 2.3 Result of total indoor common space area

Item	Average	Std. dev.	Min.	Max.
Area per resident,㎡	7.05	3.12	1.20	18.79
Ratio to floor plan,%	14.46	4.26	3.75	28.90

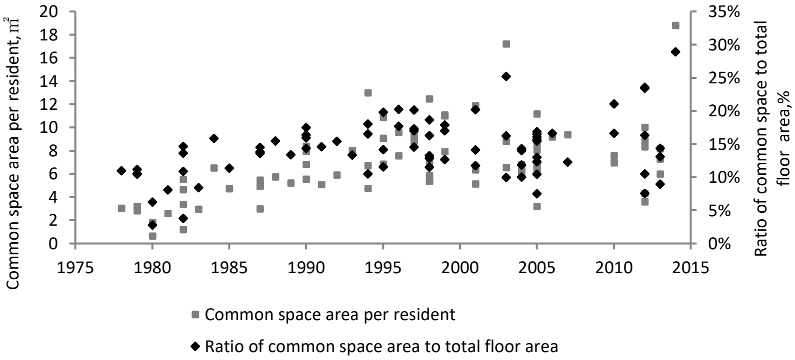

Fig. 2.2 Result of indoor common space area per resident and ratio of indoor common space to total floor area(Source: created by author)

Fig. 2.3 shows the average ICS and 95% confidence interval for each 5 years. The ratio of ICS to total floor area (broken line) increased from 9.8% in the 1980's to 16.0% in the 1995~1999, then decreased slightly, and increased to 16.7% in 2010 ~2015. The ICS area size per resident also shows similar tendency(solid line), increased from 3.2 m^2 per person in the 1980 ~ 1984 to 8.1m^2 in the 1995 ~ 1999, and remained around 8 m^2 since then.

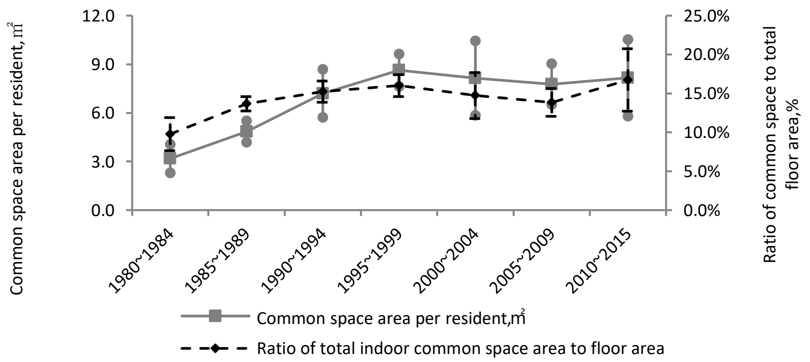

Fig. 2.3 Result of mean indoor common space area per 5 year(Source: created by author)

(2) The area size in each category

The average, standard deviation, maximum and minimum area size of ICS each category is shown in Table 2.4. The mean and deviation of each ICS category area size per resident and ratio to total floor area size in each 5 year interval are shown in Fig. 2.4 ~ Fig. 2.9.

Table 2.4 tells that the area size per resident of entrance hall category(ICS1) varies from 0.10m^2 to 1.45m^2, restaurant daily life category(ICS2) varies from 1.05m^2 to 16.46m^2, ICS for hobby is between 0.08m^2 to 1.45m^2, service category(ICS4) changes between 0.03m^2 to 1.93m^2, community space category(ICS5) is between 0.05m^2 to 2.88m^2, and ICS for external use is between from 0.04m^2 to 2.59m^2.

Table 2.4 Result of indoor common space area in each category

Category	Item	Average	Std. dev.	Min.	Max.
ICS1 Hall	Area per resident,㎡	0.53	0.30	0.10	1.45
	Ratio to site plan,%	1.16	0.63	0.21	3.03
ICS2 Daily life	Area per resident,㎡	5.14	2.62	1.05	16.46
	Ratio to site plan,%	10.48	3.83	1.99	25.31
ICS3 Hobby	Area per resident,㎡	0.51	0.32	0.08	1.45
	Ratio to site plan,%	1.13	0.75	0.23	2.83
ICS4 Service	Area per resident,㎡	0.23	0.22	0.03	0.93
	Ratio to site plan,%	0.46	0.43	0.07	1.69
ICS5 Community	Area per resident,㎡	1.03	0.75	0.05	2.88
	Ratio to site plan,%	2.06	1.49	0.21	6.52
ICS6 External	Area per resident,㎡	0.88	0.58	0.04	2.59
	Ratio to site plan,%	1.83	1.28	0.09	2.59

Following is changes of detail of each ICS category.

1) Area size increased over time

The space area size of daily life category(ICS2) which includes dining room and physical training room, common living space, and service facility category(ICS4) such as hairdressing salon/shops, and community space category(ICS5) follows this change, that is, generally in uptrend over the past 35 years.

The area size of daily life category(ICS2) has increased from 2.1m^2 per resident in the 1980 ~ 1984 to 6.5m^2 of 2010 ~ 2015 (Fig. 2.5). This increase is thought to be related to the regulation which is released in the year of 2000 by ministry of health, labor and welfare [Note 3)], that the total area of dining and physical training per resident should be more than 3m^2.

Due to the diversification of food service, there are more service facilities such as dining rooms, restaurants, coffee corner/coffee shop, salon, etc. deployed recently which may be the cause of the increasing the common area size of daily life category(ICS2) in nursing home.

Fig. 2.7 tells that the area size of service facility category(ICS4) has been increased from 0.1m^2 per resident in 1980~1984 to 0.3m^2 ~ 0.5m^2 in the 2005~2015. This increase shows the tendency to deploy more service facilities such as hairdressing salon, shops, telephone booth, service station, etc. facility in modern nursing home.

The area size of community space(ICS5) in Fig. 2.8 shows the increase from 0.4m^2 per resident in the year of 1985~1989 to 1.2m^2 after 1995s. This increase is thought to reflect the enhancement of communication and social activity in modern Japanese nursing home.

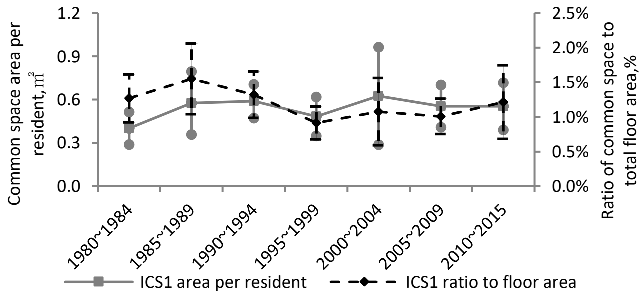

Fig. 2.4 Result of mean indoor common space area per 5 year(ICS1)(Source: created by author)

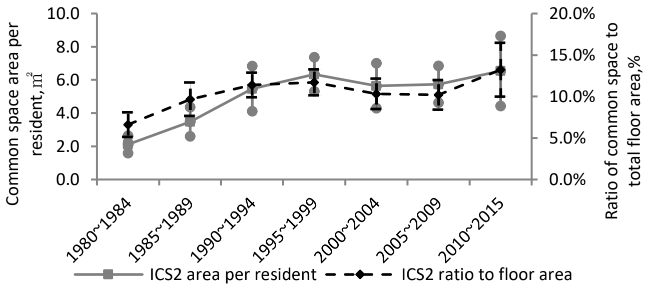

Fig. 2.5 Result of mean indoor common space area per 5 year(ICS2)(Source: created by author)

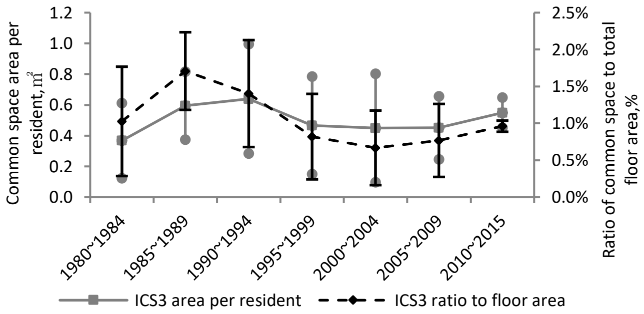

Fig. 2.6 Result of mean indoor common space area per 5 year(ICS3)(Source: created by author)

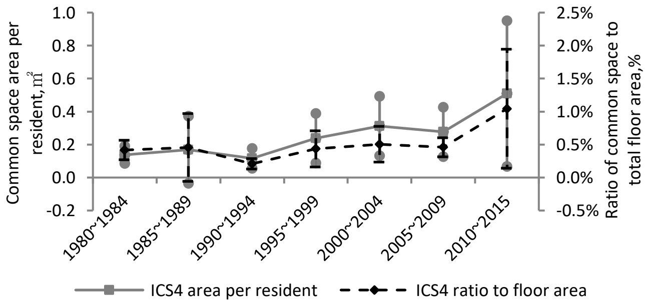

Fig. 2.7 Result of mean indoor common space area per 5 year(ICS4)(Source: created by author)

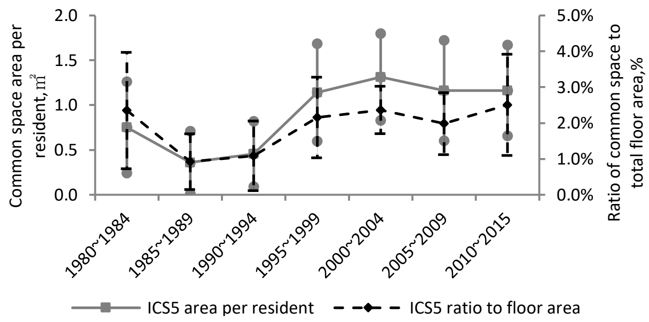

Fig. 2.8 Result of mean indoor common space area per 5 year(ICS5)(Source: created by author)

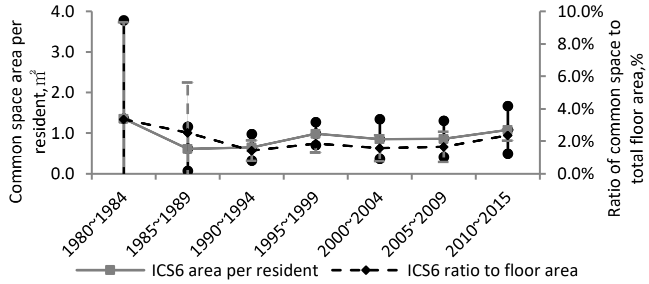

Fig. 2.9 Result of mean indoor common space area per 5 year(ICS6)(Source: created by author)

2) Common space with little changes over time

Among each ICS, the entrance hall category(ICS1, Fig. 2.4) is remained at about 0.5m^2 per resident, and external use category(ICS6, Fig. 2.9) is sustained at around 0.9m^2 over the past 35 years.

3) Common space with no obvious change tendency

The area size of hobby room category(ICS3, Fig. 2.6) shows no obvious change trend in the past.

(3) Common space area size by care type

The average ICS area size in each category per resident and ratio to total floor area for classical care and unit care type are shown in Fig. 2.10, Fig. 2.11.

It can be seen from Fig.2.10 that the area size per resident of daily life category (ICS2) in classical care type and unit care type nursing home is 4.6m^2 and 6.1m^2 respectively, it is 0.8m^2 and 1.2m^2 for community space category(ICS5), and 0.2m^2 and 0.3m^2 for service facility category(ICS4).

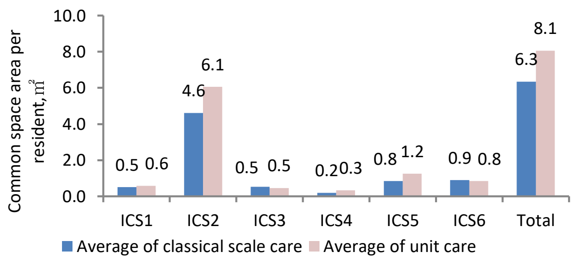

Fig. 2.10 Result of mean indoor common space area per resident in classical care and unit care nursing home(Source: created by author)

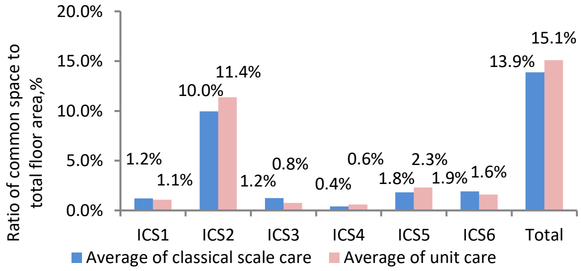

Fig. 2.11 Result of mean ratio of indoor common space area to total floor area in classical care and unit care nursing home(Source: created by author)

The ratio of each ICS category area size to the total floor area of Fig. 2.11 shows the similar result as Fig. 2.10. Compared with the classical care type nursing home, it was changed from 10.0% to 11.4%, 1.8% to 2.3%, and 0.4% to 0.6% respectively daily life category(ICS2), community space category(ICS5), and service facility category(ICS4). For the other common space categories, they are almost the same in both care types.

Japanese Ministry of Health, Labor and Welfare has defined the more than 3m^2 per resident for dining room and physical training room in the year of 2000, which can be the reason of area size increase in unit care type nursing home for daily life category(ICS2). In addition, the common living space has been added to nursing home since 2000, which also contributes to the increase of daily life category(ICS2) area size in unit care nursing home. Regard to the changes of area size in other ICS categories, with the improvement in the quality of living and the diversity of service and social activities, the area size of service category(ICS4) and community space category(ICS5) has been increased.

Table 2.5 Result of each indoor common space area in classical care and unit care nursing home(classical care/unit care)

Category	Item	Average	Std. dev.	Min.	Max.
ICS1	Area per resident,㎡	0.50/0.58	0.26/0.34	0.08/0.12	1.28/1.45
Hall	Ratio to site plan,%	1.19/1.09	0.60/0.68	0.21/0.22	2.61/3.03
ICS2	Area per resident,㎡	4.61/6.05	2.46/2.67	1.05/1.96	11.18/16.46
Daily	Ratio to site plan,%	9.96/11.36	3.46/4.32	1.99/4.59	18.07/25.31
ICS3	Area per resident,㎡	0.52/0.46	0.35/0.16	0.08/0.27	1.45/0.66
Hobby	Ratio to site plan,%	1.23/0.76	0.80/0.33	0.26/0.41	2.83/1.27
ICS4	Area per resident,㎡	0.19/0.33	0.20/0.26	0.02/0.06	0.93/0.76
Hobby	Ratio to site plan,%	0.42/0.59	0.39/0.51	0.07/0.14	1.69/1.65
ICS5	Area per resident,㎡	0.84/1.24	0.73/0.72	0.05/0.35	2.64/2.88
Comm.	Ratio to site plan,%	1.83/2.31	1.54/1.41	0.21/0.56	5.42/6.52
ICS6	Area per resident,㎡	0.89/0.84	0.59/0.59	0.04/0.14	2.59/1.66
Ext.	Ratio to site plan,%	1.91/1.61	1.34/1.09	0.09/0.29	6.39/3.69

Table 2.5 shows the range and standard deviation of each ICS category area size in two care types. Except the hobby category(ICS4) and external use category(ICS6), the area size is increased in all other ICS categories in unit care type nursing homes.

2.3.2 Public, semi-Public space area size changes

Except the area size changes in each categories of indoor common space based on common facility functionality, the area size of public, semi-public, and semi-private space area size listed in Table 2.1 are also investigated.

The mean, minimum and maximum, and value range of area size per resident is shown in Table 2.6 and Table 2.7. The community space, as public space in unit care nursing homes ranges from 0.10m^2 per resident to 3.43m^2 per resident. The physical training room, as a semi-Public space, ranges from 0.11m^2 per resident to 4.14m^2 per resident. And, living space, as a semi-Private space, ranges from 0.26m^2 per resident to 4.84m^2 per resident. This result will be used for common space occupancy analysis in Chapter 5.

Table 2.6 Result of ICS main common facilities area size per resident(m^2/resident)

Area size per resident	Space category	N	Range	Minimum	Maximum	Mean	Std. Deviation
ENH	Public space	79	1.36	0.08	1.44	0.4731	0.27953
DRM	Semi-public space	76	4.22	0.28	4.50	1.7550	0.92550
PTR	Semi-public space	67	4.03	0.11	4.14	1.1134	0.75448
MPR	Semi-public space	32	1.15	0.08	1.23	0.5131	0.31502
SST	Semi-public space, Semi-private space	36	0.80	0.02	0.82	0.2369	0.23266
CMS	Public space	44	3.33	0.10	3.43	1.1548	0.79742
DSR	Semi-public space, Semi-private space	39	2.51	0.08	2.59	0.8454	0.56210
LVS	Semi-private space	56	4.58	0.26	4.84	1.5581	1.07402

Table 2.7 Result of ICS main common facilities total area size(m^2)

Area total size	N	Range	Minimum	Maximum	Mean	Std. Deviation
ENH	79	164.00	8.00	172.00	41.5570	25.48441
DRM	76	426.00	24.00	450.00	150.1974	76.94466
PTR	67	212.00	11.00	223.00	91.2537	48.85332
MPR	32	156.00	7.00	163.00	53.9375	39.95961
SST	36	90.00	2.00	92.00	20.5833	21.77728
CMS	44	334.00	9.00	343.00	102.5495	70.27426
DSR	39	214.00	14.00	228.00	72.4359	51.77624
LVS	56	466.00	18.00	484.00	148.1071	114.93709

2.4 Summary

By the studies of the common space area size in 79 intensive care nursing homes from Japanese architecture publications since 1978, following changes in indoor and outdoor common spaces are revealed.

The total area size of the indoor common space per resident and the ratio to the total floor area size have gradually increased since the 1980s. In detail, the total area size of indoor common space per resident has increased from the beginning of 3.2m^2 to 8.1m^2 in 2010-2015, and the ratio to the total floor area increased from the 9.8% in the 1980s to 16.6% of the 2010-2015s.

For common spaces in each category, the increase in areas of daily life category, hairdressing salons, shops etc service facility category, and community space category is larger than other categories, these contribute the most to the increase of total indoor common space.

About the difference in care types, the average area size per resident in daily life category is 6.1m^2 in unit care type, is larger than the classical care type of 4.6m^2, and similarly, the community space category of unit care type is 1.2 m^2, which is larger than classical care type of 0.8 m^2.

Ministry of health, labor and welfare has defined the total area size of the dining room and physical training room per resident to be more than 3m^2 in the year of 2000. As the result of the influence, the area size of common space for dining/physical training and common living space has been increased.

The community space, as public space in unit care nursing homes ranges from 0.10m^2 per resident to 3.43m^2 per resident. The physical training room, as a semi-Public space, ranges from 0.11m^2 per resident to 4.14m^2 per resident. And, living space, as a semi-Private space, ranges from 0.26m^2 per resident to 4.84m^2 per resident.

And, the increase of area size per resident in common facilities like dining room, physical training room might be related to the introduce of regulation on more than 3m^2 per resident by Ministry of Health, Labor and Welfare about in the year of 2000. The area size increase in service facilities reflects the improvement of service in modern Japanese nursing homes, particularly the community space, which is not only the single common facility in nursing home but also the facility that forms part of important local community like Japanese version of CCRC(continuing care retirement community)(Bai L, 2017). Further, not only the space area size, the spatial relationships with other space is also important aspects which affect resident daily life, this aspect will be addressed in following chapters.

Note:

1): National Social Security and Population Research Institute In-house Research Report No.13 Japan Social Security Document IV (1980-2000).
国立社会保障・人口問題研究所　所内研究報告 No.13　日本社会保障資料Ⅳ(1980-2000)によれば、「1977（昭和 52）年 8 月、全国社会福祉協議会は、「都市型特別養護老人ホームの整備のあり方に関する研究」で、大都市部における特別養護老人ホームの新しい機能として「利用施設」への転換や、地域サービスとしての新しい機能として、ショート・ステイ・サービス、デイ・ホーム・サービス、入浴サービス、給食サービスなどをあげるとともに、今後在宅対策の確立が課題となるとした。また、1977（昭和 52）年 11 月の中央社会福祉審議会・老人福祉専門分科会の「今後の老人ホームのあり方について」（意見具申）は、社会福祉施設の多くが遠隔地に設置され、老人ホームなどの収容型社会福祉施設がとかく地域社会から孤立しがちなことを払拭するため、老人ホームの地域開放を提案した。老人福祉施設を活用した在宅施策としては、寝たきり老人短期保護事業（1978（昭和 53）年）と通所サービス事業（1979（昭和 54）年）が国の補助事業として登場した。」とあり、この時期以降に、老人ホームの新しい機能や地域との関係が強められたと考えられる。

2): Japanese Nursing Association, Nursing for the older people in Japan.

3): 厚生労働省　「介護事業所・生活関連情報検索」　「平成 27 年度介護報酬改定に向けて」（社）全国有料老人ホーム協会「有料老人ホーム・サービス付き高齢者向け住宅に関する実態調査研究」　サービス付き高齢者向け住宅情報提供サービス 2018 年 3 月 https://www.minnanokaigo.com/guide/type/

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Chapter 3 Study on Common Space Spatial Configuration in Japanese Intensive Care Nursing Home by Using Space Syntax Theory

3.1 Introduction

Except the geometrics characteristics of architectural space like space size, shape, relative position, the space connectivity, space accessibility, and its spatial relationship to all other space units in the architecture(nursing home) are also potential factors affect residents behavior or utilization in the space.

Moreover, so far there is multiple theories attempted to explain the relationship between spatial properties and human responses(Lee 2017). For example, Appleton's habitat and prospect-refuge theories(Appleton 1975), Gibson's ground theory(Gibson 1979), and Kaplan's information theory(Kaplan 1989). However, such theories use psychological and philosophical constructs to analyze environments and their social and behavioral properties, the results are not always reproducible.

On the other hand, quantitative theories and methods were also developed to understand and model the relationship between space and social patterns(Lee 2017), such as Space syntax, a famous theory in architecture. This theory uses quantitative method to measure the space spatial characteristics such as the spatial connectivity, spatial accessibility, and spatial integration of a space to all other space units. The theory itself has been getting extensive use since beginning and has been generally accepted as an appropriate means in spatial characteristics comparative study(Brown 1986; Hanson,1998).

Therefore, this chapter studies the common space spatial configuration by using Space Syntax theory to measure the common space spatial configuration like spatial connectivity, spatial accessibility, and spatial integration, etc., to clarify the current common space spatial configuration and how it was transited from the past, because these spatial metrics are main indicators to express the relationship with human space environmental behavior(Congsi 2015, Saif 2012, Teklenburg 1993, Peponis 1990, Pelin 2007). And, 62 nursing homes built in the year from 1978 to 2014 are selected from Japanese architecture publications [Note 1)] where the spatial configuration of common facilities are analyzed.

3.2 Method

3.2.1 Origin of Space syntax theory

Space syntax(SS) is a theory of space and a set of analytical, quantitative and descriptive tools for analyzing the spatial formations in different forms: buildings, cities, interior spaces or landscapes based on the graph theory(Hillier and Hanson, 1984, Hillier, 1996). The main interest of space syntax is to explain the relationship between human beings and their inhabited spaces. It is believed that the distinctive characteristics of societies exist within spatial systems, their knowledge is conveyed through space itself, and through the organization of spaces(Dursun and Saglamer, 2003).

3.2.2 Topological description of space unit

Space syntax uses 2-dimentional topological diagram to describe the 3-D space. Fig. 3.1 is an example of 3 floorplans (Hiller 1996, p21). They look almost the same except the opening position in each partition wall are slightly different. The space unit and connections in each floorplan is represented in the second column. Space syntax uses the node(i.e. the circle shown in the figure) to represent each space unit, and the link line for the connections. The resulted spatial topology diagrams as shown in the third column.

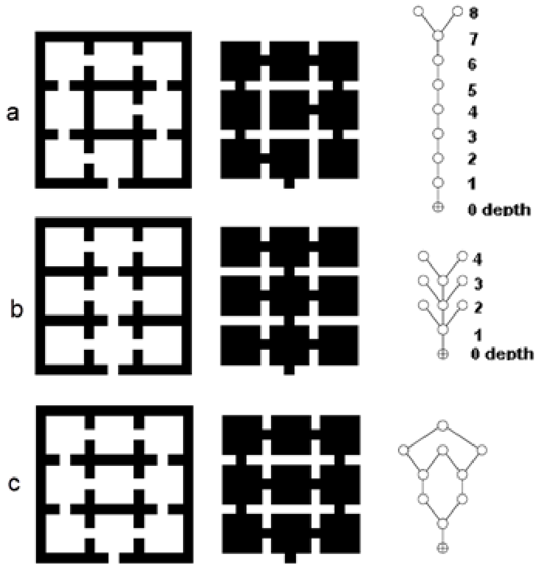


Fig. 3.1 Topological diagram of space configuration(source: Hiller 1996, p21)

From the topology diagram it is clear that although the plan view shape are similar, the topological relationship of the space unit is different.

3.2.3 Quantitative description of space

Space syntax theory defines a series of metrics to quantitatively describe space relation, the basic are as bellows.

1) Connectivity(C)

The connectivity specifies the number of units directly connected to a space. In a space system, the connectivity value represents the permeability of the space. The higher connectivity value of a space, the better the permeability.

$$C = c \qquad (1)$$

For example, the connectivity of space unit A ~ F in Fig. 3.2 are C(A)=1, C(B)=1, C(C)=3, C(D)=3, C(E)=1, C(F)=1.

2) Depth(D)

The depth represents the topology distances(steps) from one space unit to another. SS theory assume the distance to the neighboring space is 1. The total depth(TD) of a space unit is the sum of the depths from all other space units.

$$D = d \qquad (2)$$

$$\mathrm{TD} = \sum_{k=1}^{n} (Dk * k) \qquad (3)$$

Where n is the number of total space units.

The number next to node a and b in the third column of the topological relationship diagram Fig. 3.1 represent the depth value from the floorplan entrance point.

The depth value of space unit varies by different reference point. To standardize the depth in different space system, the mean depth(MD, mean depth) is used. It is the ratio of the total depth to the total number of spatial units except itself, i.e.:

$$\mathrm{MD} = \frac{\sum_{k=1}^{n} (Dk * k)}{n-1} \qquad (4)$$

For example, the MD of entrance space in Fig. 3.1(c) is

$$MD = (1 * 1 + 2 * 2 + 3 * 2 + 4 * 3 + 5 * 1) / (9-1) = 3.5$$

The TD and MD of space unit A ~ F in Fig. 3.2(left) is shown at the right.

The depth expresses the space reachability from the perspective of topological view. It represents the number of steps to turn over, not the actual distance. The greater the depth value of a space, the worse the space reachability.

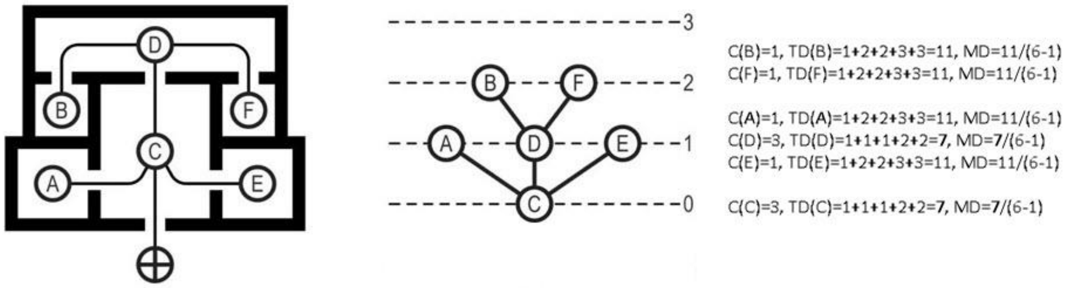


Fig. 3.2 Connectivity, total depth, and mean depth(source: Michael 2013, p3, modified by author)

3) Integration(INT)

To relatively demonstrate how deep a space system is, Hillier introduced the RA concept(Relative Asymmetry). It is(Hillier 1984, p111):

$$RA = \frac{2(MD-1)}{n-2} \qquad (5)$$

Because depth is always positive and the mean depth of any given space unit by definition can never exceed the maximum range of a space unit in the space system, RA values range from 0 to 1. This relatively makes it possible to compare how deep a space system is(Bafna 2003).

RA depends on the number of space unit n, it is impossible to compare RA among different sized of space system. To solve this problem, RRA(Real Relative Asymmetry) was introduced by means of using Dn which is the RA of a space system with diamond shaped topology, and defined by Hillier as(Hillier 1984, p111; Maria 2003):

$$Dn = \frac{2[n\{log2(\frac{n+2}{3})-1\}+1]}{(n-1)(n-2)} \qquad (6)$$

$$RRA = \frac{RA}{Dn} \qquad (7)$$

The diamond graph is characterized by an almost normal distribution of nodes across its levels in topology and so has been found to represent a more realistic benchmark for comparing spatial characteristics of different sizes(Bafna 2003, Bjorn K. 1993), as an example shown in Fig. 3.3.

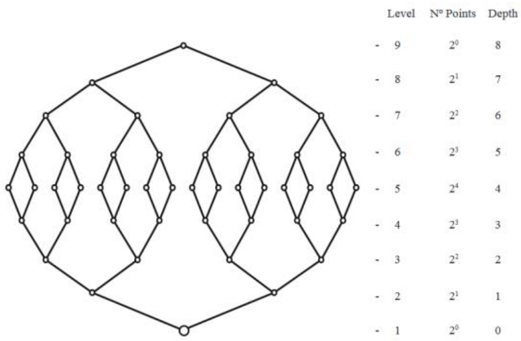


Fig. 3.3 Diamond shape with 46 points and 9 levels of depth(source: Mario 2012, p198)

The RRA value is independent from the size of graph, and comparable among different space system. The lower the RRA value, the more accessible a space is(Munro, 2016). In SS studies typically use the integration(INT) which is defined as a reciprocal number of RRA to describe the spatial characteristics of a space unit(Bafna 2003).

$$\text{INT} = \frac{1}{RRA} \quad (8)$$

Therefore, the high integration values of a space unit indicates its less deep on an average from all other space units, or in other words, is more integrated into a spatial system. Generally, the integration values above 1 means strong 'integration', the values between 0.4 and 0.6 shows more 'segregation'(Haghighi, 2014).

As Dettlaff pointed out in his research that the integration is the key parameter to understand the relationships between human and space. The greater integration of a space, the easier access it has(Dettlaff W, 2014). For this reason, integration is also used to stand for the spatial centrality, and space accessibility(Szczepanska, 2011).

3.2.4 SS theory analysis method

SS theory uses different approaches to calculate spatial metrics(Varoudis, 2013). One of the approaches is convex map analysis method which utilizes vertical boundaries to convert 3-D space to a number of 2-D convex polygon(Peponis 2002), and establishes connection based on the availability of direct access(Klarqvist 1993). Due to this "fat" nature of the convex shape, it is said that this method is best suited for defining spaces such as building interiors(Daniel 2013; Peiman, 2014). This approach is applied in this research for calculating the spatial metrics of nursing home.

For nursing home architecture, based on space functionality each space unit is presented by one or multiple convex shapes and to use least possible number of convex shapes to cover all the architecture spaces. The wall, any kind of partition which separates space is taken as boundary while doors and openings are considered as connection points. For multi-story buildings, according to the allocation of common facilities, elevators and staircases are regarded as connection points.

Fig. 3.3 is an example of convex map analysis. The architectural floorplan is shown in the left, the convex shapes based on floorplan is shown in the middle, and the connectivity and depth of each space unit from building entrance point(#32) expressed by Justified graph(Bjorn K., 1993) is shown in the right.

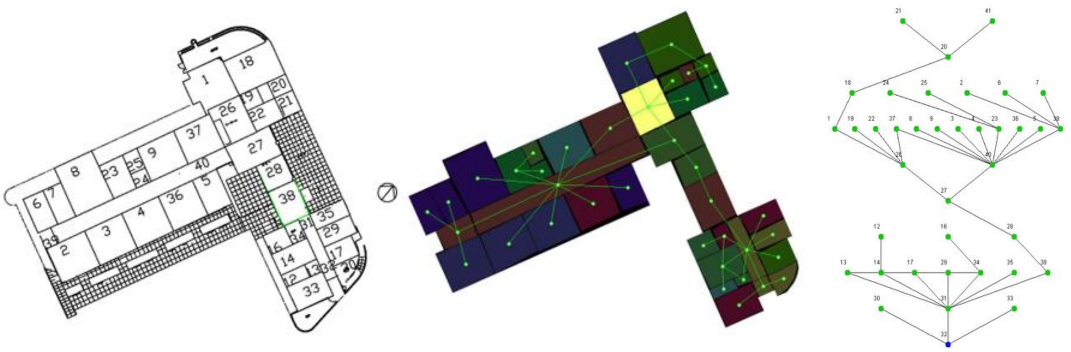


Fig. 3.4 The convex map analysis method, and justified graph(right) (Source: created by author, Bai L 2017)

3.2.5 SS theory analysis tool

There are several computer tools for SS analysis. Among them the DepthMapX is a multi-platform software to perform spatial network analyses for understanding of spatial characteristics within defined space. This tool works at a variety of scales from building, small urban to whole cities or states(Varoudis, 2012), and has been applied to a wide range in urban planning and commercial facilities, art museum, library etc spatial structure analysis(Varoudis T. et al., 2014; Varoudis T. et al., 2015). In this research, this tool is selected to evaluate the spatial structures in Japanese nursing homes.

3.2.6 Analysis workflow

Floor plan of nursing home is scanned and converted to AutoCAD file, then imported to DepthMapX tool to create convex map. Then the SS spatial integration, connectivity, and depth etc metrics are calculated and exported, as the workflow shown in Fig. 3.5.

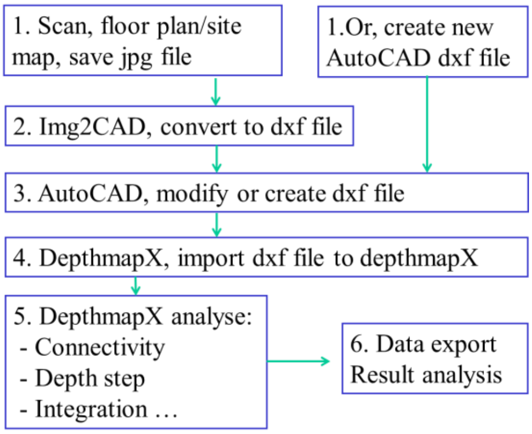


Fig. 3.5 Space syntax analysis workflow(Source: created by author)

3.2.7 Nursing home structure changes and spatial centrality

Since the introduce of regulation on unit care nursing home by Ministry of Health, Labor and Welfare in 2002 [Note 1)], Japanese nursing homes has been transited from classical large-scale nursing care to unit care. By this transition, the space structure has also been changed, as shown in Fig. 3.6. In classical large-scale care nursing home, the bed rooms were mainly allocated along a long corridor, where a centralized common facility link dining room is designed to server all residents. In unit care nursing home, the private rooms are allocated in different care units, there is living space in each unit as common space and be shared by residents in the unit, and each unit is connected by corridors or other common space.

Based on the location, the common space is divided to private space, semi-private space, semi-public space, and public space [Note 3)]. As shown in Table 3.1, the public space is open area to both internal resident and external visitors like community space, entrance hall, lobby [Note 4)]; the semi-public space is the area basically for residents to perform collective and disciplinary activities like physical training and food service; the semi-private space is an area outside the private room and shared by multiple residents, like living space.

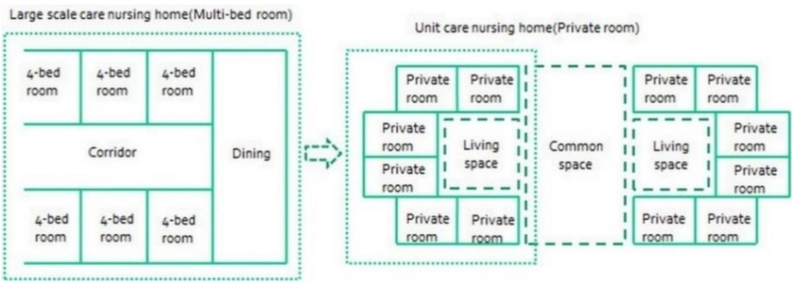


Fig. 3.6 Transition of nursing home from classical large-scale care to unit care type (Source: MHLW, 2015 Note 4)

Table 3.1 Common space in Japanese nursing home

Domain*	Definition(translated by author)	Example	Domain Controller
Private Zone	The area to manage the resident personal belongings	Private room	Resident
Semi-Private Zone	An area that is voluntarily used by multiple users outside of the Private zone	Living space	Multiple residents
Semi-Public Zone	An area in which a collective and disciplined act is basically performed (voluntary acts of an individual in the space in the interval between organized programs)	Dining room, physical training room	Staff
Public Zone	An area of facilities open to both internal residents and external societies	Hall, day service, community space	Personnel (administrative staff) and local residents

In this chapter, the space with the higher SS integration is referred as core space, or space with high spatial centrality. The common facilities considered is listed in Table 3.2, the dining room, physical training room, service station, community space are taken as typical common space to analyze in detail.

Table 3.2 Common facilities considered in Japanese nursing home

Symbol	Space category	Example
ENH	Public space	Entrance hall, lobby
DRM	Semi-public space	Restaurant, dining room
PTR	Semi-public space	Rehabilitee center, club room, club house, physical training room
MPR	Semi-public space	Multiple purpose room, hobby room, game room etc
SST	Semi-public space, semi-private space	Care station, service station
CMS	Public space	Community center, community space
DSR	Public space, semi-public space	Daily service room
LVS	Semi-private space	Living space, common room

3.3 Findings and discussion

3.3.1 Core space by nursing home special centrality

Firstly, the spatial centrality in Japanese nursing homes are investigated, and considered on its transition. By referring to the research done by Koike about core space distribution in Japanese museums, the space with the highest spatial integration is referenced as core space, and nursing homes with following core space types are defined(Koike 2011).

A. Corridor – The nursing home where the main or long corridor is the core space.
B. Connection corridor – The corridor which links different living or service zones is core space.
C. Hall – The entrance hall, reception lobby, lounge, and EV hall etc. is the space with high spatial centrality.
D. Common facility – The community space, physical training room, dining room and service station is core space.
E. Other – The space like staircases, terrace, etc. is of high spatial centrality.

3.3.1.1 Core space and common facility order of integration

The result of spatial centrality in 62 nursing home is shown in Table 3.3. The nursing home care type, and orders of spatial integration of 4 main common facilities are also listed.

The detail floorplan and SS result are listed in Chapter 3 appendix.

1. Core space and relationship with care type

(1) Corridor as core space

There are 24 corridor core space nursing homes in Table 3.3, all are classical large-scale type. This tells that the main corridor was the spatial centrality in most of classical large-scale nursing homes, where residents can be easily access and gathering.

Fig. 3.7(left) is an example of nursing home with corridor as spatial centrality built in 1982. There was a "D" shape long corridor, living rooms and service facilities were allocated to both sides of this corridor. The result of spatial integration is shown in the right, where the integration is colored based on its value, the high value of well-integrated location to the poor is represented from thick to thin.

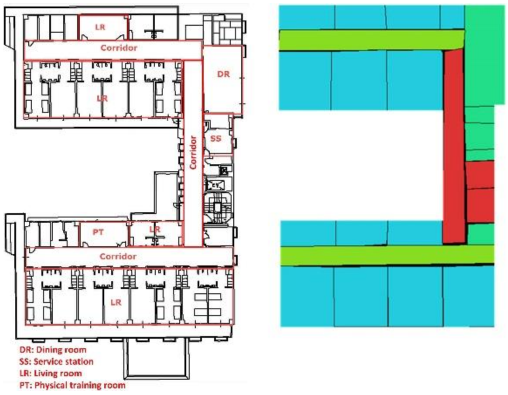


Fig. 3.7 Floorplan(left) and integration result(right) of nursing home(NHID 9) with the long corridor as core space(Source: created by author)

(2) Connection corridor as core space

There are 10 connection corridor core space nursing homes in Table 3.3, nine of them are unit care type, and one is classical large-scale type. This tells that the connection corridor was spatially very important in unit care nursing home, where residents can be easily access and gathering.

Fig. 3.8 is an example of this type nursing home which was built in the 2005s. There are five care units on the floor, each has ten private bedrooms. The care units are allocated in three areas and connected by connection corridors. The SS calculation shows that the connection corridor is the core space as shown in Fig. 3.8(right), where the number in the figure is the order from high SS integration to low.

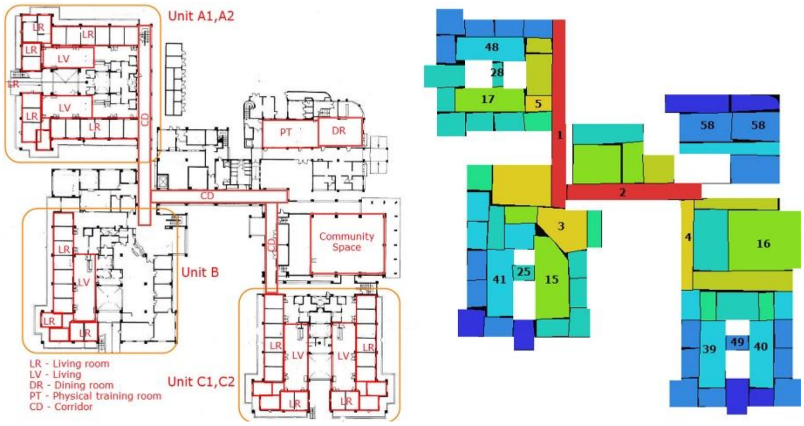


Fig. 3.8 Floorplan(left) and integration result(right) of nursing home (NHID 66) with connection corridor as core space(Source: created by author)

(3) Hall as core space

There are 20 hall core space nursing homes in Table 3.3, twelve of them are large-scale care type, and eight are unit care type. Slightly, the hall space has more spatial centrality than that in unit care nursing homes.

Fig. 3.9 is an example of this type nursing home which was built in 2013. There are four care units on a floor, a lounge is designed in the center of floor which serves as a public space in the nursing home.

The SS calculation shows that it is the lounge which is the core place as shown in Fig. 3.9(right).

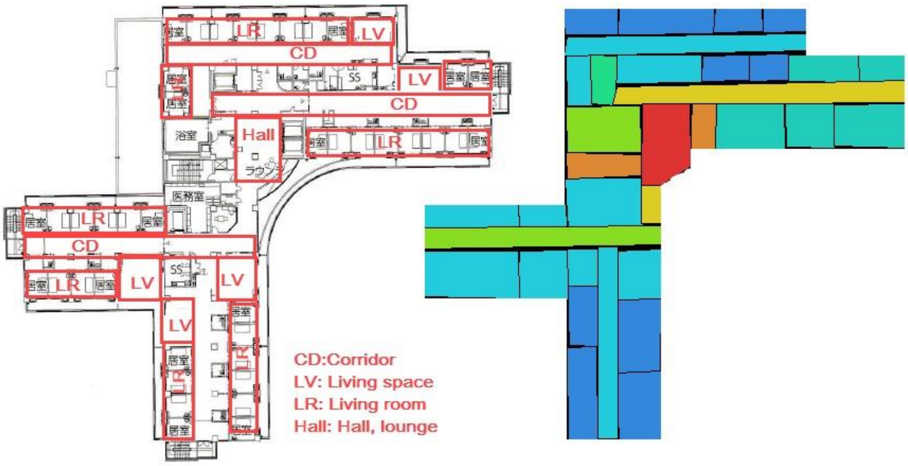


Fig. 3.9 Floorplan(left) and integration result(right) of nursing home(NHID 76) with the hall as core space(Source: created by author)

(4) Common space as core space

There are 6 nursing homes where the core space is common facility space in Table 3.3, five of them are unit care type, and one is large-scale care type. It can be seen that the common facilities own more spatial centrality than that in large-scale care nursing homes.

The example shown in Fig. 3.10 is a nursing home built in the 2005s, where there are three care units located in the low half side of the site plan, a community space is suited in the center. The SS calculation shows that the community space is the core space.

The other nursing homes in this category also show similar spatial layout that the common facility was either allocated in the center of the site plan or surrounded by different care units.

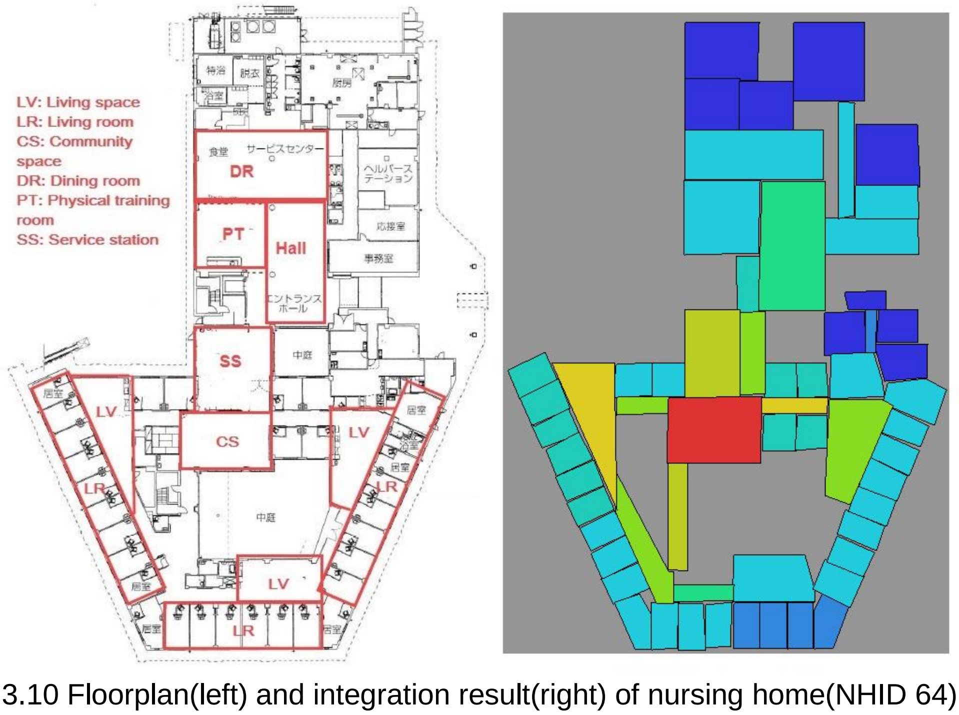


Fig. 3.10 Floorplan(left) and integration result(right) of nursing home(NHID 64) with community space as core space(Source: created by author)

Table 3.3 Spatial integration result of common facilities in Japanese nursing homes

Integration of core space	Care type	NHID	Build year	Community space	Physical training room	Service station	Dining room	INT order	Highest Common facility	NH Ave INT	HI/NH Ave(%)
Corridor	L	21	1990	1.2752	1.0611		1.1032	CMS>DRM>NH>PTR	1.2752	0.9913	129
	L	34	1996	1.1514	1.1341	0.9492	1.0196	CMS>PTR>DRM>SST>NH	1.1514	0.9383	123
	L	2	1979	0.7806		1.0103	1.1366	DRM>NH>SST>CMS	1.1366	1.0772	106
	L	25	1991		0.4297	1.4932	1.5895	DRM>SST>NH>PTR	1.5895	0.9841	162
	L	29	1994		1.0500	1.4417	1.4636	DRM>SST>PTR>NH	1.4636	0.8809	166
	L	43	1998		1.4690	1.7488	1.8834	DRM>SST>PTR>NH	1.8834	1.4389	131
	L	26	1992		1.2601	1.0081	1.2312	PTR>DRM>SST>NH	1.2601	0.9852	128
	L	3	1979		0.8265	1.2700	1.1038	SST>DRM>NH>PTR	1.2700	1.0186	125
	L	5	1980		1.7921	1.8123	1.2127	SST>PTR>NH>DRM	1.8123	1.2127	149
	L	7	1981		1.1035	1.2086	1.1280	SST>>DRM>PTR>NH	1.2086	1.0607	114
	L	8	1982	0.8070	0.8646	1.1131	0.8685	SST>NH>DRM>PTR>CMS	1.1131	0.9419	118
	L	9	1982		0.8295	1.0522	0.8567	SST>NH>DRM>PTR	1.0522	0.9775	108
	L	10	1982	0.8700		1.1814	0.8522	SST>NH>CMS>DRM	1.1814	0.9731	121
	L	11	1982		1.2774	1.9041	1.3278	SST>NH>DRM>PTR	1.9041	1.3352	143
	L	14	1985	1.1955	0.9831	1.4898	1.1528	SST>CMS>NH>DRM>PTR	1.4898	1.1700	127
	L	16	1987	0.9983	1.0193	1.0193	1.0035	SST=PTR>DRM>CMS>NH	1.0193	0.9370	109
	L	17	1987		0.8488	1.3092	0.9087	SST>NH>DRM>PTR	1.3092	1.1985	109
	L	19	1988		0.7810	0.9953	0.8460	SST>NH>DRM>PTR	0.9953	0.9309	107
	L	27	1993		1.0204	1.6678	1.3399	SST>DRM>NH>PTR	1.6678	1.1548	144
	L	31	1995	0.9879	1.2756	1.3498	0.9922	SST>PTR>NH>DRM>CMS	1.3498	1.0933	123
	L	33	1995		1.0631	1.3162	0.9813	SST>PTR>NH>DRM	1.3162	1.0329	127
	L	47	1999	1.1967		1.4286	1.2887	SST>DRM>NH>CMS	1.4286	1.2856	111
	L	48	2001			1.3592	0.9551	SST>NH>DRM	1.3592	1.1212	121
	L	49	2001			1.2346	0.6838	SST>NH>DRM	1.2346	0.9642	128
Conn. corridor	L	40	1998	0.9062		0.6354	0.7274	CMS>NH>DRM>SST	0.9062	0.7737	117
	U	65	2005	1.0500	0.8077	0.9633	0.8077	CMS>SST>NH>PTR=DRM	1.0500	0.9475	111
	U	77	2013	1.3374	1.3374	0.9012	1.0237	CMS=PTR>DRM>NH>SST	1.3374	1.0216	131
	U	73	2012		0.7682	0.7014	1.4745	DRM>NH>PTR>SST	1.4745	0.9185	161
	U	72	2012		1.3796	0.9529	0.6695	PTR>SST>NH>DRM	1.3796	0.8924	155
	U	36	1997	1.1008	1.1532	1.1531	0.9314	SST=PTR>CMS>NH>DRM	1.1531	1.0670	108
	U	52	2003	1.1775		1.2007	0.7443	SST>CMS>NH>DRM	1.2007	0.8796	137
	U	61	2005		0.9767	1.1543	0.9862	SST>DRM>PTR>NH	1.1543	0.9310	124
	U	66	2005	0.9144	0.5842	0.9207	0.5842	SST>CMS>NH>PTR=DRM	0.9207	0.7443	124
	U	79	2014	1.0269	1.3350	1.4751	1.2899	SST>PTR>DRM>NH>CMS	1.4751	1.0327	143
Hall	L	30	1994	0.8370	0.7650	0.7236	0.7830	CMS>DRM>PTR>SST>NH	0.8370	0.7210	116
	L	39	1997	1.0553	0.7904	0.9059	0.7811	CMS>SST>NH>PTR>DRM	1.0553	0.8417	125
	U	51	2003	1.1200	0.8960	0.8425	0.9535	CMS>PTR>DRM>SST>>NH	1.1200	0.8406	133
	U	62	2005	1.4175	0.9596	1.0942	1.1340	CMS>NH>DRM>SST>PTR	1.4175	1.2381	114
	U	74	2012	0.8289	0.6780	0.7469	0.6360	CMS>SST>NH>PTR>DRM	0.8289	0.7455	111
	L	12	1983	0.6629		0.9699	1.3007	DRM>SST>NH>CMS	1.3007	0.8353	156
	L	50	2001	0.8644	1.2246	1.2285	1.4742	DRM>SST>PTR>NH>CMS	1.4742	1.0235	144
	U	69	2010	1.0316	1.0869	1.0867	0.8281	PTR>SST>CMS>NH>DRM	1.0869	0.9797	111
	L	1	1978		0.9169	1.0195	0.8537	SST>PTR>DRM>NH	1.0195	0.8100	126
	L	13	1984	0.8931	0.8852	1.2459	1.0623	SST>DRM>NH>CMS>PTR	1.2459	0.9225	135
	L	15	1987		0.7008	1.6049	1.5062	SST>DRM>NH>PTR	1.6049	1.0073	159
	L	18	1987		0.8758	1.1700	0.9388	SST>DRM>NH>PTR	1.1700	0.8996	130
	L	20	1989	1.1255	0.9413	1.3992	0.9413	SST>CMS>NH>PTR=DRM	1.3992	1.1146	126
	L	28	1994		0.5661	0.7746	0.4925	SST>NH>PTR>DRM	0.7746	0.7351	105
	L	32	1995			1.3475	1.2752	SST>DRM>NH	1.3475	0.9021	149
	L	38	1997	0.7938	0.7908	0.9249	0.8827	SST>DRM>CMS=PTR>NH	0.9249	0.7098	130
	U	59	2005	1.1785		1.3902	1.1325	SST>CMS>DRM>NH	1.3902	1.0172	137
	U	71	2012	0.9324	0.9241	0.9366	0.9001	SST>NH>CMS>PTR>DRM	0.9324	0.9332	100
	U	75	2012	1.4156	0.9957	1.9582	0.9957	SST>CMS>NH>PTR=DRM	1.9582	1.3503	145
	U	76	2013		0.6654	0.7544	0.6272	NH>SST>PTR>DRM	0.7544	0.7811	97
Common space	U	55	2004	0.9322	0.5299	0.5822	0.5299	CMS>SST>NH>PTR=DRM	0.9322	0.5767	162
	U	67	2006		1.3029		0.9049	PTR>DRM>NH	1.3029	0.7959	164
	L	45	1999	0.9631	1.0305	1.4458	1.1959	SST>DRM>PTR>NH>CMS	1.4458	0.9759	148
	U	53	2003	1.0264	1.2394	1.4236	1.0522	SST>PTR>DRM>CMS>NH	1.4236	0.8530	167
	U	57	2004	1.3462	0.7576	1.4345	0.9115	SST>CMS>DRM>NH>PTR	1.4345	0.8668	165
	U	64	2005	0.8871	0.8795	1.4207	0.7179	SST>NH>CMS>PTR>DRM	1.3651	0.9870	144
Other	L	24	1990	0.9920	0.8479	0.7348	0.8479	CMS>PTR=DRM>NH>SST	0.9920	0.7577	131
	L	23	1990		0.9084	0.7561	0.8395	PTR>DRM>NH>SST	0.9084	0.7862	116

Note: NHID: nursing home ID; C.F.: common facilities; Hi/NH Ave(%): percentage of common facilities highest integration to nursing home average. CMS: community space; PTR: physical training room; SST: service station; DRM: dining room.

2. Core space and relation with common facility

Further, we investigate the spatial characteristics(spatial integration) of common facilities in each core space type nursing home, the spatial integration order from high to low for common facilities and nursing home average is also shown in Table 3.3, the summary is shown in Table 3.4, and Fig. 3.11.

Table 3.4 Summary of core space and common facilities

INT Order	Core space type					Total
	Corridor	Connection corridor	Hall	Common space	Other	
SST> Other C.F. and NH*	17	5	11	4	0	37
CMS> Other C.F. and NH	2	3	5	1	1	12
DRM> Other C.F. and NH	4	1	2	0	0	7
PTR> Other C.F. and NH	1	1	1	1	1	5
NH> all C.F.	0	0	1	0	0	1
Total	24	10	20	6	2	62

Note: the spatial integration of SST is higher than other common facilities, and nursing home average

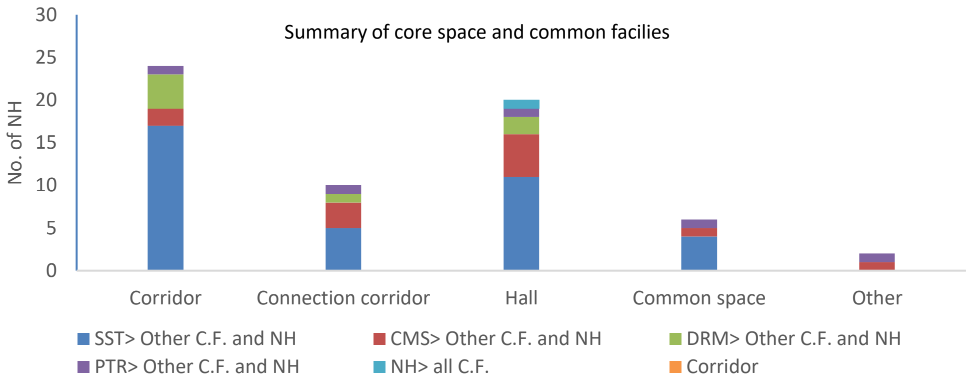


Fig. 3.3 Core space and common facility in Japanese nursing home (Source: Created by the author)

(1) Corridor as core space

It can be seen that in this type nursing home, the service station owns the high spatial centrality of common space, takes 17 of the 24 nursing homes in total.

Because all corridor core space nursing homes are large-scale care type, where the care service was performed to all residents in large group, the service station was allocated to the center of floor plan to reduce the moving distance when taking care service, which makes it higher spatial centrality.

Besides, there is 2 nursing homes in this core space type that the community space owns higher spatial centrality with in the common facilities.

(2) Connection corridor as core space

Still, the service station takes more portion of spatial centrality of common space in this core space type, it is 5 in 10 nursing homes. But, compared with the corridor core space type, there are more nursing homes where the community space is of higher spatial centrality. This also confirmed the spatial importance of community space in unit care nursing homes.

(3) Hall as core space

11 of 20 nursing homes in this type provide the service station with high spatial centrality of common space, as in Table 3.3. Five nursing homes take community space with high spatial centrality of common space in this core space type. These two common facilities are more centered space in this type.

(4) Common space as core space

Four of six nursing homes in this type take the SST as high spatial centrality, same as other core space type, it tells that the SST is spatial centered common facility.

In short, the service station shows the large portion as the common facility owns the higher spatial centrality than others in all type nursing homes, especially in the corridor core space type classical large-scale care nursing homes. However, the portion decreased and more community space become common facility with higher spatial centrality in connection corridor core space nursing homes, and which are mainly unit care type nursing homes.

It is easy to imagine that service station is the center because it is care base of nursing home. And, around service station, the communication is mainly held by resident and care worker. This result tells that the community space as the space for communications between residents is important common facility in Japanese nursing homes.

3.3.1.2 Core space changes over time

The core space changes in each five year interval is in Table 3.5, and Fig. 3.12.

Table 3.5 Number of nursing home by core space

Build year	Corridor	Connect corridor	Hall	Common space	Other	Total
1980	2		1			3
1985	6		2			8
1990	4		3			7
1995	5		2		2	9
2000	5	2	3	1		11
2005	2	1	2	3		8
2010		3	2	2		7
2015		4	5			9
Total	24	10	20	6	2	62

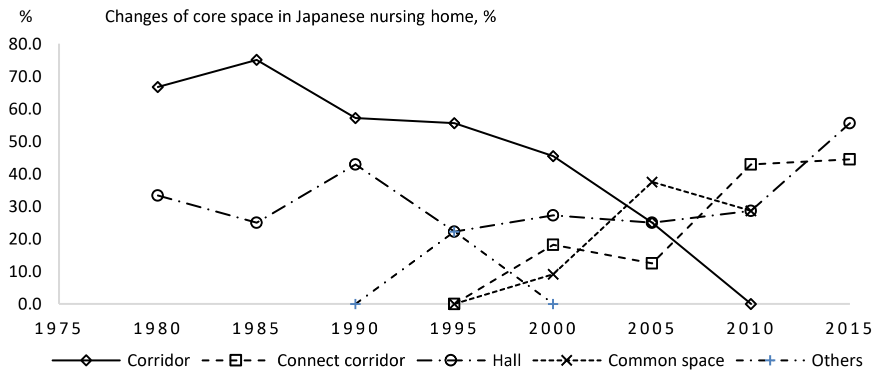


Fig. 3.4 Changes of spatial centrality in Japanese nursing home (Source: Created by the author)

It can be seen from Fig. 3.12 that the spatial centrality was changed from corridor in the 1980s to hall in the 2010s. In detail:

1. The corridor was spatial centrality in most of Japanese nursing homes built before 2000s, it accounted for 70%~80% in the period of the 1975~1980, and went down to less than 25% after the 2000.
2. The connection corridor started to be spatial centrality from the 1995 and increased gradually up to 44% in the period of 2010.
3. The hall space became to be spatial centrality in most of nursing homes built after the 2010, reached 55%.
4. The common facility also started to be spatial centrality after the 1995 and reached 28% in the 2005.

The above result tells that by the transition of nursing home from classical large-scale care type to unit care type, the spatial centrality is also changed, from the corridor in classical large-scale care type to hall in unit care type. The entrance hall, lounge etc. space is most important place for residents' social exchange in modern unit care nursing home.

3.3.2 Each common facility in the past 35 years

The spatial metrics overall changes in the past 35 years for each common facility is listed in Table 3.6 and Table 3.7(in page 49, 50). The average result per five year and 95% confidence interval for each common facility is as follows.

3.3.2.1 Community space

The spatial integration of community space shows uptrend in the past 35 years, from 0.78 in 1980s to 1.09 in 2010-2015. The spatial connectivity also shows increased tendency, from 2.0 in 1980s to 4.29 in 2010-2015(Fig. 3.13).

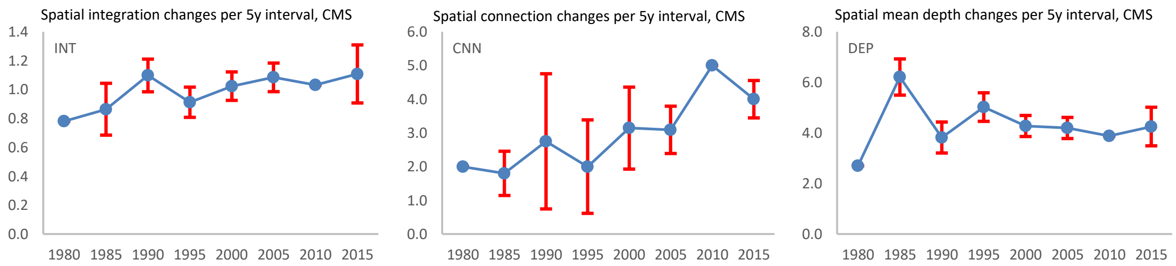
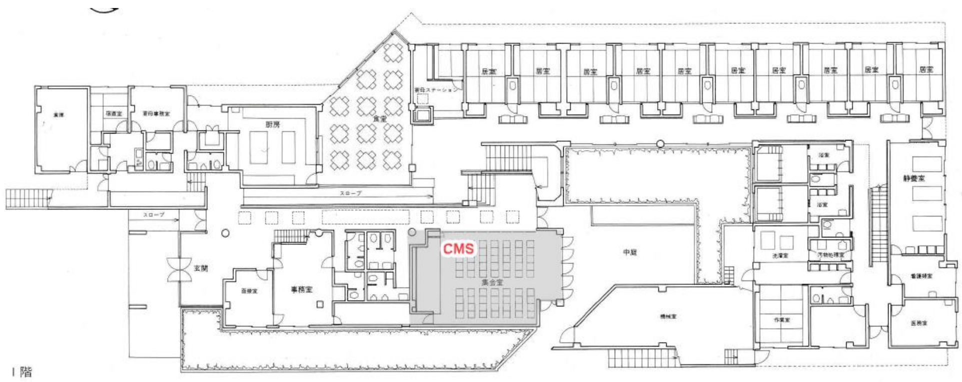


Fig. 3.5 CMS spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)(For period when only 1 sample data exist, the confidence interval is 0)

Because both spatial integration and connectivity are the indicators of accessibility, the increase in spatial integration and spatial connectivity tells the tendency to allocate community space to place with higher spatial centrality for residents' easier access and gathering in Japanese nursing homes.

Fig. 3.14 is a nursing home built in 1978, where the community space was built close to the staff office at the middle left part of floor plan with spatial integration of 0.7806 as shown on the right.



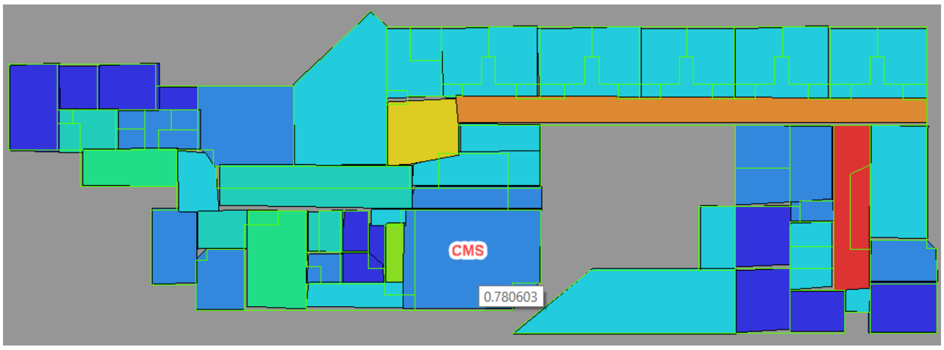


Fig. 3.6 CMS in a nursing home built in 1978(Source: created by author, NHID:2)

Fig. 3.15 is a nursing home built in 2003, it is an unit-care type nursing home where the community space was built close to central of living area, its spatial integration is 1.11997 as shown on the right. From SS point of view, the community space is better spatially integrated with the other space units(INT=1.11997 > INT= 0.7806 in NHID 2) , and better accessibility is expected.

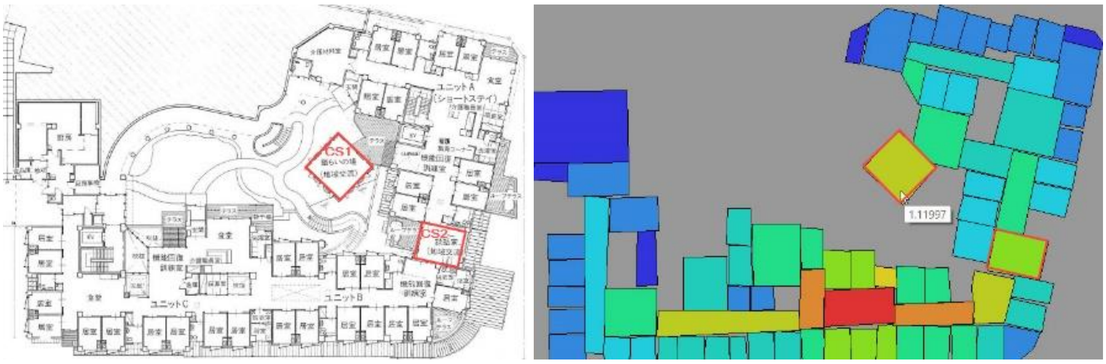


Fig. 3.7 CMS in a nursing home built in 2003(Source: created by author, NHID:51)

3.3.2.2 Physical training room

The integration of physical training room shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.0003, in Table 3.7). However, the 5 year interval average spatial connectivity shows uptrend from 1.83 in 1985s to 3.13 in 2011-2015(Fig. 3.16).

This reveals the tendency to have more access routines for PTR in modern unit care nursing homes.

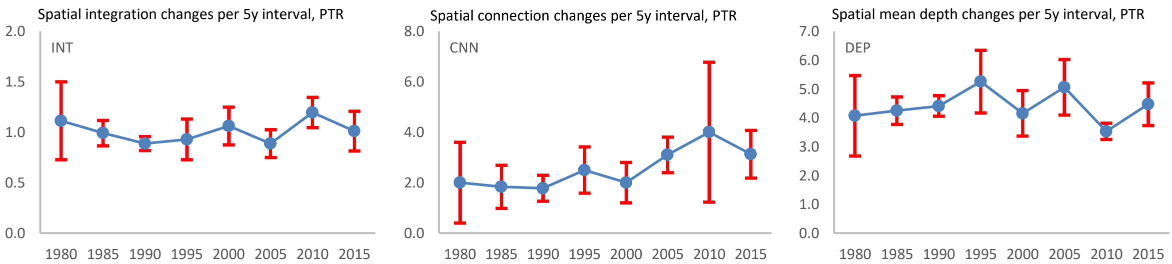


Fig. 3.8 PTR spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

Fig. 3.17 is a nursing home built in 2013, where the physical training room and dining room was built close to entrance hall with 5 spatial connections with community space(lobby), entrance hall, the main corridor, the day service room at right hand, and the terrace.

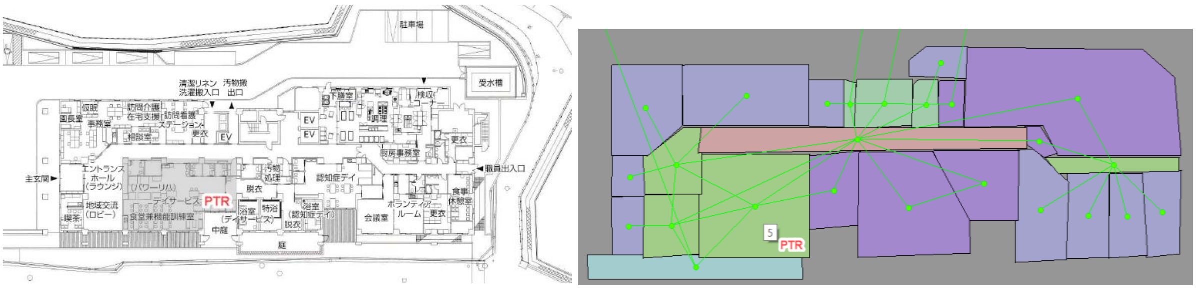


Fig. 3.9 PTR in a nursing home built in 2013(Source: created by author, NHID:77)

3.3.2.3 Service station

The spatial integration, connectivity, and mean depth of service station shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.0051, 4E-05, 0.0579 respectively in Table 3.7). However, the 5 year interval average of spatial integration reveals the downtrend in the past 35 years, from 1.28 in 1980s to 1.05 in 2015(Fig. 3.18).

In classical large scale care type nursing homes, the care service was done in large group, it’s better to allocate the service station in the central of living areas for easy access both for care staff and residents, this resulted the higher spatial integration. While in unit care nursing homes, the care service is performed and distributed in each living units, allocate the service station to central part of living areas is not so important as it is in classical large-scale care nursing homes.

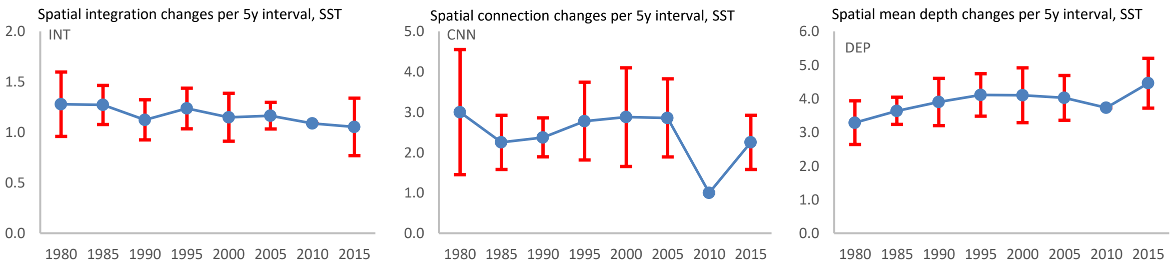


Fig. 3.10 SST spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

Fig. 3.19 is a classical large-scale care type nursing home built in 1982, where the service station was allocated in the central of floor plan which resulted its higher spatial integration of 1.90.

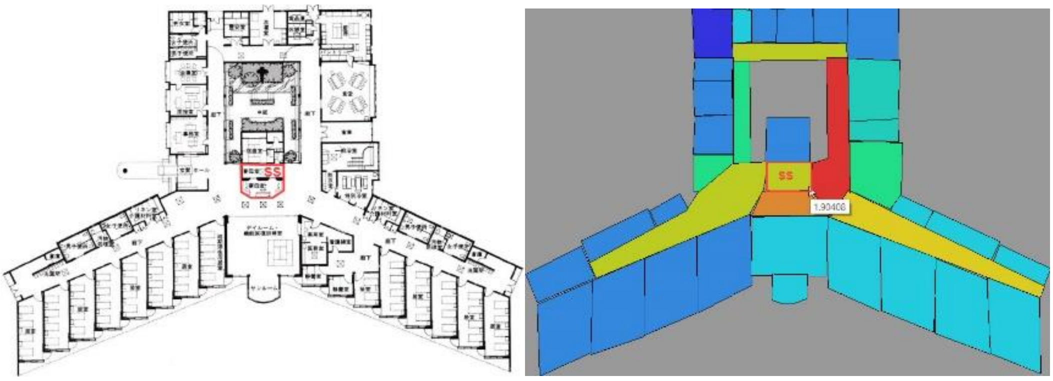


Fig. 3.11 SST in a classical large-scale care type nursing home (Source: created by author, NHID:11)

Fig. 3.20 is a unit scale care type nursing home built in 2012, where the service station(care staff room) was allocated at side of right hand, which resulted the lower spatial integration of 0.94 compared with that in classical large-scale care nursing home.

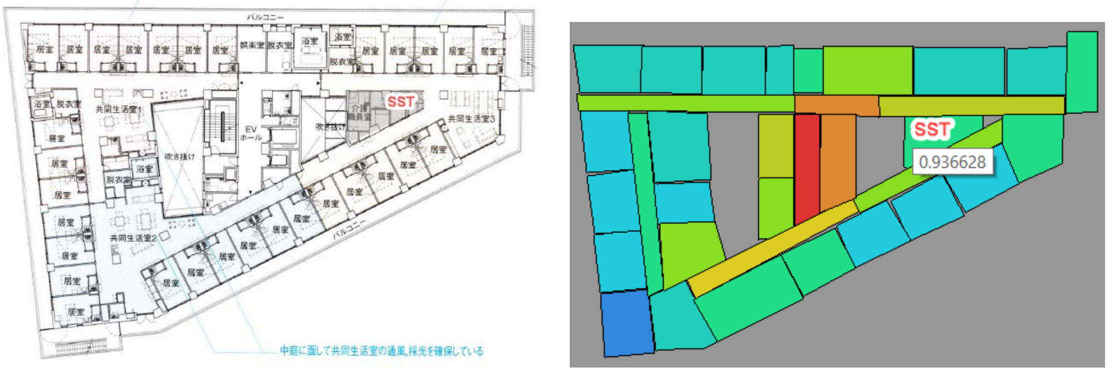


Fig. 3.20 SST in an unit care type nursing home(Source: created by author, NHID:71)

3.3.2.4 Dining room

The spatial integration, connectivity, and mean depth of dining room shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.0184, 0.0005, 0.0878 respectively in Table 3.7). However, the average spatial integration per 5 year intervals significant change down tendency(Fig. 3.21).

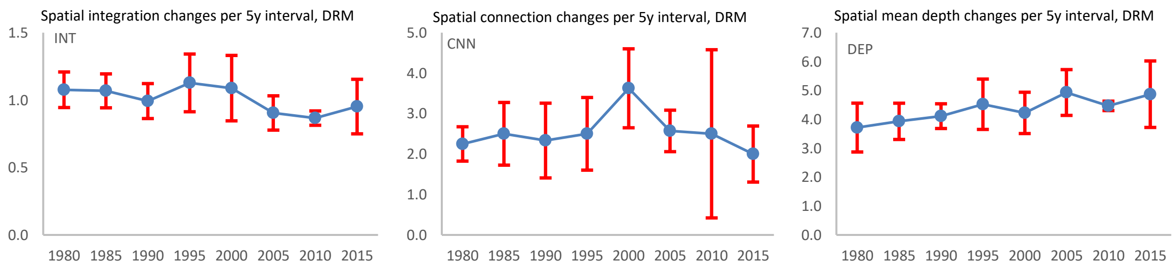


Fig. 3.12 DRM spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

3.3.2.5 Entrance hall

The spatial integration, connectivity, and mean depth of entrance hall shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.006, 0.049, 0.0091 respectively in Table 3.7). However, the average value per 5 year interval tells the increase in spatial connectivity in entrance hall(Fig. 3.22).

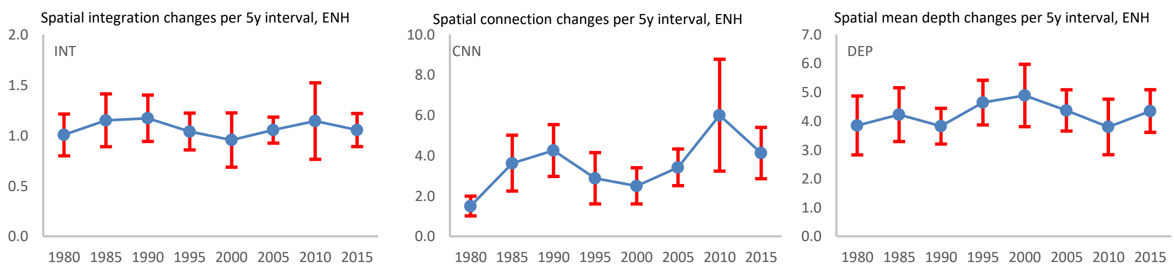


Fig. 3.13 ENH spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

Fig. 3.23 is a nursing home built in 2012, where the entrance hall was built with 6 spatial connections to dining room, physical training room, staff room, lobby, community space, and corridor.

Fig. 3.14 ENH in a nursing home built in 2012(Source: created by author, NHID:75)

3.3.2.6 Multiple purpose room

The spatial integration, connectivity, and mean depth of multiple purpose room shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.0057, 0.0771, 0.0171 respectively in Table 3.7).

The average value per 5 year interval shows a downtrend in connectivity(Fig. 3.24). This also tells that the not so importance in spatial metrics of MPR in Japanese nursing homes.

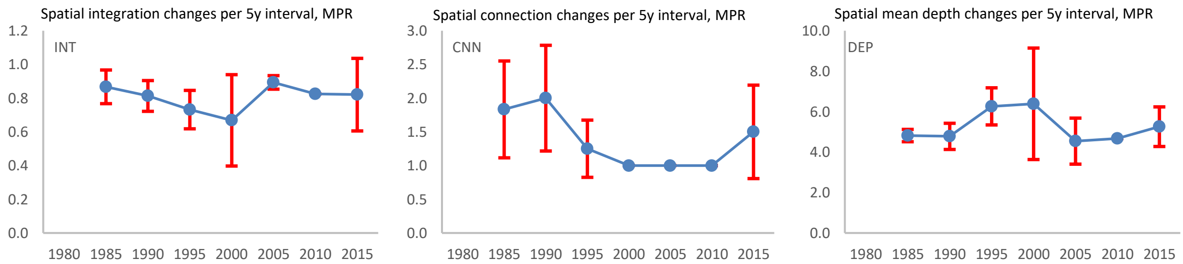


Fig. 3.15 MPR spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

3.3.2.7 Day service room

The spatial integration, connectivity, and mean depth of day service room shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=8E-07, 0.145, 0.0048 respectively in Table 3.7).

The average value per 5 year interval also doesn’t shows significant tendency in spatial integration, connectivity, and mean depth(Fig. 3.25).

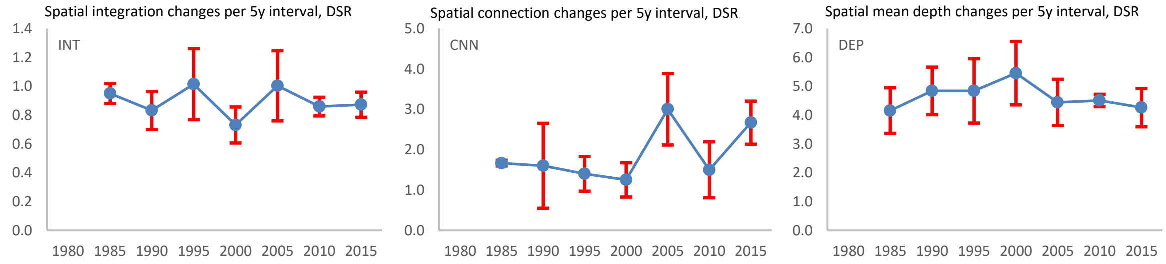


Fig. 3.16 DSR spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

3.3.2.8 Living space

The spatial integration, connectivity, and mean depth of DRM shows uncertain changes in the past 35 years due to the very low coefficient of determination(R-square=0.013, 0.0522, 0.0003 respectively in Table 3.7).

However, the 5 year interval average shows significant uptrend in spatial connectivity, and spatial integration(Fig. 3.26).

This indicates that more space connections in modern unit care nursing homes.

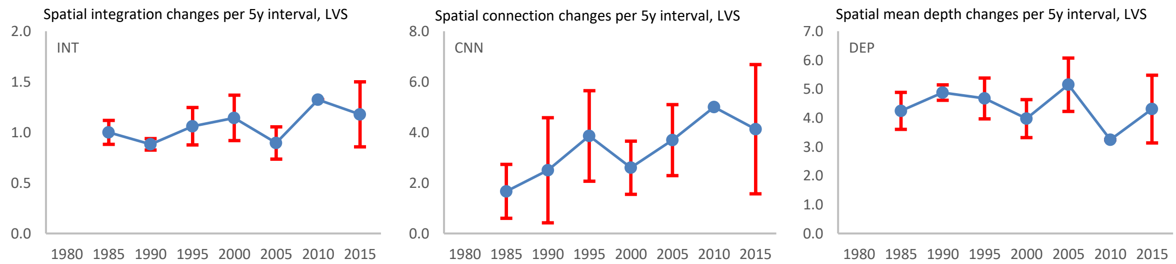


Fig. 3.17 LVS spatial metrics changes per 5 year and 95% confidence interval(Source: created by author)

3.3.3 SS metrics average and distribution

The SS connectivity, integration, and mean depth for the main public space(community space, CMS; entrance hall, ENH; day service room, DSR), semi-public space(physical training room, PTR; dining room, DRM; service station, SST; multiple purpose room, MPR), and semi-private space(living space, LVS) of the total 62 investigated nursing homes is shown in Table 3.8. The average, range, standard deviation, maximum and minimum value, and 95% confidence level is shown in Table 3.8.

Table 3.8 Statistics of spatial metrics of each common facility in Japanese nursing home

SS		N	Range	Minimum	Maximum	Mean		Std. Deviation
Metrics		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
CNN	ENH*	56	7.00	1.00	8.00	3.4464	0.25852	1.93456
	DRM	62	6.00	1.00	7.00	2.5565	0.16265	1.28070
	PTR	52	5.00	1.00	6.00	2.4808	0.18925	1.36469
	MPR	22	2.00	1.00	3.00	1.5455	0.17065	0.80043
	SST	60	7.00	1.00	8.00	2.6000	0.19045	1.47522
	CMS	36	5.00	1.00	6.00	2.9722	0.25035	1.50211
	DSR	29	4.00	1.00	5.00	1.9655	0.21336	1.14900
	LVS	39	11.00	1.00	12.00	3.4872	0.42978	2.68399
INT	ENH	56	1.2455	0.5894	1.8348	1.070211	0.0398947	0.2985446
	DRM	62	1.3909	0.4925	1.8834	1.010723	0.0348423	0.2743485
	PTR	52	1.3624	0.4297	1.7921	0.973101	0.0359436	0.2591933
	MPR	22	0.6340	0.4727	1.1067	0.808559	0.0303940	0.1425604
	SST	60	1.3760	0.5822	1.9582	1.173348	0.0413024	0.3199273
	CMS	36	0.8624	0.5551	1.4175	1.027415	0.0321906	0.1931434

	DSR	29	1.1831	0.4961	1.6792	0.908220	0.0450707	0.2427134
	LVS	39	1.6657	0.5101	2.1758	1.032841	0.0535957	0.3347050
Mean Depth	ENH	56	4.0952	2.5278	6.6230	4.299902	0.1628984	1.2190203
	DRM	62	6.3963	1.9000	8.2963	4.431380	0.1645785	1.2958924
	PTR	52	5.5950	2.7241	8.3191	4.571177	0.1728271	1.2462739
	MPR	22	4.9423	3.4348	8.3770	5.222091	0.2443841	1.1462628
	SST	60	5.1976	2.4444	7.6420	3.982859	0.1395480	1.0809340
	CMS	36	4.3441	2.6923	7.0364	4.289960	0.1483949	0.8903693
	DSR	29	4.8071	2.5333	7.3404	4.671054	0.2009723	1.0822692
	LVS	39	6.6802	1.9000	8.5802	4.607184	0.2317164	1.4470687

* CMS, community space; PTR, physical training room; SST, service station; DRM, dining room; ENH, entrance hall; MPR, multiple purpose room; DSR, day service room; LVS, living space. CNN, connectivity; INT, integration; MD, mean depth.

For community space, the average connectivity is 3.324, ranges from 1.0 to 7.0, and the standard deviation is 1.6091. The average integration is 1.0278, ranges from 0.7806 to 1.4175. The average mean depth is 4.2477, ranges from 2.6923 to 5.4306.

Similarly, the average connectivity, integration, mean depth and ranges for physical training room are 2.442, .9490, 4.6579, and 1.0 to 6.0, .4297 to 1.5526, 2.7241 to 8.3191 respectively.

The average connectivity, integration, mean depth and ranges for service station are 2.767, 1.1774, 3.9794, and 1.0 to 9.0, .5822 to 2.7778, 1.9697 to 7.6420 respectively.

The average connectivity, integration, mean depth and ranges for dining room are 2.476, .9869, 4.5230, and 1.0 to 7.0, .5300 to 1.8834, 1.9000 to 8.2963 respectively.

These average value and data range will be the reference for common space occupancy regression analysis in chapter 5.

3.3.4 Comparison by nursing home care type

The average integration for four common facilities in classical large-scale care nursing home and unit care nursing home is presented in Fig. 3.27.

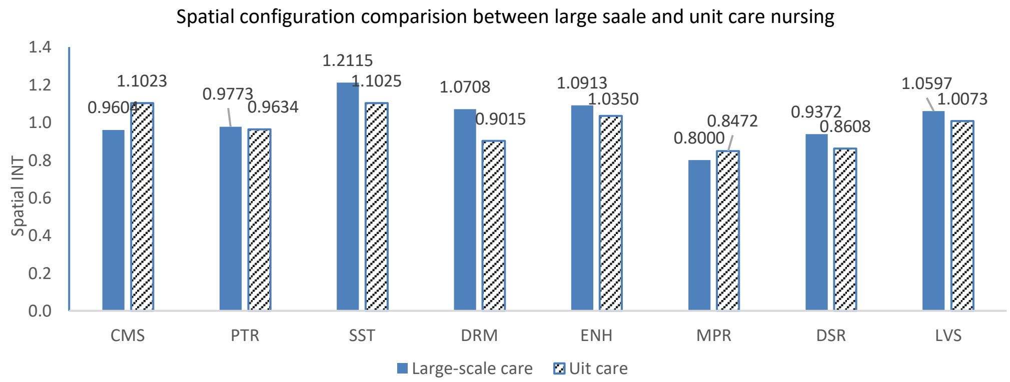


Fig. 3.18 Spatial metrics comparison between classical large-scale care and unit care nursing home, INT(Source: created by author)

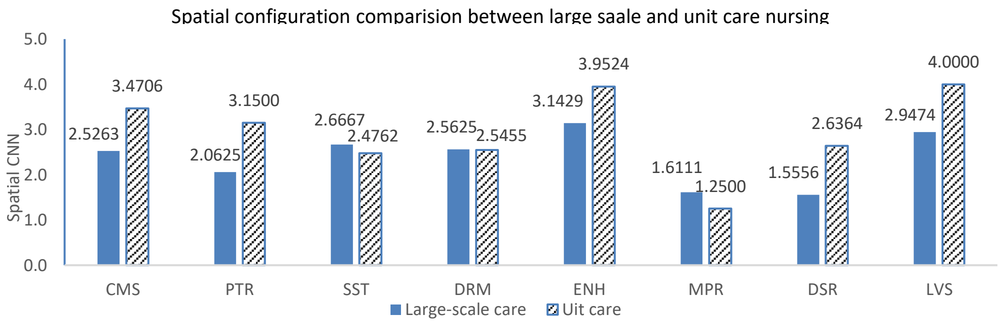


Fig. 3.19 Spatial metrics comparison between classical large-scale care and unit care nursing home, CNN(Source: created by author)

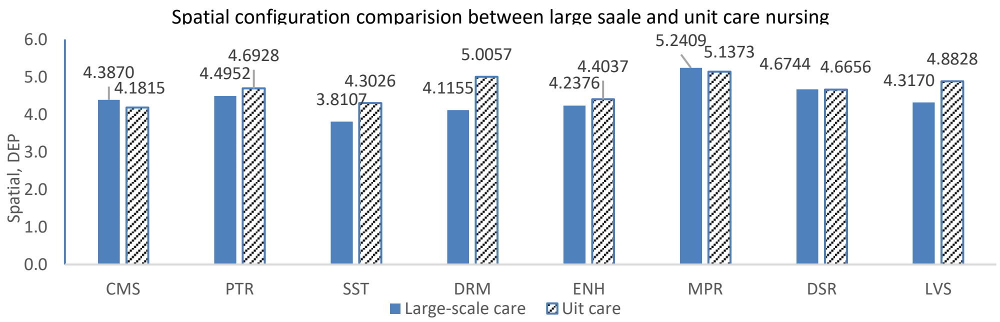


Fig. 3.20 Spatial metrics comparison between classical large-scale care and unit care nursing home, DEP(Source: created by author)

It can be seen from this Fig. 3.27 that compared with classical large-scale care nursing home, spatial integration of community space in unit care nursing home is increased about 15% from 0.9604 to 1.1023, but service station and dining room are reduced about 10% and 13% from 1.2115 to 1.1025, and 1.0708 to 0.9025 respectively.

The spatial connectivity in Fig. 3.28 tells that compared with classical large-scale care nursing homes, the spatial connectivity is increased in community space, physical training room, entrance hall, day service room, and living spaces. This also reflects that these common spaces are easier to access and gather for social exchange for residents in modern Japanese nursing homes.

3.4 Summary

The analysis of spatial characteristics of 62 Japanese nursing homes by space syntax theory clarifies:

(1) The spatial centrality(space with the highest spatial integration value) in Japanese nursing home has been changed from the corridor in the 1980s to hall space in modern Japanese nursing homes. It counted for 70%~80% of nursing homes built in the 1975s~1980s where the corridor was spatial centrality, and got down to less than 25% after the 2000s

(2) The community space, physical training room, service station, and, dining room, etc. common facilities were also started to be the spatial centrality in some of Japanese nursing home after the 1995s.

(3) The service station shows the large portion as the common facility owns the higher spatial centrality than others in all core space type nursing homes, specially in the corridor core space type for classical large-scale care nursing homes. However, this portion decreased and more community space become to be common facility with higher spatial centrality in connection corridor core space type nursing homes which are mainly unit care type nursing homes.

(4) About the overall changes of spatial configuration, the community space shows the increase in spatial integration and spatial connectivity in the past 35 years, from 0.78 in 1980s to 1.09 in 2010-

2015, and from 2.0 in 1980s to 4.29 in 2010-2015; the physical training room shows small increase in spatial integration and spatial connectivity, from the 0.99 in 1985s to 1.02 in 2010-2015, and from 1.83 in 1985s to 3.13 in 2010-2015. Because both spatial integration and connectivity are the indicator of accessibility, this spatial transition tells the tendency to allocate place with higher spatial centrality for community space and physical training room in Japanese nursing homes. On the other hand, the analysis also reveals that the service stations which were allocated with high spatial integration place in classical large-scale care nursing homes are allocated in lower spatial integration in modern unit care nursing homes.

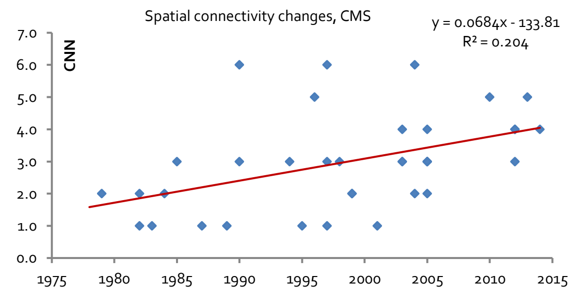
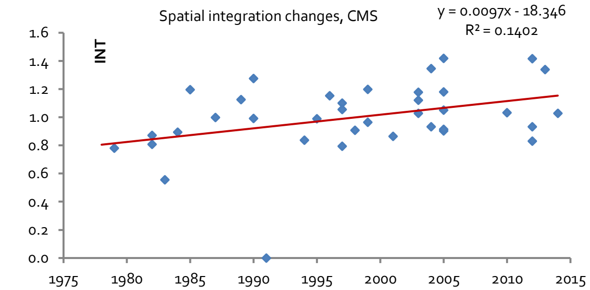
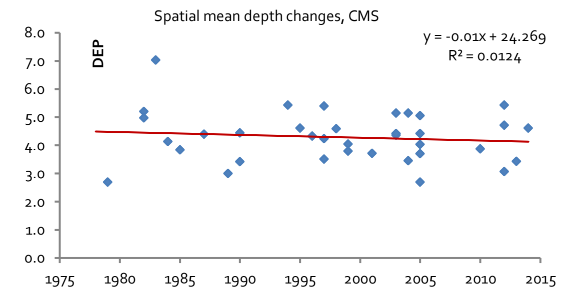
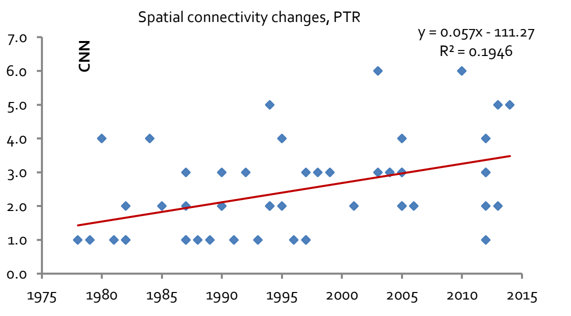
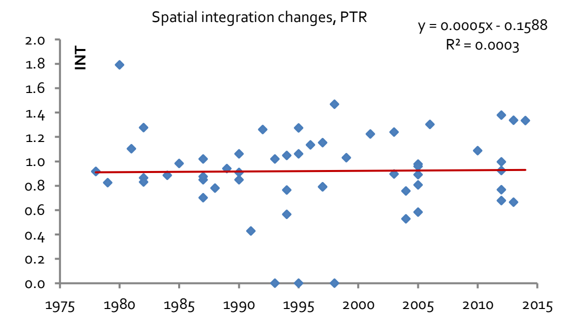
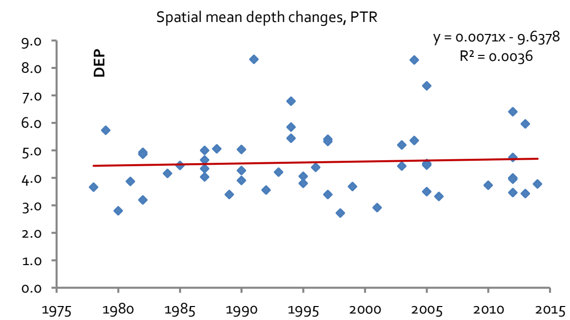
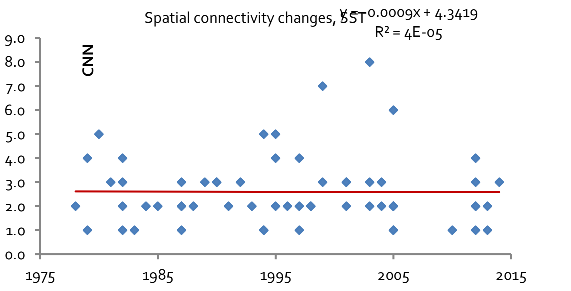
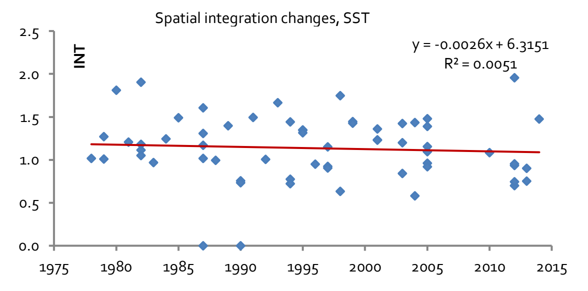
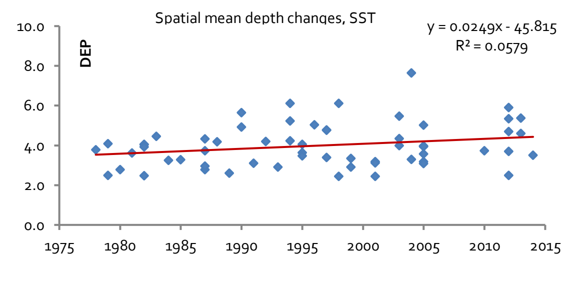
(5) With the transition of Japanese nursing home from classical large-scale care to unit care, the spatial integration of community space is increased about 15%, but service station and dining room are reduced about 10% and 13%. All the results disclose the importance of community space and physical training room in modern nursing home spatial design.

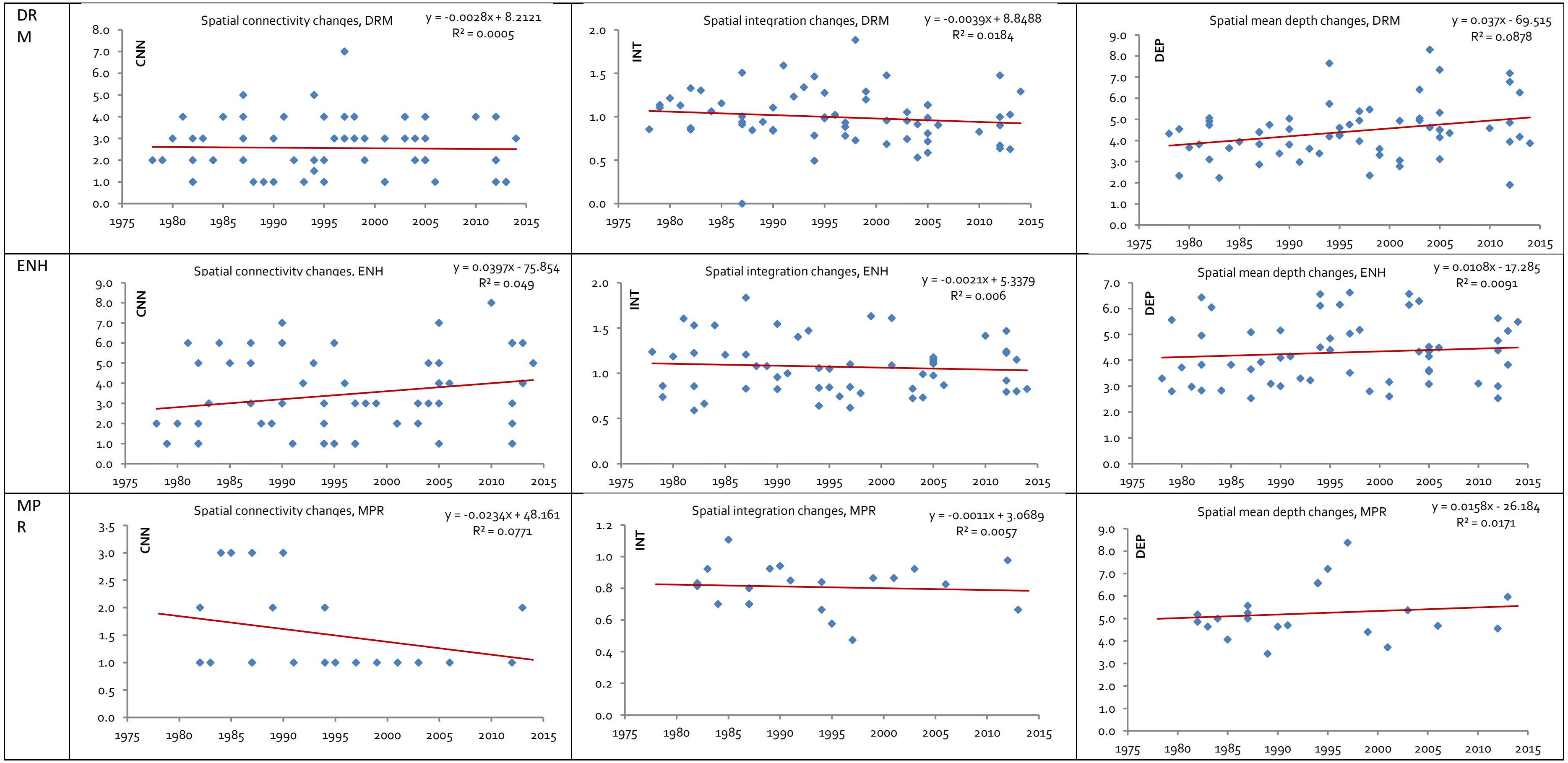
Table 3.6 Common space spatial configuration result in Japanese nursing home

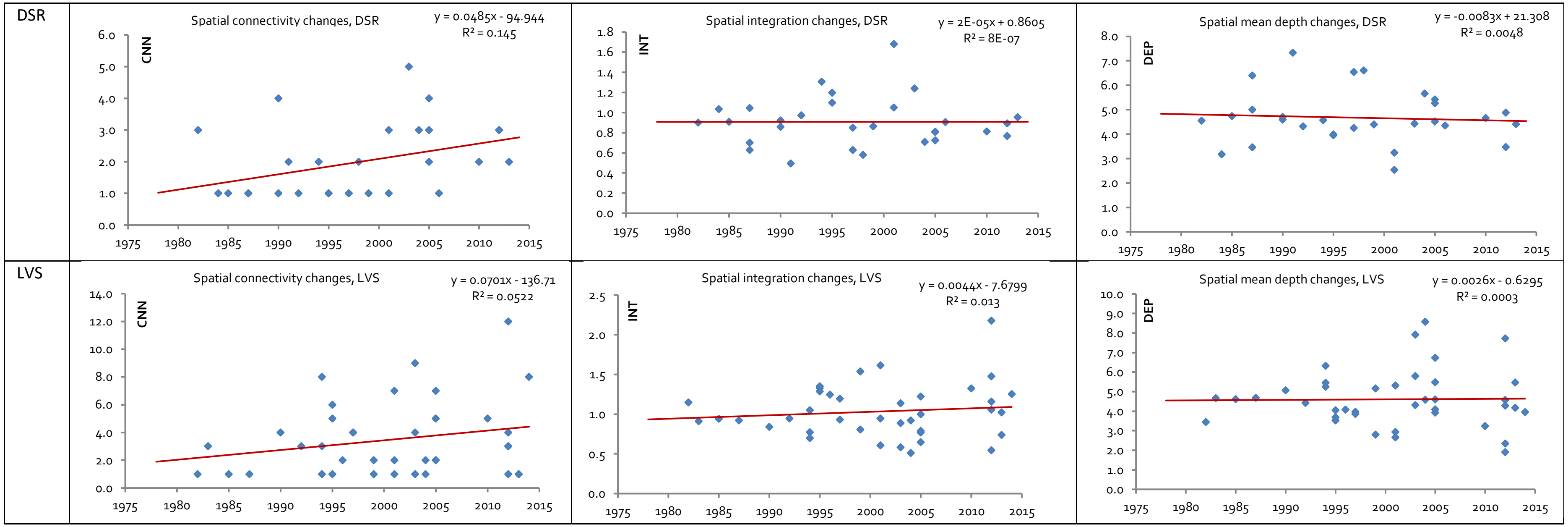
No.	NHID	Built year	Care Type	CMS			PTR			SST			DRM			ENH			MPR			DSR			LVS		
				CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP	CNN	INT	DEP
1	1	1978	L					0.9169		2.0	1.0195	3.7838	2.0	0.8537	4.3243	2.0	1.2353	3.2973									
	1(2F)	1978					1.0	0.9169	3.6667																		
2	2	1979	L	2.0000	0.7806	2.7000				1.0	1.0103	2.5000	2.0	1.1366	2.3333	1.0	0.7372	2.8000									
3	3	1979	L				1.0	0.8265	5.7381	4.0	1.2700	4.0833	2.0	1.1038	4.5476	1.0	0.8588	5.5595									
4	5	1980	L				4.0	1.7921	2.8000	5.0	1.8123	2.7800	3.0	1.2127	3.6600	2.0	1.1860	3.7200									
5	7	1981	L				1.0	1.1035	3.8750	3.0	1.2086	3.6250	4.0	1.1280	3.8125	6.0	1.6030	2.9792									
6	8	1982	L	1.0000	0.8070	5.2105	2.0	0.8646	4.9298	3.0	1.1131	4.0526	3.0	0.8685	4.9123	1.0	0.8570	4.9649	1.0	0.8137	5.1754						
7	9	1982	L				1.0	0.8295	4.8571	1.0	1.0522	4.0408	1.0	0.8567	4.7347	1.0	0.5894	6.4286	1.0	0.8295	4.8571	3.0	0.9010	4.5510			
8	10	1982	L	2.0000	0.8700	4.9833				2.0	1.1814	3.9333	2.0	0.8522	5.0667	5.0	1.2231	3.8333	2.0	0.8317	5.1667						
9	11	1982	L				1.0	1.2774	3.1944	4.0	1.9041	2.4722	1.0	1.3278	3.1111	2.0	1.5290	2.8333							1.0	1.1468	3.4444
10	12	1983	L	1.0000	0.5551	7.0364				1.0	0.9699	4.4545	3.0	1.3007	2.2308	3.0	0.6629	6.0545	1.0	0.9214	4.6364				3.0	0.9123	4.6727
11	13	1984	L	2.0000	0.8931	4.1389	4.0	0.8852	4.1667	2.0	1.2459	3.2500	2.0	1.0623	3.6389	6.0	1.5290	2.8333	3.0	0.7008	5.0000	1.0	1.0354	3.1739			
12	14	1985	L	3.0000	1.1955	3.8421	2.0	0.9831	4.4561	2.0	1.4898	3.2807	4.0	1.1528	3.9474	5.0	1.2029	3.8246	3.0	1.1067	4.0702	1.0	0.9093	4.7368	1.0	0.9402	4.6140
13	15	1987	L				1.0	0.7008	5.0000				5.0	1.5062	2.8611	6.0	1.8348	2.5278	1.0	0.7008	5.0000	1.0	0.7008	5.0000			
	15(2F)	1987								3.0	1.6049	2.7895															
14	16	1987	L	1.0000	0.9983	4.4035	2.0	1.0193	4.3333	1.0	1.0193	4.3333	3.0	1.0035	4.3860	3.0	0.8312	5.0877	3.0	0.8003	5.2456	1.0	0.6288	6.4035	1.0	0.9222	4.6842
15	17	1987	L				1.0	0.8488	4.0333	2.0	1.3092	2.9667	4.0	0.9087	3.8333							1.0	1.0438	3.4667			
16	18	1987	L				3.0	0.8758	4.6531	2.0	1.1700	3.7347	2.0	0.9388	4.4082	5.0	1.2060	3.6531	1.0	0.6999	5.5714						
17	19	1988	L				1.0	0.7810	5.0625	2.0	0.9953	4.1875	1.0	0.8460	4.7500	2.0	1.0800	3.9375									
18	20	1989	L	1.0000	1.1255	3.0000	1.0	0.9413	3.3913	3.0	1.3992	2.6087	1.0	0.9413	3.3913	2.0	1.0786	3.0870	2.0	0.9245	3.4348						
19	21	1990	L	3.0000	1.2752	3.4222	2.0	1.0611	3.9111				3.0	1.1032	3.8000	7.0	1.5444	3.0000				1.0	0.8580	4.6000			
20	23	1990	L				3.0	0.9084	4.2683	3.0	0.7561	4.9268	1.0	0.8395	4.5366	6.0	0.9585	4.0976									
21	24	1990	L	6.0000	0.9920	4.4483	2.0	0.8479	5.0345	3.0	0.7348	5.6552	1.0	0.8479	5.0345	3.0	0.8232	5.1552	3.0	0.9403	4.6379	4.0	0.9228	4.7069	4.0	0.8407	5.0690
22	25	1991	L				1.0	0.4297	8.3191	2.0	1.4932	3.1064	4.0	1.5895	2.9787	1.0	0.9988	4.1489	1.0	0.8496	4.7021	2.0	0.4961	7.3404			
23	26	1992	L				3.0	1.2601	3.5600	3.0	1.0081	4.2000	2.0	1.2312	3.6200	4.0	1.4025	3.3000				1.0	0.9716	4.3200	3.0	0.9432	4.4200
24	27	1993	L				1.0	1.0204	4.2115							5.0	1.4690	3.2308									
	27(2F)	1993								2.0	1.6678	2.9184	1.0	1.3399	3.3878												
25	28	1994	L				2.0	0.5661	6.7885	1.0	0.7746	5.2308	2.0	0.4925	7.6538	1.0	0.6406	6.1154							3.0	0.7711	5.2500
26	29	1994	L				5.0	1.0500	5.4414	5.0	1.4417	4.2345	5.0	1.4636	4.1862	2.0	0.8389	6.5586	2.0	0.8389	6.5586	2.0	1.3054	4.5724	8.0	1.0483	5.4483
27	30	1994	L	3.0000	0.8370	5.4306	2.0	0.7650	5.8472	1.0	0.7236	6.1250	1.5	0.7830	5.7361	3.0	1.0595	4.5000	1.0	0.6642	6.5833				1.0	0.6971	6.3194
28	31	1995	L	1.0000	0.9879	4.6154	2.0	1.2756	3.8000	2.0	1.3498	3.6462	1.0	0.9922	4.6000	1.0	1.0505	4.4000	1.0	0.5761	7.2000	1.0	1.1967	3.9846	1.0	1.3267	3.6923
29	32	1995	L							5.0	1.3475	4.0612	2.0	1.2752	4.2347										5.0	1.3520	4.0510
30	33	1995	L				4.0	1.0631	4.0588	4.0	1.3162	3.4706	4.0	0.9813	4.3137	6.0	0.8461	4.8431				1.0	1.0983	3.9608	6.0	1.2856	3.5294
31	34	1996	L	5.0000	1.1514	4.3291	1.0	1.1341	4.3797	2.0	0.9492	5.0380	3.0	1.0196	4.7595	4.0	0.7440	6.1519							2.0	1.2461	4.0759
32	36	1997	U	1.0000	1.1008	3.5143	1.0	1.1532	3.4000	1.0	1.1532	3.4000	4.0	0.9314	3.9714	1.0	1.1008	3.5143				1.0	0.8497	4.2571	4.0	0.9314	3.9714
33	38	1997	L	6.0000	0.7938	5.3934	3.0	0.7908	5.4098	4.0	0.9249	4.7705	7.0	0.8827	4.9508	3.0	0.6202	6.6230	1.0	0.4727	8.3770	1.0	0.6294	6.5410			
34	39	1997	L	3.0000	1.0553	4.2414	1.0	0.7904	5.3276	2.0	0.9059	4.7759	3.0	0.7811	5.3793	1.0	0.8479	5.0345							4.0	1.1952	3.8621
35	40	1998	L	3.0000	0.9062	4.5882				2.0	0.6354	6.1176	3.0	0.7274	5.4706	3.0	0.7786	5.1765				2.0	0.5798	6.6078			
36	43	1998	L				3.0	1.4690	2.7241	2.0	1.7488	2.4483	4.0	1.8834	2.3448												
37	45	1999	L	2.0000	0.9631	4.0500										3.0	1.6319	2.8000	1.0	0.8639	4.4000	1.0	0.8639	4.4000	2.0	1.5376	2.8000
	45(3F)	1999					3.0	1.0305	3.6857	3.0	1.4458	2.9143	3.0	1.1959	3.3143												
38	47	1999	L	2.0000	1.1967	3.8000				7.0	1.4286	3.3455	2.0	1.2887	3.6000										1.0	0.8048	5.1636
39	48	2001	L							2.0	1.3592	2.4444	1.0	0.9551	3.0556	2.0	1.6092	2.6000				3.0	1.6792	2.5333	2.0	0.9442	2.9375
40	49	2001	L							3.0	1.2346	3.1818	1.0	0.6838	4.9394										7.0	1.6162	2.6667
41	50	2001	L	1.0000	0.8644	3.7200	2.0	1.2246	2.9200							2.0	1.0886	3.1600	1.0	0.8644	3.7200	1.0	1.0497	3.2400			
	50(2F)	2001	L							3.0	1.2285	3.1290	3.0	1.4742	2.7742										1.0	0.6051	5.3226
42	51	2003	U	4.0000	1.1200	4.3600	3.0	0.8960	5.2000	3.0	0.8425	5.4667	4.0	0.9535	4.9467										9.0	1.1380	4.3067
43	52	2003	U	3.0000	1.1775	4.4176				2.0	1.2007	4.3516	3.0	0.7443	6.4066	2.0	0.7223	6.5714	1.0	0.9224	5.3626				4.0	0.5822	7.9121
44	53	2003	U	3.0000	1.0264	5.1481	6.0	1.2394	4.4352	8.0	1.4236	3.9907	4.0	1.0522	5.0463	3.0	0.8285	6.1389				5.0	1.2394	4.4352	1.0	0.8877	5.7963
45	55	2004	U	2.0000	0.9322	5.1481	3.0	0.5300	8.2963	2.0	0.5822	7.6420	3.0	0.5300	8.2963	3.0	0.7318	6.2840							2.0	0.5101	8.5802
46	57	2004	U	6.0000	1.3462	3.4528	3.0	0.7576	5.3585	3.0	1.4345	3.3019	2.0	0.9115	4.6226	5.0	0.9888	4.3396				3.0	0.7085	5.6604	1.0	0.9211	4.5849
47	59	2005	U	2.0000	1.1785	4.0308				2.0	1.3902	3.5692	2.0	1.1325	4.1538	4.0	1.1325	4.1538				3.0	0.8089	5.4154	2.0	1.2219	3.9231
48	61	2005	U				4.0	0.9767	4.5254	1.0	1.1543	3.9831	4.0	0.9862	4.4915	3.0	0.9767	4.5254							5.0	0.7695	5.4746
49	62	2005	U	4.0000	1.4175	2.6923	3.0	0.9596	3.5000	2.0	1.0942	3.1923	3.0	1.1340	3.1154	1.0	1.1550	3.0769									
50	64	2005	U	3.0000	0.8871	4.8813	3.0	0.8795	4.9153	2.0	1.4207	3.4237	2.0	0.7179	5.7966	7.0	1.1413	4.0169				4.0	0.7282	5.7288	5.0	0.9319	4.6949
51	65	2005	U	3.0000	1.0500	3.7027	2.0	0.8077	4.5135	1.0	0.9633	3.9459	2.0	0.8077	4.5135	5.0	1.1053	3.5676				2.0	0.8077	4.5135	2.0	0.7895	4.5946
52	66	2005	U	3.0000	0.9144	5.0556	2.0	0.5842	7.3472	6.0	0.9207	5.0278	2.0	0.5842	7.3472	4.0	1.1079	4.3472							7.0	0.6465	6.7361
53	67	2006	U				2.0	1.3029	3.3256				1.0	0.9049	4.3488	4.0	0.8687	4.4884	1.0	0.8247	4.6744	1.0	0.9048	4.3488			
54	69	2010	U	5.0000	1.0316	3.8780	6.0	1.0869	3.7317	1.0	1.0867	3.7317	4.0	0.8281	4.5854	8.0	1.4154	3.0976				2.0	0.8115	4.6585	5.0	1.3231	3.2439
55	71	2012	U	4.0000	0.9324	4.7167	4.0	0.9241	4.7500	2.0	0.9366	4.7000	2.0	0.9001	4.8500	2.0	0.9201	4.7667	1.0	0.9762	4.5500	3.0	0.8924	4.8833	3.0	1.0555	4.2833
56	72	2012	U				3.0	1.3796	4.0000	2.0	0.9529	5.3434	2.0	0.6695	7.1818	1.0	1.2231	4.3838							3.0	1.1575	4.5758
57	73	2012	U				3.0	0.7682	3.4706	1.0	0.7014	3.7059	4.0	1.4745	1.9000	3.0	1.2410	2.5294				3.0	0.7682	3.4706	4.0	1.4745	1.9000
58	74	2012	U	4.0000	0.8289	5.4286	1.0	0.6780	6.4143	4.0	0.7469	5.9143	1.0	0.6360	6.7714	6.0	0.7930	5.6286							1.0	0.5455	7.7286
59	75	2012	U	3.0000	1.4156	3.0750	2.0	0.9957	3.9500	3.0	1.9582	2.5000	2.0	0.9957	3.9500	6.0	1.4687	3.0000							12.0	2.1758	2.3500
60	76	2013	U				2.0	0.6654	5.9623	2.0	0.7544	5.3774	1.0	0.6273	6.2642	4.0	0.7991	5.1321	2.0	0.6654	5.9623				1.0	0.7384	5.4717
61	77	2013	U	5.0000	1.3374	3.4314	5.0	1.3374	3.4314	1.0	0.9013	4.6078	1.0	1.0237	4.1765	6.0	1.1516	3.8235				2.0	0.9531	4.4118	1.0	1.0237	4.1765
62	79	2014	U	4.0000	1.0269	4.6111	5.0	1.3350	3.7778	3.0	1.4751	3.5139	3.0	1.2899	3.8750	5.0	0.8266	5.4861							8.0	1.2535	3.9583

* Care type, L – classical large scale care type, U – unit care type;

Table 3.7 Common space spatial configuration changes over past 35 year

	Spatial connectivity	Spatial integration	Spatial mean depth
CMS			
PTR			
SST			


DR
M
Spatial connectivity changes, DRM
y = -0.0028x + 8.2121
R² = 0.0005
CNN
Spatial integration changes, DRM
y = -0.0039x + 8.8488
R² = 0.0184
INT
Spatial mean depth changes, DRM
y = 0.037x - 69.515
R² = 0.0878
DEP
ENH
Spatial connectivity changes, ENH
y = 0.0397x - 75.854
R² = 0.049
CNN
Spatial integration changes, ENH
y = -0.0021x + 5.3379
R² = 0.006
INT
Spatial mean depth changes, ENH
y = 0.0108x - 17.285
R² = 0.0091
DEP
MP
R
Spatial connectivity changes, MPR
y = -0.0234x + 48.161
R² = 0.0771
CNN
Spatial integration changes, MPR
y = -0.0011x + 3.0689
R² = 0.0057
INT
Spatial mean depth changes, MPR
y = 0.0158x - 26.184
R² = 0.0171
DEP


DSR
Spatial connectivity changes, DSR
y = 0.0485x - 94.944
R² = 0.145
CNN
Spatial integration changes, DSR
y = 2E-05x + 0.8605
R² = 8E-07
INT
Spatial mean depth changes, DSR
y = -0.0083x + 21.308
R² = 0.0048
DEP
LVS
Spatial connectivity changes, LVS
y = 0.0701x - 136.71
R² = 0.0522
CNN
Spatial integration changes, LVS
y = 0.0044x - 7.6799
R² = 0.013
INT
Spatial mean depth changes, LVS
y = 0.0026x - 0.6295
R² = 0.0003
DEP

Note:

1): The nursing homes are selected from following Japanese architecture publications:
ShinKenchiku - 10 nursing homes
All nursing homes published from No. 3, 1980 to No. 1, 2016
Architecture Design – 42 nursing homes
Two special edition of senior housing design
Modern Architecture – 10 nursing homes
Special edition on senior housing design

2): Ministry of Health, Labor and Welfare(Sep. 28,2009), http://www.mhlw.go.jp/topics/kaigo/kaigi/010928/siryo5-1.html (accessed May 25, 2018)

3): Mitsubishi Research Institute, Inc.(JP), ユニットリーダー プレ研修 カリキュラム細則, 2015.3 https://www.mri.co.jp/project_related/roujinhoken/uploadfiles/h27/h27_03_05.pdf (accessed Aug. 18, 2018)

4): 山口 健太郎, セミパブリック・パブリックゾーンの再考, 日本経済新聞, Vol 36, https://www.yamaguchi-lab.org/wordpress/wp-content/uploads/column/vol36.pdf (accessed Aug. 18, 2018)

5): MHLW (2015), Ministry of Health, Labor and Welfare. Appendix 2 About unit care. http://www.mhlw.go.jp/topics/kaigo/kentou/15kourei/3b.html (Accessed May 25, 2018)

6): Spatial analysis. https://en.wikipedia.org/wiki/Spatial_analysis (Accessed Oct. 20, 2018)

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Varoudis T(2013). Space Syntax Angular Betweenanes Centrality Revisited. Proceedings of the 9th International Space Syntax Symposium, pp.057:7.

Varoudis T. et al. (2015), Visibility, accessibility and beyond: Next generation visibility graph analysis. SSTS10 Proceedings of the 10th International Space Syntax Symposium. pp. 152:1-152:13

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Chapter 4 Common Space Occupancy Survey of Japanese Intensive Care Nursing Home

4.1 Introduction

The residents may have various behaviors in common space, like chatting, reading, excising, and siting etc. In common sense, the opportunity of communication would increase when residents stay in common space longer, therefore, compared with the activity in specific, the stay time itself, or the occupancy of common space, is more fundamental to residents' social life.

By this consideration, the survey of common space occupancy in Japanese nursing home is conducted in this chapter to get the actual common space occupancy data, and to clarify the tendency of occupancy over a day in each common space. First, the survey method are defined, then, the survey result is analyzed and summarized. The result from this chapter will be used as data input for space occupancy regression model analysis in next chapter.

4.1.1 Definition of space occupancy

For a common facility, the space occupancy is defined as the ratio of the average staying time of a resident in the facility within certain time interval. That is, the percentage of time a resident spent in the facility. Assuming that the service time of common facility is generally in day time, the occupancy would be the percentage of staying time during a day, like 8:00am ~ 20:00pm.

4.1.2 Definition of common space

As in Chapter 2, Chapter 3, the common space in this chapter is also the parts of a building providing shared facilities. For example: entrance hall, lounge, meeting room, physical training room, dining room, living space, community space, corridor, library, coffee corner, etc. Hereafter, these common facilities are also taken as common space.

The facility or space for nursing home staff management and medical service, and the private living room is not taken as common space. For example: staff office, medical room, private bed room etc.

And, based on the location of facility outside or inside the nursing home building, the common facility is divided as inner common space and outdoor common space. Because investigation shows residents spent more than 90% time staying inside nursing home(Kanki 2005, Tachibana 2002, Ishibashi 2015), only occupancy of inner common space is conducted. The common space surveyed is listed in Table 4.1.

Table 4.1 The common space investigated in nursing home

Symbol	Space category	Example
ENH	Public space	Entrance hall, lobby
DRM	Semi-public space	Restaurant, dining room
PTR	Semi-public space	Rehabilitee center, club room, club house, physical training room
MTR	Semi-public space	Multiple purpose room, hobby room, game room etc
SST	Semi-public space, semi-private space	Care station, service station
CMS	Public space	Community center, community space
DSR	Public space, semi-public space	Daily service room
LVS	Semi-private space	Living space, common room

Moreover, even corridor and connection corridors show to be the space with the highest spatial integration in some of nursing homes, however, basically the corridor are place for residents to passing through. And, compared with other general buildings(like school building, museum etc.), there are more occurrences of residents taking wheelchairs within it. Therefore, the corridor in nursing home is not such an important common place for collective activities as in school building, and, the occupancy of corridor is excluded in this survey.

4.1.3 Nursing care level in Japanese intensive care nursing homes

Intensive care nursing home in Japan is a facility where nursing care is necessary for the elderly people who need nursing care and/or with dementia [Note 1)]. Based on the health condition, the nursing care is divided to 6 levels, the detail is listed in Table 4.2. By the elderly nursing care regulation [Note 2)], the target residents of intensive nursing home are as follows.

1) Elderly people over 65 years of age with nursing care level 3 and above;
2) People of 40 to 64 years of age with specific diseases and nursing care level 3 and above;
3) People with nursing care level 1 and 2 and with specific permission.

Table 4.2 Nursing care level and target residents in Japanese intensive care nursing home*

Nursing care level	Health status	Eating	Cloth	Excretion	Target residents
Level 0	Can take meals, excretion, and clothes mostly in independent, but they need assistance from time to time.	Independent	Independent	Independent	No
Level 1	Can take meals, excretion, and clothes mostly in independent, but they need assistance for some parts.	Can be independent anyway	Can be independent anyway	Can be independent anyway	Need special admission
Level 2	Can take meals, clothes themselves, but need some help in excretion.	Can be independent anyway	Can be independent anyway	Need some assistance	Need special admission
Level 3	Need some nursing help for taking foods, clothes, and excretion	Can be independent anyway	Need some assistance	Need some assistance	Yes
Level 4	Status with a severe dementia symptom, and it is necessary in nursing care for taking meal, excretion and clothes.	Need assistance	Need assistance	Need assistance	Yes
Level 5	Status of bedridden condition, necessary in nursing care to carry out meal, excrement, and clothes, and spend all day on bed.	Need assistance	Need assistance	Need assistance	Yes

* Note 1) Definition of nursing care level. https://www.senior-anshin.com/guide/basic/type

4.2 Onsite survey

4.2.1 Survey target

The survey target is nursing home residents, the difference in resident age, gender, and health condition is not considered. That is, the survey result is for overall residents in nursing home.

4.2.2 Choice of survey site

The selection criteria of nursing homes to survey and limitation in the selection includes:

1. The nursing homes where the common space area size and spatial configuration have been studied in Chap.2(space area size analysis) and Chap.3(spatial configuration analysis).

2. The samples should include different types of care, different types of story, and the nursing homes having important dining room, physical training room, community space, service station etc. common facilities.

3. The nursing homes where I can visit and make survey. Therefore, the samples in Tokyo and Yokohama area are selected.

4. The nursing homes that can cooperate to survey.

And, the conditions I paid attention during the survey includes:

1. The room temperature are almost well conditioned.
2. The proportion of resident's nursing care level and proportion of residents with dementia should within the average level of all Japan.
3. The occupancy of room where event was held are exclude and its negative effect is considered on the occupancy analysis

Based on this consideration, the 24 nursing homes within Tokyo and Yokohama area were selected. However, due to the internal administrative activity only 12 of them agreed to cooperate with this survey, within 12 nursing homes surveyed, 1070 nursing home residents were involved.

4.2.3 Survey condition

During the survey, the residents health status, like the percentage of residents with dementia, and the residents with different nursing care level Note 3) is checked. The surveyed nursing home and residents' health status data is listed in Table 4.3. The health condition of residents in this surveyed nursing homes is in average level of all Japanese intensive care nursing homes.

Table 4.3 The list of nursing homes surveyed

NHID	Year of build	NH Care type	Observed residents/ capacity	Dementia proportion, %	Nursing care level 1, %	Nursing care level 2, %	Nursing care level 3, %	Nursing care >= level 4, %	Site area, m^2	Total floor space, m^2	Construction scale
7	1981	L	66	80	7.6	7.6	16.7		21,205	3,225	2F
12	2007	U	87	80	n/a	4.6	20.7	n/a	2,852*	3,599*	2F
13	1984	L	100	85	n/a	n/a	100.0	n/a	16,606	6,150	4F
14	1985	L	72		2.8	8.3	16.7	72.2	11,790	4,989	2F
16	1987	L	63	90	n/a	11.1	12.7	n/a	6,693	3,904	3F
23	1990	L	60	50	n/a	1.7	6.7	91.7	2,200	3,288	3F
27	1993	L	52	85	n/a	13.5	42.3	n/a	4,603	6,636	3F
30	1994	L	50	80	n/a	n/a	14.0	n/a	9,441	8,145	1F
45	1999	L	80	70	1.3	3.8	n/a	n/a	3,895	5,517	4F
48	2001	U	54	20	n/a	n/a	n/a	n/a	5,991	3,531	3F
50	2001	U	96	80	4.2	29.2	n/a	n/a	2,670	4,036	3F
74	2012	U	140	85	8.6	10.7	23.6	n/a	4,006	7,989	5F
Ave.				73.2%	4.9	10.0	28.1	81.9			
H28**				74.9%	2.2	6.1	23.0	68.6			

* Estimated from floor plan. ** The average of 2016 year in all Japanese intensive care nursing home, refer to MHLW(2017).

4.2.3.1 Percentage of residents with dementia

It can be seen from Table 4.3 that the proportion of people with dementia is 73.2% in our surveyed nursing home(Fig. 4.1). And, according to the survey from the Ministry of Health, Labor, and Welfare that 74.9% of residents in Japanese intensive care nursing homes have dementia with daily life independence degree Ⅲ or above(MHLW 2017, Fig. 4.2). Therefore, the people with dementia in surveyed nursing homes in this research is in accordance with the average of nursing homes in all Japan.

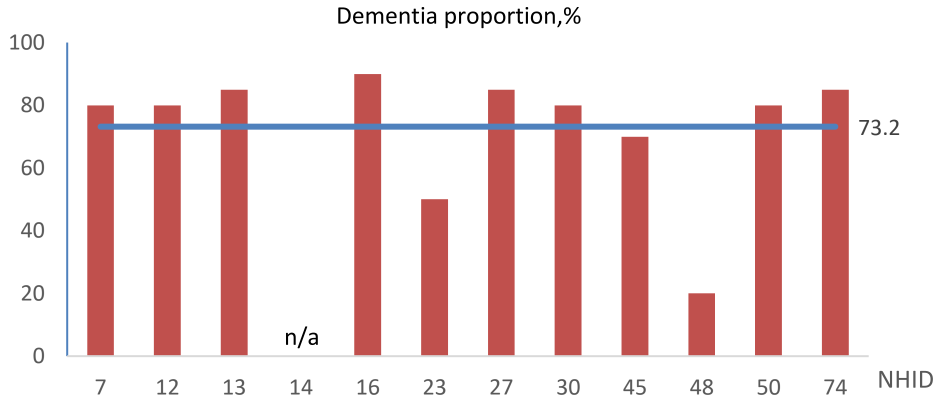


Fig. 4.1 Percentage of residents with dementia(Source: created by author)

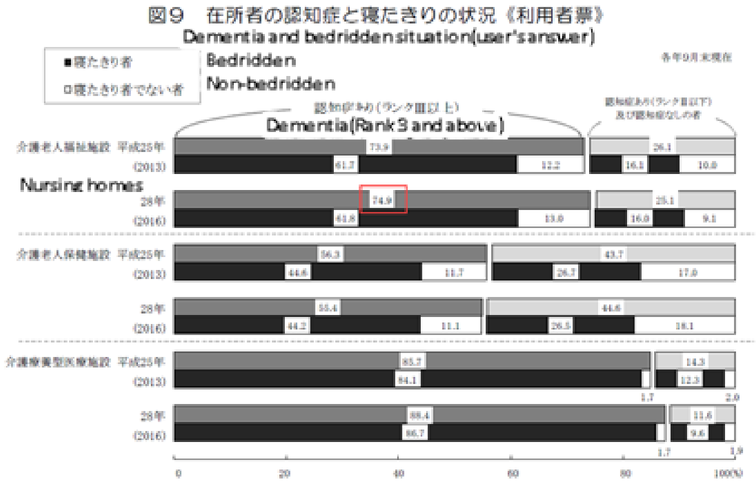


Fig. 4.2 Percentage of residents with dementia in Japanese nursing homes(Source: MHLW 2017, p.17)

4.2.3.2 Percentage of residents with different nursing care level

The residents with nursing care level 1, 2, 3 and above 3 is 4.9% 10.0%, 28.1, and 81.9% in our surveyed nursing homes(Table 4.3 and Fig. 4.3). On the other hand, according to the survey from Ministry of Health, Labor, and Welfare for all Japanese intensive care nursing homes, it is 2.2%, 6.1%, 23.0%, and 68.6% in Sep. 2016(MHLW 2017, Fig. 4.4). The surveyed target in this research is also in accordance with the average of nursing homes in all Japan.

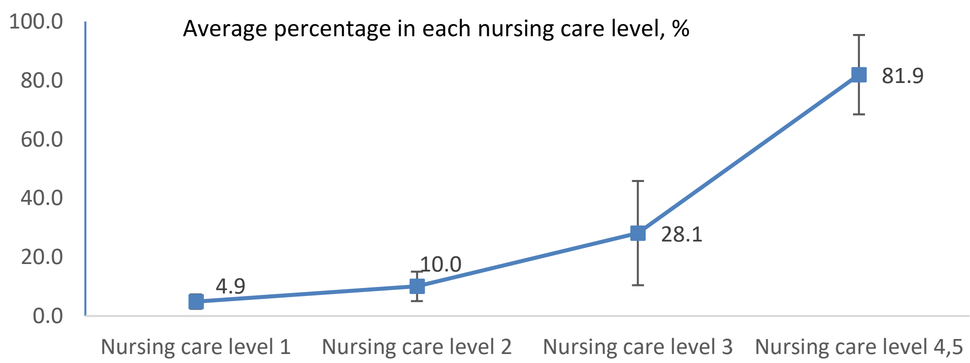


Fig. 4.3 Percentage of residents with each nursing care level in surveyed nursing homes (Source: created by author)

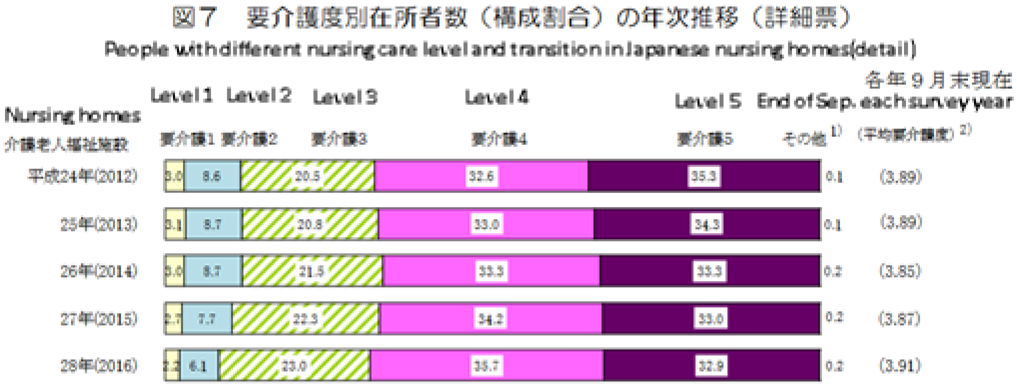


Fig. 4.4 Annual trend of percentage of residents with each nursing care level(Source: MHLW 2017, p.15)

4.2.4 Intensive survey

For each of selected nursing home, the questionnaire to nursing home staffs and onsite observation of nursing home residents staying time and the number of residents in common facility is conducted. The survey was done from Sep. 6, 2017 to Dec. 20, 2017. In detail, the staying time of residents in common space in these nursing homes from 8:00 ~ 18:00 were recorded in each 30 minutes interval, then the total staying time of all observed residents are summarized and is used to calculate the average occupancy of common space of residents in nursing home by

$$OCP = \frac{\sum(NUM*TIM)}{Total\ observed\ residents*DUR} \quad (1)$$

Here, OCP is occupancy(or occupancy rate, %), the NUM is the number of people who are staying in the common place, and TIM is the time interval of the observation(30 minutes). DUR is observation period, 8:00 am ~ 18:00 pm, 600mins.

The survey questionnaire sheet and answer example is listed in Table 4.4. All the answer sheets are listed in Chapter 4 Appendix.

Table 4.4 Nursing home common space occupancy investigation answer sheet(NHID 23)

平成２９年度 特別養護老人ホームの共有空間の利用実態調査アンケート

施設名：　定員：60名　所在地：東京都　号　記入日：平成29年10月24日

観察対象所在階数：2.3F　対象階数の居住者数：60　全施設入居者の内、認知症方の割合：50%

朝食：7:30　昼食：11:45　夕食：18:00　入浴 [illegible]　介護度１の人数：0　介護度２の人数：1　介護度３の人数：4　要4 17　要5 38

（下記時間枠内利用者の人数を各フロアことに具体的にご記入ください。必ずこの階の入居者数、と認知症方の割合をご記入ください。　施設の各室のスケジュール、各ユニットの一日の生活スケジュール（食事、入浴など）があればもご添付をお願いします。）

階	共有施設名	8時		9時		10時		11時		12時		13時		14時		15時		16時		17時		合計	平均
		30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60	30	60		
屋外施設	屋上庭園／テラス						3人																
屋外施設	ベランダ／バルコニー				4人																		
屋外施設	中庭／光庭／庭園					3人																	
屋内施設	玄関／ロビー		10人											8人				10人					
屋内施設	食堂／茶室／レストラン									30人													
屋内施設	機能回復室／日常訓練室／娯楽室／クラブ室															2人							
屋内施設	趣味室／図書室／教室／多目的室											3人											
屋内施設	サービスステーション／理美容室／売店／電話亭													3人									
屋内施設	地域交流／会議室／集会室／談話室																			3人			
屋内施設	ゲストルーム／デイサービス															5人							
屋内施設	共同生活室／リビング																						
	その他																						

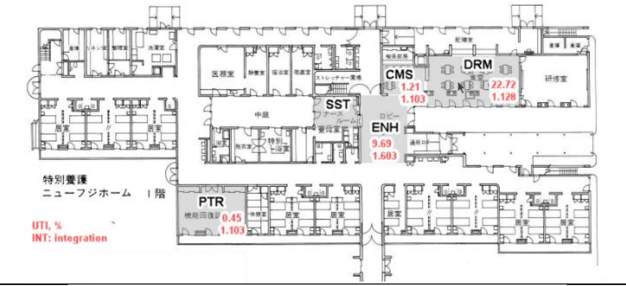
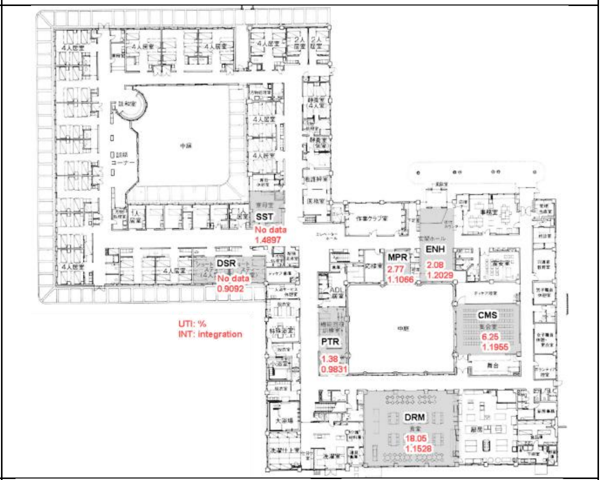
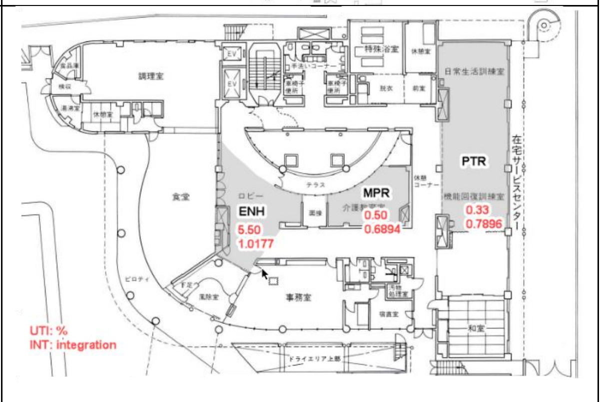
※備考：屋内施設は、各フロアことの利用者数をご記入ください。

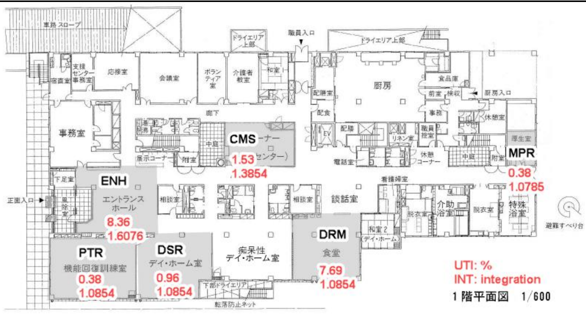
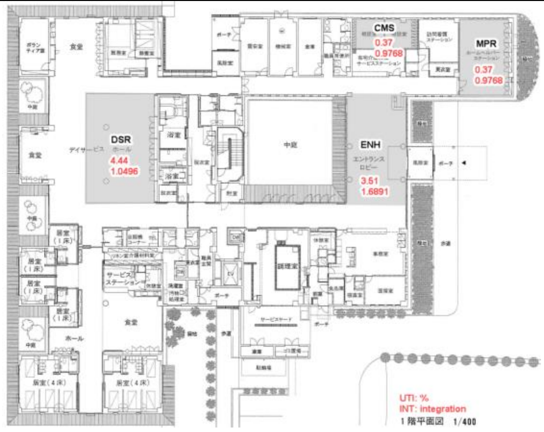
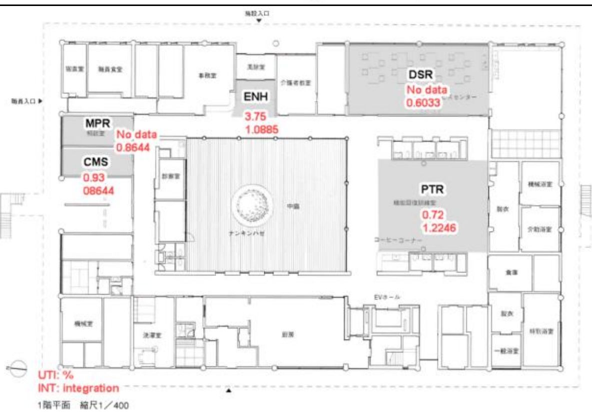
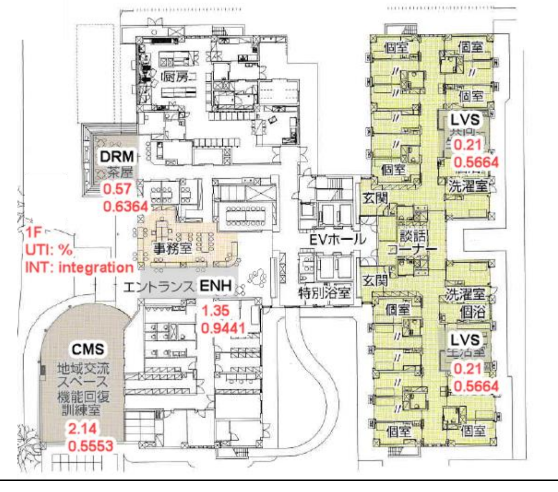
4.3 Survey result

4.3.1 Floorplan and common facility

Table 4.5 is the floor plan of the 12 nursing homes where the occupancy of common facilities was observed, the occupancy and SS spatial integration is also listed. For nursing homes with multiple floors investigated, only the floor plan of the 1st floor is listed.

Table 4.5 Floorplan and common facility of investigated nursing home(Source: created by author)

No.	Floorplan	No.	Floorplan
1-1F		2-1F	
3-1F		4-1F	
5-1F		6-1F	

<table>
<tr><th>No.</th><th>Floorplan</th><th>No.</th><th>Floorplan</th></tr>
<tr><td>7-1F</td><td>
</td><td>8-1F</td><td>
</td></tr>
<tr><td>9-1F</td><td>
</td><td>10-1F</td><td>
</td></tr>
<tr><td>11-1F</td><td>
</td><td>12-1F</td><td>
</td></tr>
</table>

4.3.2 Occupancy survey result

The overall investigation result from 12 nursing homes is listed in Table 4.6 and Fig. 4.5 ~ Fig. 4.6, where the blank in the table means no such common facility or no occupancy data is available.

The average occupancy of entrance hall in the surveyed nursing homes is 3.92%, dining room is 9.70%, community space is 1.52%, physical training room is 0.77%, and the total average occupancy of all common facilities is 3.59%.

This reveals that compared with other common facilities, dining room getting the most highest occupancy, 9.7%. Next is entrance hall. The occupancy of community space and physical training room is only about 1.52%, and 0.77%. And total average occupancy is also low, 3.59%, which is in accordance with the result by Kanki Y. in 2005 that the time staying in hall, lobby, community space, physical training room etc. common space was only about 4% to less than 10%(Kanki 2005) in Chapter 1.1.2.

By consideration of samples' characteristics, these data are estimates of occupancy of residents in average in each common facility, and because the health status of residents in these 12 surveyed nursing homes are in average level of all Japanese intensive nursing homes, these data might be a reflect to the estimation of residents in other Japanese intensive nursing homes.

Table 4.6 Nursing home common space occupancy investigation result, %

No.	NH ID	ENH	DRM	PTR	MPR	SST	CMS	DSR	Ave
1	7	9.70	22.73*1	0.45			1.21		8.52
2	12	1.49	6.90			0.23	0.86		2.37
3	13	3.15	9.20	1.40			1.00	1.60	3.27
4	14	2.08	18.06*2	1.39	2.78		6.25		6.11
5	16	1.27	15.87	0.63			1.27		4.76
6	23	5.50	7.50	0.33	0.50	0.50	0.50	0.83	2.24
7	27	8.37	7.69	0.38	0.38		1.54	0.96	3.22
8	30	6.00	0.60			0.60	2.00	4.00	2.64
9	45	0.88	13.44	1.25	0.75	0.50	0.19	0.50	2.50
10	48	3.52	5.56		0.37	0.56	0.37	4.44	2.47
11	50	3.75	14.06	0.73		0.73	0.94		4.04
12	74	1.36	0.57	0.36		0.07	2.14		0.90
Ave		3.92	9.70	0.77	0.89	0.46	1.52	2.06	3.59

*1,2 These two occupancy data is extremely higher than others, the reason is there was a special event hold. This data from extreme case is removed for following analysis.

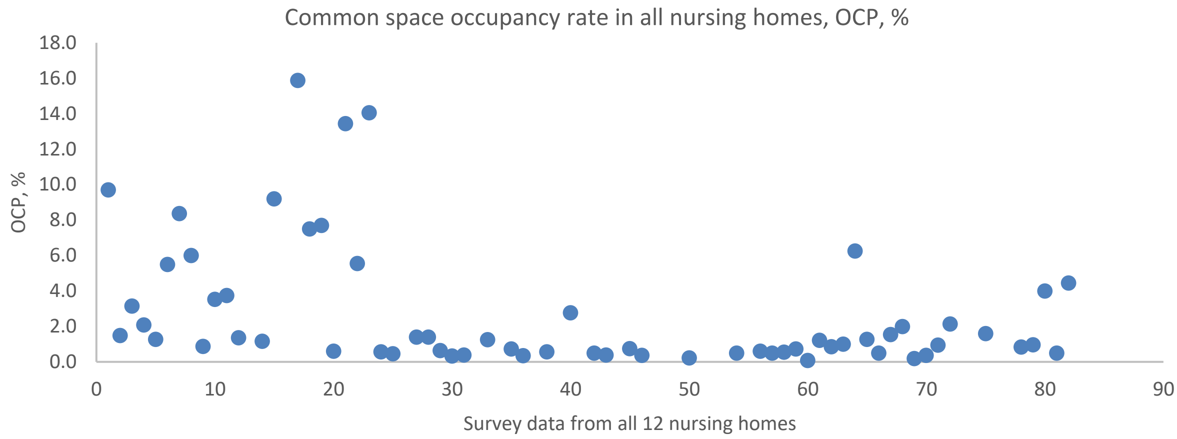
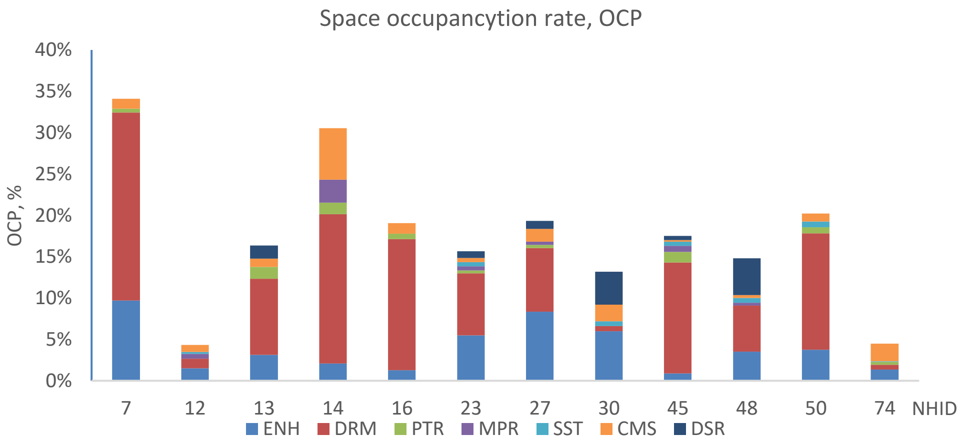


Fig. 4.5 Occupancy investigation result in all common space(Source: created by author)



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room; LVS – living space

Fig. 4.6 Occupancy investigation result in all common space by each nursing home(Source: created by author)

4.3.3 Occupancy rate over time

The average occupancy rate of each common space over time in the 12 surveyed nursing home within the 8:00am ~ 18:00pm time interval is shown in Fig. 4.7 ~ Fig. 4.14, the data is averaged for each hour.

For entrance hall, lobby, etc, the occupancy rate doesn't change much a day, as in Fig. 4.7.

The occupancy rate for dining room has extinguish features that is concentrated in 8:00am~9:00am, 12:00pm, 13:00pm, and 17:00pm time interval, as in Fig. 4.8. Generally, the dining room is used for meal service and opened at 7:00am ~ 8:00am, 12:00pm ~ 13:00pm, and 17:00pm~18:00pm for breakfast, lunch, and dinner. This meal service time interval is in accordance with our survey result. Due to this meal service in "fixed" time interval for occupancy in dining room, it's reasonable to separate dining room from other common facilities for occupancy regression analysis. Therefore, the occupancy regression analysis will be done in two models, one is for all common facilities including dining room, the other is common facilities exclude dining room.

The occupancy of physical training room is also concentrated in 10:00am, 11:00am, and 14:00, 15:00. This tells that physical training room is most utilized at the middle of morning, and at the middle of afternoon.

The occupancy of multiple purpose room, and community space are also concentrated in 14:00 15:00 time interval.

By the common space occupancy rate above, it seems that residents have more free time in afternoon and take use of these common facilities. There might be planned or group activity concentrated in the morning, such as care service in living units.

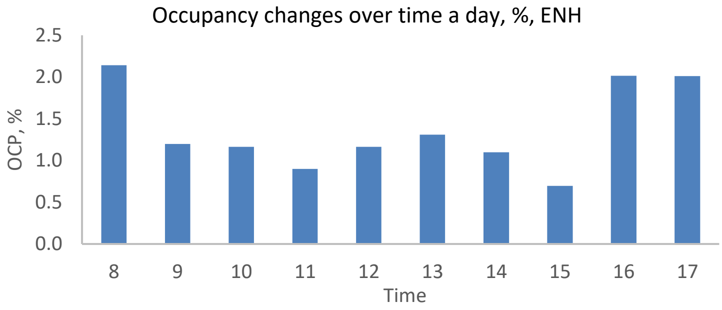


Fig. 4.7 Occupancy over time in a day, entrance hall(Source: created by author)

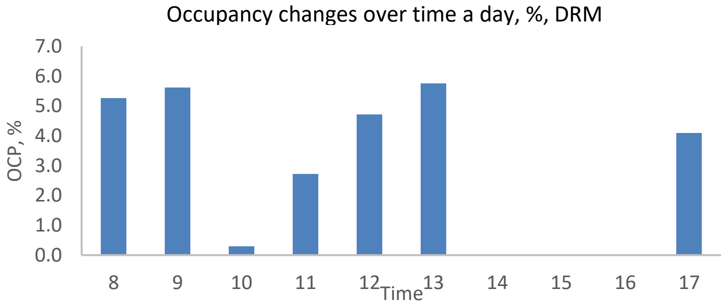


Fig. 4.8 Occupancy over time in a day, dining room(Source: created by author)

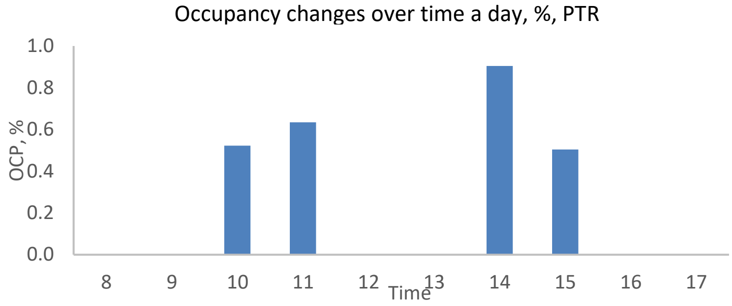


Fig. 4.9 Occupancy over time in a day, physical training room(Source: created by author)

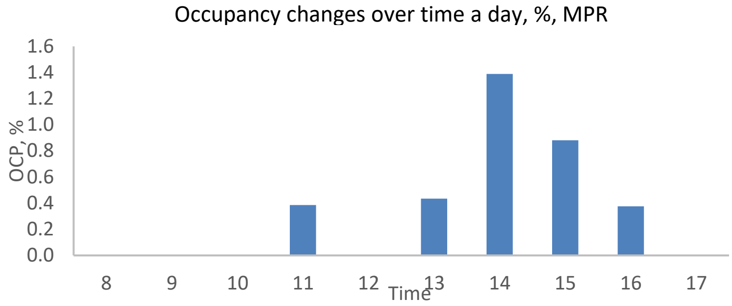


Fig. 4.10 Occupancy over time in a day, multiple purpose room(Source: created by author)

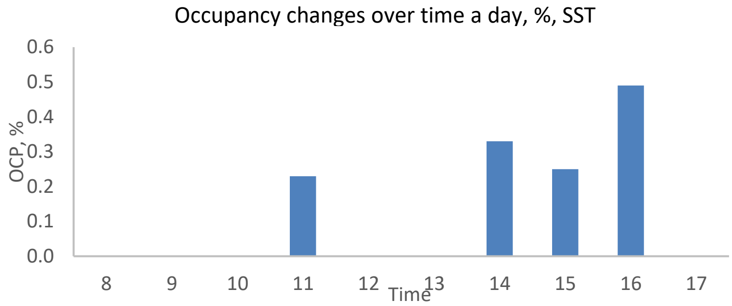


Fig. 4.11 Occupancy over time in a day, service station(Source: created by author)

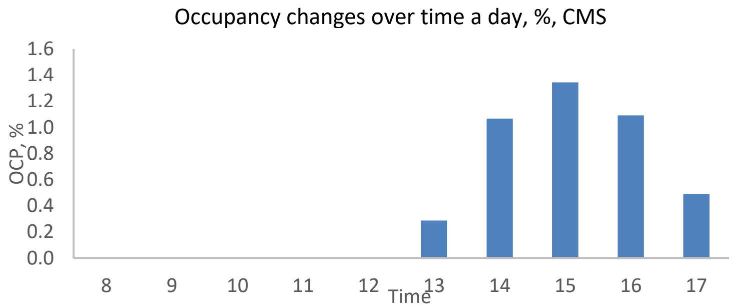


Fig. 4.12 Occupancy over time in a day, community space(Source: created by author)

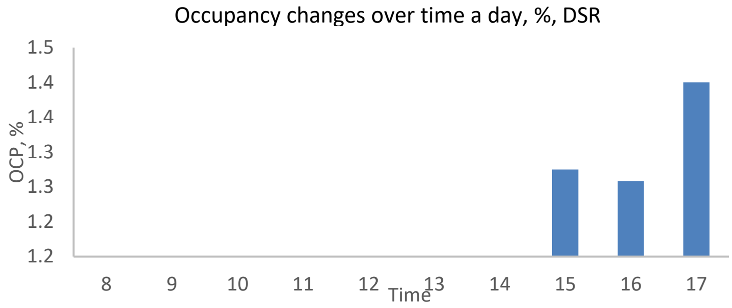
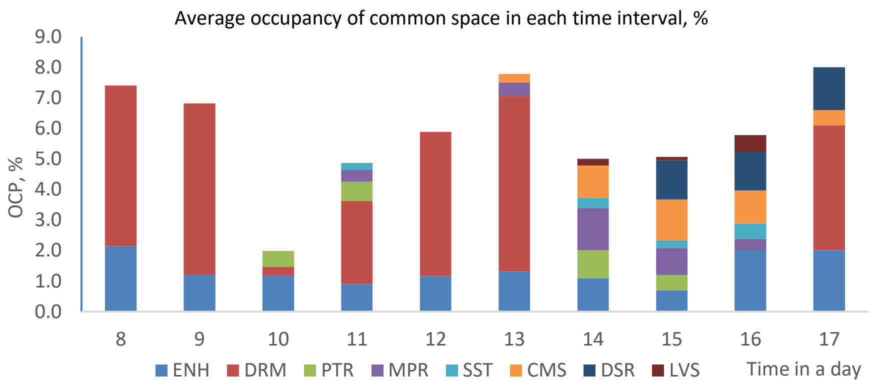


Fig. 4.13 Occupancy over time in a day, day service room(Source: created by author)

4.3.4 Occupancy rate by common space

The average occupancy in each time slot by different common space is shown in Fig. 4.14.

It can be seen that at the 8:00, 9:00, 12:00, 13:00 and 17:00 time slot, the dining room is the most occupied common space, takes large proportion of the occupancy rate. In the morning time, the main used common facilities is entrance hall, lobby, dining room, and physical training room. In the afternoon, the community space becomes to be important common space, specially at 14:00 ~ 16:00 time interval.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room; LVS – living space

Fig. 4.14 Average occupancy of common space in each time slot(Source: created by author)

4.4 Summary

In this chapter, we selected 12 nursing homes around Tokyo area by which the Occupancy rate of residents in 8 common facilities in each nursing homes were surveyed, which involves 1070 target residents, and presents the result of up to 96 common space occupancy data.

Compared with other common facilities, dining room is the most highest occupancy common space, 9.7%. Next is entrance hall. The occupancy of community space and physical training room is only about 1.52%, and 0.77%. And total average occupancy is also low, 3.59%, which is in accordance with the result by other researchers that the time staying in hall, lobby, community space, physical training room etc. common space was only about 4% to less than 10%. This data also verifies the benefit to raise the common space utilization in Japanese intensive care nursing home.

About each common space, the occupancy of physical training room is concentrated in 10:00am, 11:00am, and 14:00, 15:00. The occupancy of multiple purpose room, and community space are also concentrated in 14:00, 15:00 time interval.

The occupancy for dining room is concentrated in 8:00, 12:00, 13:00, and 17:00 time interval. Due to this meal service in "fixed" time interval, the occupancy regression analysis will be done in two models, one is for all common facilities including dining room, the other is common facilities exclude dining room

Together with the common space area size in Chapter 3, spatial characteristics data in Chapter 4, it will be used in Chapter 6 for common space Occupancy analysis.

Note:

1) Definition of nursing care level. https://www.senior-anshin.com/guide/basic/type (accessed Feb. 7, 2019)
2) What is intensive nursing home, https://kaigo.homes.co.jp/manual/facilities_comment/list/hoken/tokuyo/ (accessed Feb. 7, 2019).
3) Definition of nursing care level. http://www.rikubetsu.or.jp/kaigo/hoken6.html (accessed Jan. 13, 2019)

Reference:

Kanki Y. et al.(2005), Study on the residents' space-use and behavior at common spaces inside their own units at the assisted living with private rooms and units - Actual conditions of residents' space-use and behavior at the assisted living with private rooms and units, Part 1 -, J. Archit. Plann., AIJ, No. 592, pp. 65-70.

Tachibana H (2002), A comparative study on meanings of semi-private and semi-public zones of nursing homes - Studies on spatial structure of nursing home with private rooms 4, J. Archit. Plann., AIJ, No. 557, pp. 157 - 164.

Ishibashi K. et al.(2015), Analysis of occupancy and related factors of common living space in unit care nursing homes. Welfare Indicator, 62(11), pp. 32-38.

MHLW, Ministry of Health, Labor and Welfare (2017). 2016 year nursing care service facility · Business survey.

Chapter 5 Common Space Occupancy Regression Analysis In Japanese Intensive Care Nursing Home

5.1 Introduction

As mentioned in Chapter 1, the goal of this research is to promote residents social interaction in nursing homes via higher occupancy of common space. Because SS theory has verified the association of space spatial characteristics with people's space involvement(Hillier 1996, Dettlaff 2014), there also might be potential relationship exist between the common space occupancy and space spatial characteristics in nursing homes. Therefore, based on the survey result of common space occupancy and common space spatial characteristics study in previous chapters, we analyze the association model of common space occupancy with space spatial characteristics in nursing homes. And based on this model to explore the way of effective common space spatial configuration design, so as to advocate the common space occupancy and to have better social life for residents in nursing homes.

5.2 Common space occupancy model

5.2.1 Factors affect space occupancy

There are many factors which may affect the occupancy of common space. These factors can be human administrative, external changeable factors and the space internal inherent characteristics.

5.2.1.1 Human administrative factors

Human factors is out of control of spatial configuration. However the administrative factors such as special event will be carefully excluded through the onsite observation.

The other human factors such as the health status(dementia, nursing care level) in surveyed nursing home are also checked. As the result in Chapter 4.2.2 that the residents with dementia, and different nursing care levels in surveyed nursing home are in same level of all Japan intensive care nursing home average, the data from this survey should be applicable to other intensive care nursing homes in Japan.

5.2.1.2 External changeable factors

The external changeable factors include the equipment deployed on-purpose, like air conditioner, the installed sofa/chair, table, as well as decorations.

5.2.1.3 Inherent spatial configuration of space

The space spatial configuration includes spatial metrics described by Space syntax theory, and the area size, shape, distance etc characteristics. All these spatial characteristics are supposed to influence the space occupancy.

- The Space syntax syntactic metrics:
    - Spatial connectivity
    - Spatial depth
    - Spatial integration
- The spatial characteristics, like:
    - Space area size
    - Space shape: circle, square, rectangle, triangle, etc
    - The proximity(distance between each other)

This research focus on the common space spatial inherent space characteristics, therefore only inherent spatial configuration is considered.

5.2.2 Factors related to space inherent spatial configuration

5.2.2.1 Space area size, ARE

In common sense, the wider a space is, the more people can be hold(Fig. 5.1). To count in the effect of common space area size, the area size per resident(m^2/p) is investigated.

The common space area size per residents in 12 surveyed nursing homes is shown in Table 5.1 and Fig. 5.2.

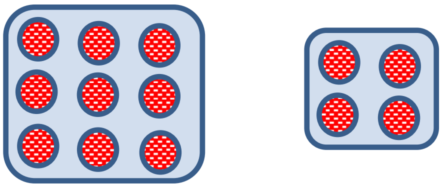
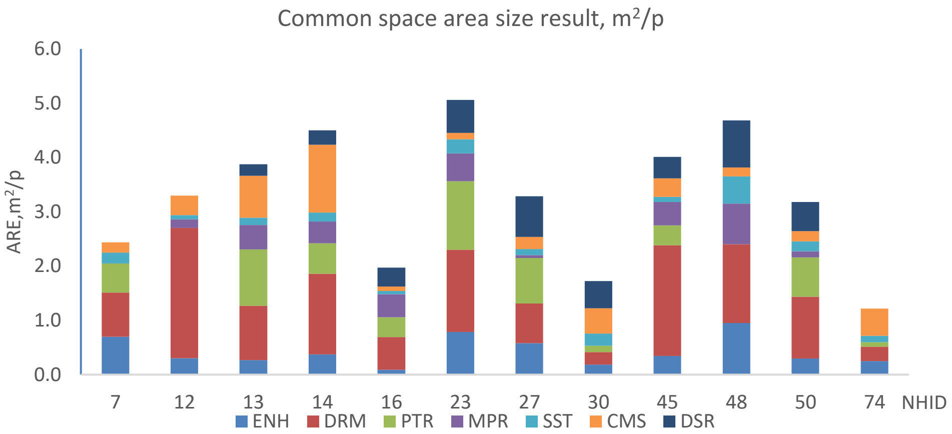


Fig. 5.1 ARE, space area size per resident(Source: created by author)

Table 5.1 Common space area size per resident, ARE, m^2/p

	Common space											
NHID	7	12	13	14	16	23	27	30	45	48	50	74
ENH*	0.70	0.30	0.27	0.38	0.09	0.79	0.58	0.18	0.34	0.95	0.30	0.25
DRM	0.81	2.40	1.00	1.48	0.61	1.52	0.73	0.23	2.05	1.45	1.14	0.26
PTR	0.54		1.04	0.56	0.36	1.26	0.84	0.12	0.36		0.73	0.09
MPR		0.16	0.45	0.40	0.43	0.52	0.06		0.43	0.75	0.11	
SST	0.20	0.08	0.13	0.17	0.06	0.26	0.11	0.22	0.09	0.50	0.18	0.11
CMS	0.19	0.36	0.77	1.25	0.08	0.12	0.23	0.47	0.34	0.17	0.19	0.50
DSR			0.21	0.27	0.35	0.61	0.75	0.50	0.40	0.87	0.54	

*ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.2 Common space area size per resident, ARE, m^2/p(Source: created by author)

The correlation analysis between common space area size ARE and occupancy rate OCP is shown in Fig. 5.3. The correlation coefficient of determination, R-square(R^2) of 0.2773 indicates that the correlation between occupancy and area size per resident is not as expected. However, the space area size is a very important factor in common space design, it is necessary to include its influence to space occupancy.

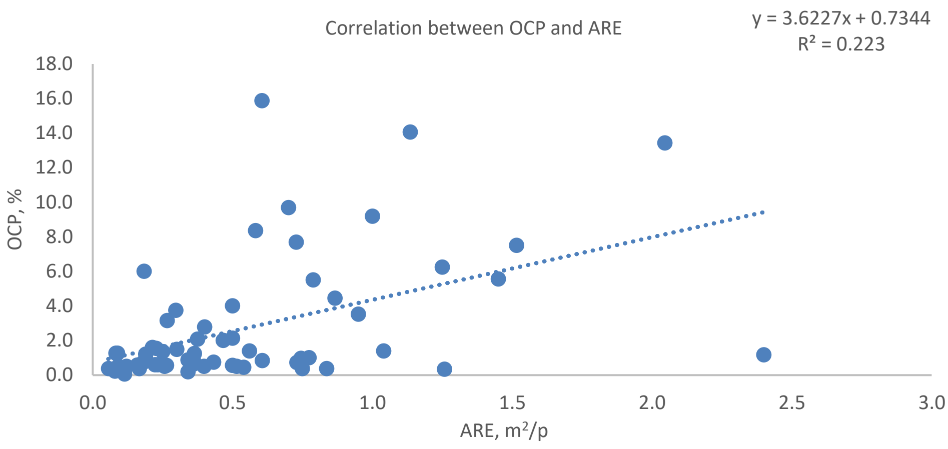
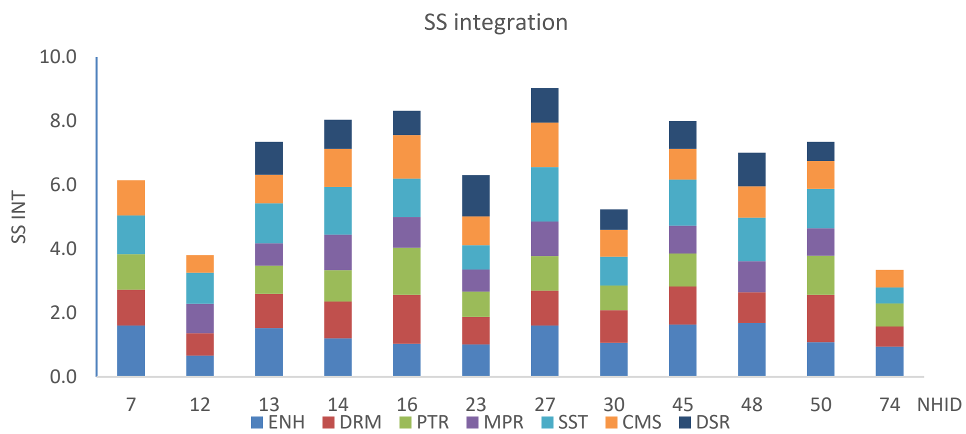


Fig. 5.3 Correlation between space occupancy OCP and space area size ARE, m2/p(Source: created by author)

5.2.2.2 SS integration, INT

The spatial integration(INT) is an indicator of how a space is integrated with all other space units in a system(nursing home)(Bjorn 1993), refers as a syntactic metric to the closeness of each segment(space) to all others(Maria 2016), and highly related to peoples involvement in the space(Hiller 1996). This spatial metric is included for the occupancy analysis.

DepthMapX is used to calculate the SS integration(Chapter 3),the result for surveyed nursing home is shown in Fig. 5.4



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.4 Common space SS integration(Source: created by author)

The correlation analysis between SS integration and occupancy rate OCP is shown in Fig. 5.5. The figure reveals the relationship between space occupancy(OCP) and SS integration(INT) is not certain, however, it shows the uptrend in total that the higher the SS integration, the higher space occupancy can be expected.

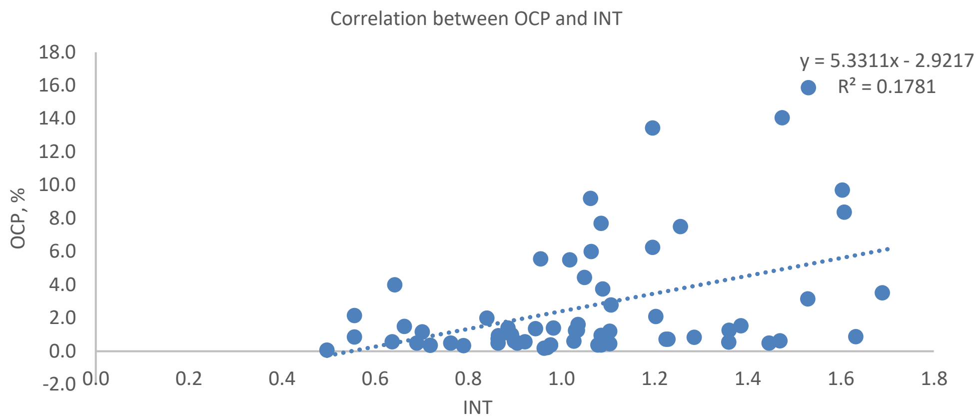


Fig. 5.5 Correlation between space occupancy OCP and SS integration(Source: created by author)

On the other hand, if we focus on relatively frequent used space(OCP >= 1%), the SS integration is better described the occupancy shown in Fig. 5.6. It implies that for more residents using common space, the SS spatial integration may affect obviously the occupancy.

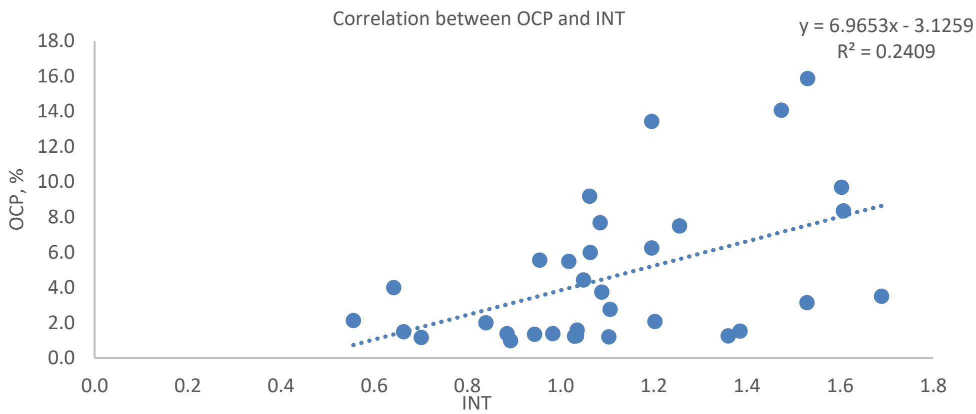
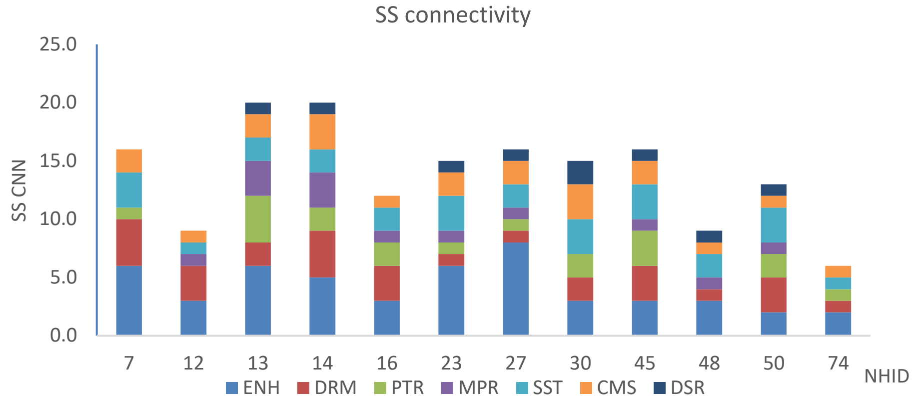


Fig. 5.6 Correlation between space occupancy OCP and SS integration for frequent used space(Source: created by author)

5.2.2.3 SS connectivity, CNN

The spatial connectivity(CNN) measures the number of immediate neighbours that are directly connected to a space(Bjorn 1993). The more spatial connectivity a space is, the higher possibility it can be accessed.

The calculated SS connectivity by using DepthMapX(Chapter 4) method is shown in Fig. 5.7.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.7 Common space SS connectivity(Source: created by author)

The correlation analysis between SS connectivity and occupancy rate OCP is shown in Fig. 5.8. The figure reveals the relationship between space occupancy(OCP) and SS connectivity(CNN) is not certain for all common facilities investigated include ENH, DRM, PTR etc.

However, by considering the specialty in dining room occupancy, and remove it, the correlation between SS connectivity and occupancy for all other common facilities are fairly good as shown in Fig. 5.9. It implies that the SS spatial connectivity(CNN) is a good indicator which may affect the occupancy of most common spaces in nursing homes.

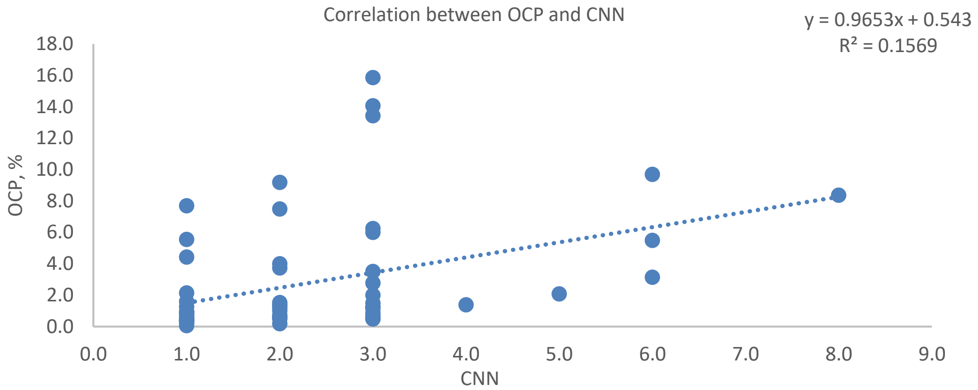


Fig. 5.8 Correlation between space occupancy OCP and SS connectivity(CNN) (Source: created by author)

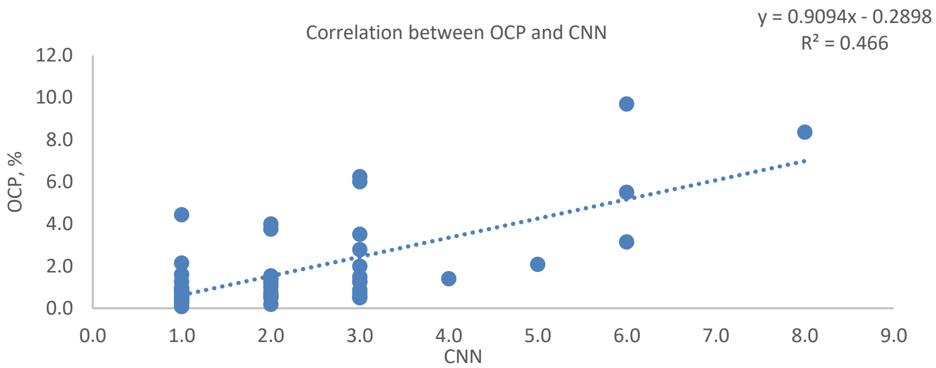
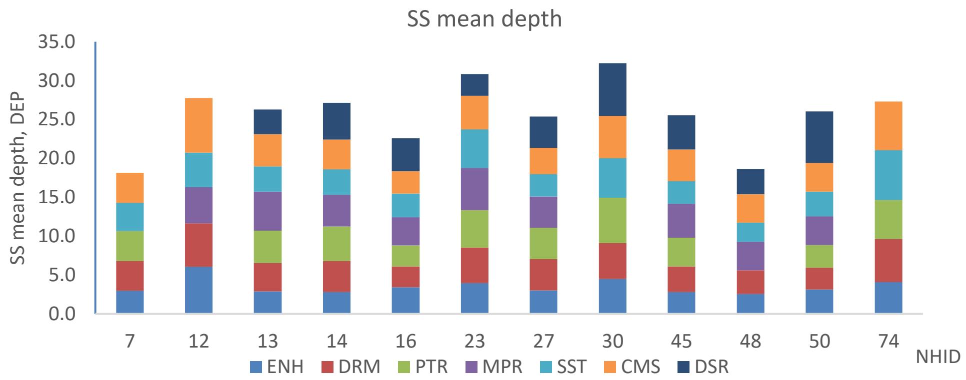


Fig. 5.9 Correlation between space occupancy OCP and SS connectivity(CNN)(exclude DRM) (Source: created by author)

5.2.2.4 SS mean depth, DEP

The spatial mean depth(DEP) measures the average geometry distance(not physical distance) from all other spaces(Hiller 2009), it is actually the indicator of a space accessibility.

The calculated SS mean depth by using DepthMapX(Chapter 4) method is shown in Fig. 5.10.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.10 Common space SS mean depth(Source: created by author)

The correlation between SS mean depth(DEP) and occupancy rate OCP is shown in Fig. 5.11.

The figure discloses the relationship between space occupancy(OCP) and SS mean depth(DEP) is uncertain. This factor may not be included in occupancy regression analysis.

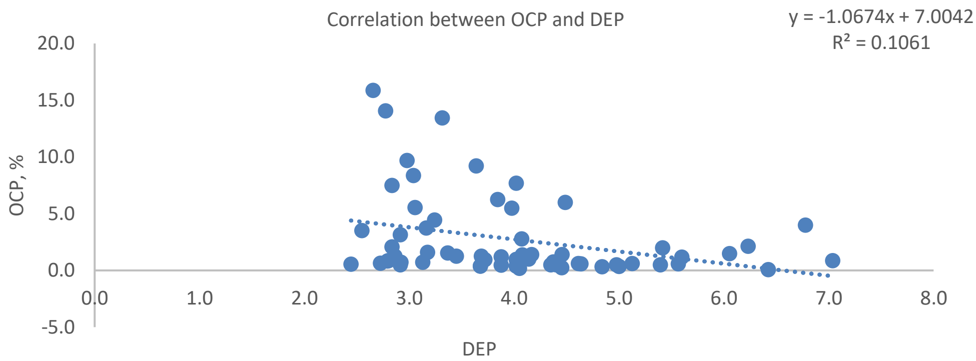
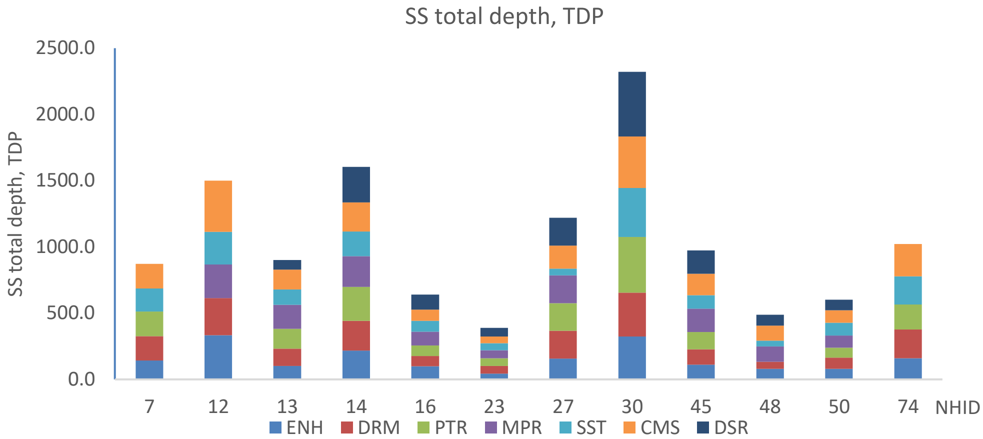


Fig. 5.11 Correlation between space occupancy OCP and SS mean depth(CNN)(exclude DRM) (Source: created by author)

5.2.2.5 SS total depth, TDP

The spatial total depth(TDP) measures the sum of the topological depth from all other spaces, it is also one indicator about space accessibility(Teklenburg J 1993).

The calculated SS total depth TDP by using DepthMapX(Chapter 4) method is shown in Fig. 5.12.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.12 Common space SS total depth(Source: created by author)

The correlation between SS total depth(TDP) and occupancy rate OCP is shown in Fig. 5.13.

The figure discloses the relationship between space occupancy(OCP) and SS total depth(TDP) is very week. This factor may not be included in occupancy regression analysis.

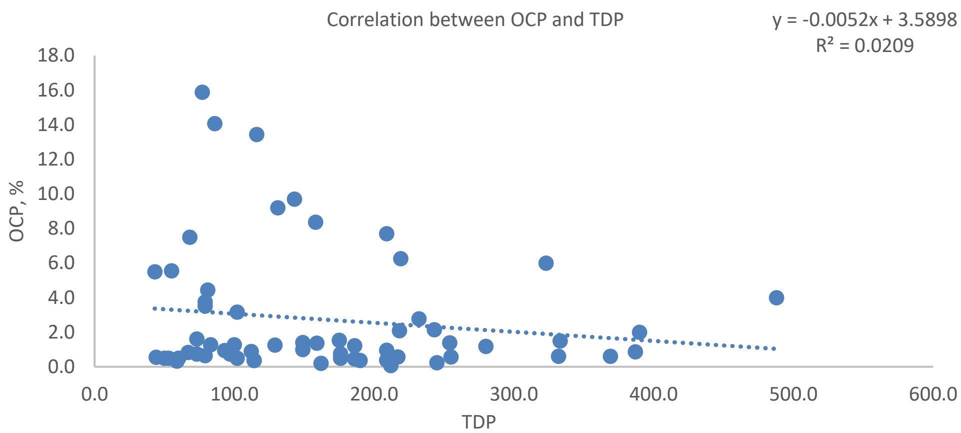


Fig. 5.13 Correlation between space occupancy OCP and SS total depth (Source: created by author)

5.2.2.6 Common space shape proportion by Vertical and Horizontal length Ratio, VHR

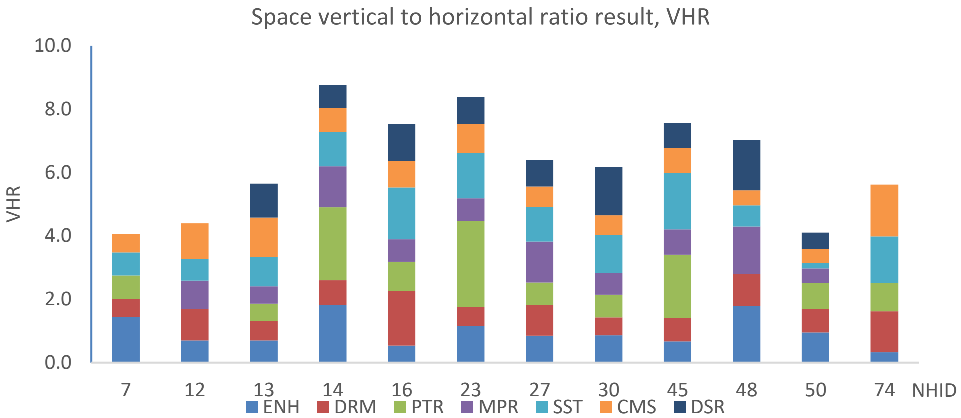
The space shape is also one of the spatial metrics that may affect people stay. Even the spaces with same area size but different shape may result different occupancy. In common sense, people may not like to stay in a very narrow space for long time. For this reason, the ratio of length in vertical direction to length in horizontal direction is investigated. It is

$$VHR = \frac{\textit{The length in veritcal direction,vln}}{\textit{The length in horizontal direction,hln}}$$

The VHR example is shown in Fig. 5.14.

Fig. 5.14 VHR, ratio of vertical to horizontal(Source: created by author)

The investigated common space VHR result in the 12 surveyed nursing homes is shown in Fig. 5.15.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.15 Common space vertical to horizontal ratio of surveyed nursing homes, VHR(Source: created by author)

The correlation between space vertical to horizontal ratio VHR and occupancy rate OCP is shown in Fig. 5.16.

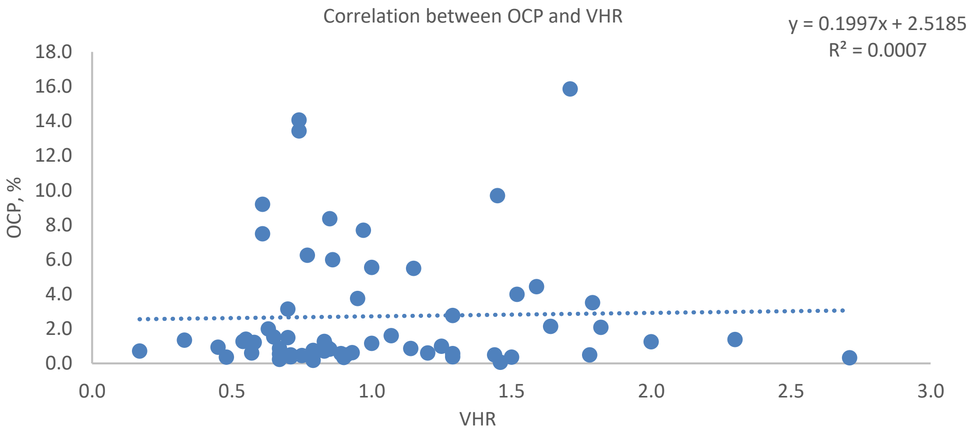


Fig. 5.16 Correlation between space occupancy OCP and space vertical to horizontal ratio(Source: created by author)

The figure shows the relationship between space occupancy(OCP) and space vertical to horizontal ratio(VHR) is very week. This factor may not be included in occupancy regression analysis.

5.2.2.7 Proximity to living rooms, PRX

The distance is a factor that can affect the occupancy. In common sense, the shorter a common space to livings, the easier people can be there, and a higher occupancy can be expected.

To count in the effect of distance to common space occupancy, the average distance(m) from living zone to common space is defined. It is:

$$\text{PRX} = \frac{\sum(Dis)}{Number\ of\ living\ zones}$$

Where the Dis is the distance from a living room to common space(m), PRX is the average distance from each living rooms to the common space.

The example in Fig 5.17 is a nursing house divided to 4 living zones, the PRX is (Dis1 + Dis2 + Dis3 + Dis4)/4.

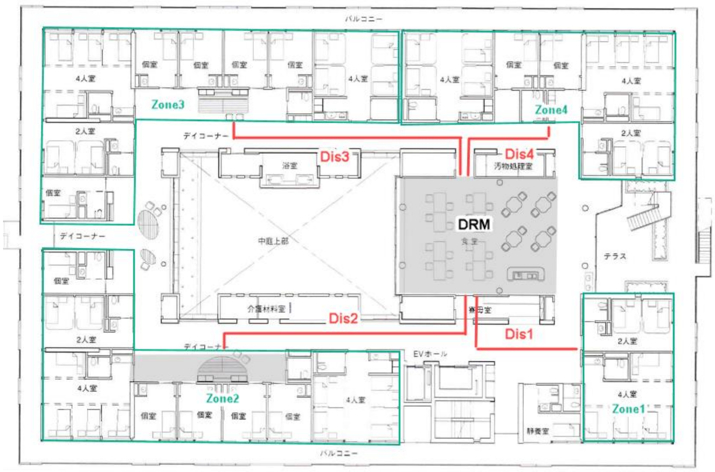
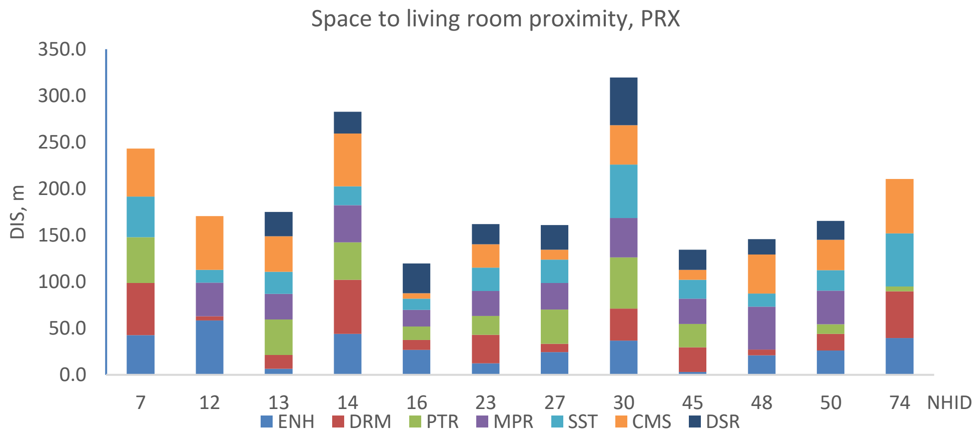


Fig. 5.17 Proximity to living zone, PRX(Source: created by author)

The investigated common space proximity PRX result is shown in Fig. 5.18.



ENH - entrance hall; DRM - dining room; PTR – physical training room; MPR – multiple purpose room; SST – service station; CMS – community space; DSR – day service room

Fig. 5.18 Common space proximity of surveyed nursing homes, PRX(Source: created by author)

The correlation between space proximity DIS and occupancy rate OCP is shown in Fig. 5.19.

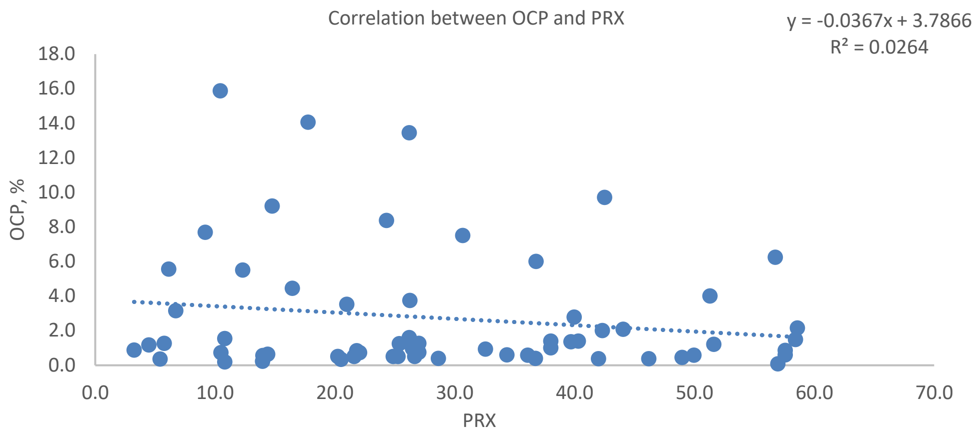


Fig. 5.19 Correlation between space occupancy OCP and space proximity(Source: created by author)

The figure shows the relationship between space occupancy(OCP) and space proximity DIS is very week. This factor may not be included in occupancy regression analysis.

5.2.3 Space occupancy model

The purpose of this research is to find the association between common space occupancy and space spatial configuration in Japanese nursing home. Among these space inherent spatial configuration factors, to explore significance of each factor to space occupancy.

Because multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data [Note 1], it fits the need to find the significance of each spatial configuration factors, it is selected in this research.

To perform the analysis, the IBM SPSS data analysis tool is applied [Note 2].

5.2.3.1 Occupancy explanatory model

The space inherent spatial configuration factors that may affect space occupancy is discussed in previous chapter, they are grouped in Table 5.2. In multiple linear regression analysis, these can be independent variables(IVs), while the space occupancy(OCP) is dependent variable(DV).

Dependent variable:

Occupancy rate(OCP, 0.0 ~ 1.0)

Potential independent variables:

Area size per resident(ARA, m^2/person)
Spatial Integration(INT)
Connectivity(CNN)
Mean depth(DEP)
Total depth(TDP)
Space vertical to horizontal ratio(VHR)
Space proximity(PRX)

Table 5.2 Independent variables considered for space occupancy

Factors			Variables	Explanation	Equation definition	Chapter
Dependent variable, DV	Space occupancy, OCP		OCP	Space occupancy rate for all staying activity	OCP = (∑(NUM*TIM))/(Total observed residents*600) Where NUM is the number of people who are staying in the common place, and TIM is the time interval of the observation	Chapter 4 Section 4.2.3
Independent variables, IVs	Space syntax metrics	Spatial integration	INT	The spatial integration to all space units in nursing home.	INT = 1/RRA RRA is Real Relative Asymmetry defined in Chapter 2, section 2.3.	Chapter 5 Section 5.2.2.2
		Spatial connectivity	CNN	The direct connection of a space to its surrounding spaces	CNN = c Where c is the connection routines with surrounding spaces.	Chapter 5 Section 5.2.2.3
		Spatial mean depth	DEP	The mean depth of a space from all other space units.	DEP =(∑_(k=1)^n▒〖(Dk* k)〗)/(n-1) Where D is depth from a space unit, n is total space unit number.	Chapter 5 Section 5.2.2.4
		Spatial total depth	TDP	The total depth from all other space units.	TDP =∑_(k=1)^n▒〖(Dk〗 *k) Where D is depth from a space unit, n is total space unit number.	Chapter 5 Section 5.2.2.5
	Geometric factors	Area size	ARE	The space area size per resident, m2/a	Evaluated by floor plan	Chapter 5 Section 5.2.2.1
		Vertical to horizontal ratio	VHR	The ratio of vertical length to horizontal length	VHR = (The length in vertical direction, vln)/(The length in horizontal direction, hln) Evaluated by floor plan	Chapter 5 Section 5.2.2.6
		Proximity	PRX	The average distance(PRX, m) from living space to common space, m.	PRX = (∑(Dis))/(Number of living zones) Where Dis is distance from a living zone to common space.	Chapter 5 Section 5.2.2.7

5.2.3.2 Data input

The surveyed common space occupancy rate and considered space inherent spatial configuration data for 12 Japanese nursing homes is listed in Table 5.3, where the blank in the table means no such common facility or no occupancy data is available for that nursing home.

Table 5.3 Common facility occupancy and spatial configuration data

Common space	NHID	ARE, m^2/p	INT	CNN	DEP	TDP	VHR	PRX	OCP, %
ENH	7	0.70	1.603010	6.0	2.979170	143.00	1.45	42.51	9.70
	12	0.30	0.662910	3.0	6.054545	333.00	0.70	58.43	1.49
	13	0.27	1.5290344	6.0	2.914290	102.00	0.70	6.71	3.15
	14	0.38	1.2029306	5.0	2.8333333	218.00	1.82	44.06	2.08
	16	0.09	1.034520	3.0	3.448280	100.00	0.54	27.00	1.27
	23	0.79	1.017796	6.0	3.976740	43.00	1.15	12.30	5.50
	27	0.58	1.607630	8.0	3.038460	158.00	0.85	24.30	8.37
	30	0.18	1.063750	3.0	4.486110	323.00	0.86	36.77	6.00
	45	0.34	1.631850	3.0	2.800000	112.00	0.67	3.24	0.88
	48	0.95	1.689170	3.0	2.548390	79.00	1.79	21.00	3.52
	50	0.30	1.0885593	2.0	3.1600001	79.00	0.95	26.25	3.75
	74	0.25	0.944118	2.0	4.076920	159.00	0.33	39.69	1.36
DRM	7	0.81	1.128040	4.0	3.812500	183.0	0.55	56.29	
	12	2.40	0.70126456	3.0	5.5999999	280.0	1.00	4.47	1.17
	13	1.00	1.0622765	2.0	3.6388888	131.0	0.61	14.75	9.20
	14	1.48	1.1528085	4.0	3.9473684	225.0	0.78	58.05	
	16	0.61	1.530230	3.0	2.655170	77.0	1.71	10.44	15.87
	23	1.52	1.255640	2.0	2.833333	68.0	0.61	30.65	7.50
	27	0.73	1.085410	1.0	4.019230	209.0	0.97	9.18	7.69
	30	0.23	1.026930	2.0	4.611110	332.0	0.57	34.34	0.60
	45	2.05	1.195890	3.0	3.314290	116.0	0.74	26.19	13.44
	48	1.45	0.95512819	1.0	3.0555556	55.0	1.00	6.13	5.56

	50	1.14	1.474182	3.0	2.7741935	86.0	0.74	17.76	14.06
	74	0.26	0.636484	1.0	5.564100	217.0	1.29	49.95	0.57
PTR	7	0.54	1.103520	1.0	3.875000	186.0	0.75	48.97	0.45
	12								
	13	1.04	0.885230	4.0	4.1666665	149.0	0.55	38.00	1.40
	14	0.56	0.983106	2.0	4.456141	254.0	2.30	40.30	1.39
	16	0.36	1.469020	2.0	2.724140	79.0	0.93	14.40	0.63
	23	1.26	0.789687	1.0	4.837210	59.0	2.71	20.50	0.33
	27	0.84	1.085410	1.0	4.019230	209.0	0.71	36.72	0.38
	30	0.12	0.767246	2.0	5.833330	420.0	0.71	55.29	
	45	0.36	1.030500	3.0	3.685710	129.0	2.00	25.38	1.25
	48								
	50	0.73	1.2246293	2.0	2.9200001	73.0	0.83	10.50	0.73
	74	0.09	0.717967	1.0	5.000000	190.0	0.90	5.40	0.36
MPR	7								
	12	0.16	0.921445	1.0	4.636364	255.0	0.89	36.10	0.57
	13	0.45	0.70080745	3.0	5	180.0	0.55	27.71	
	14	0.40	1.1066961	3.0	4.0701756	232.0	1.29	39.95	2.78
	16	0.43	0.966462	1.0	3.620690	105.0	0.71	18.00	
	23	0.52	0.689409	1.0	5.395350	60.0	0.71	26.65	0.50
	27	0.06	1.078540	1.0	4.038460	210.0	1.29	28.62	0.38
	30						0.68	42.04	
	45	0.43	0.863922	1.0	4.375000	176.0	0.79	27.00	0.75
	48	0.75	0.976868	1.0	3.677420	114.0	1.50	46.20	0.37
	50	0.11	0.864444	1.0	3.720000	93.0	0.45	36.05	
	74								
SST	7	0.20	1.208620	3.0	3.625000	174.0	0.73	43.88	
	12	0.08	0.969942	1.0	4.454546	245.0	0.67	13.97	0.23
	13	0.13	1.245880	2.0	3.250000	117.0	0.92	23.69	
	14	0.17	1.489783	2.0	3.280702	187.0	1.08	20.21	
	16	0.06	1.200250	2.0	3.037040	82.0	1.64	12.00	
	23	0.26	0.761979	3.0	4.976740	53.0	1.44	25.27	0.50
	27	0.11	1.704064	2.0	2.877551	50.0	1.09	24.98	
	30	0.22	0.898995	3.0	5.125000	369.0	1.20	57.57	0.60
	45	0.09	1.445772	3.0	2.914286	102.0	1.78	20.25	0.50
	48	0.50	1.3592209	2.0	2.4444444	44.0	0.67	14.00	0.56
	50	0.18	1.228485	3.0	3.1290324	97.0	0.17	22.05	0.73
	74	0.11	0.496585	1.0	6.424240	212.0	1.46	56.97	0.07
CMS	7	0.19	1.103520	2.0	3.875000	186.0	0.58	51.62	1.21
	12	0.36	0.555087	1.0	7.036364	387.0	1.14	57.57	0.86
	13	0.77	0.89306432	2.0	4.1388888	149.0	1.25	38.00	1.00
	14	1.25	1.195505	3.0	3.842105	219.0	0.77	56.75	6.25
	16	0.08	1.360210	1.0	2.862070	83.0	0.83	5.76	1.27
	23	0.12	0.904850	2.0	4.348840	50.0	0.91	24.86	0.50
	27	0.23	1.385440	2.0	3.365380	175.0	0.65	10.80	1.54
	30	0.47	0.839627	3.0	5.416670	390.0	0.63	42.32	2.00
	45	0.34	0.963061	2.0	4.0500002	162.0	0.79	10.80	0.19
	48	0.17	0.976868	1.0	3.677420	114.0	0.48	42.00	0.37
	50	0.19	0.864444	1.0	3.720000	93.0	0.45	32.55	0.94
	74	0.50	0.555364	1.0	6.230770	243.0	1.64	58.59	2.14
DSR	7								
	12								
	13	0.21	1.035430	1.0	3.173910	73.0	1.07	26.19	1.60
	14	0.27	0.90925741	1.0	4.7368422	270.0	0.72	23.27	
	16	0.35	0.758781		4.222220	114.0	1.17	32.22	
	23	0.61	1.284840	1.0	2.791667	67.0	0.85	21.83	0.83
	27	0.75	1.085410	1.0	4.019230	209.0	0.84	26.46	0.96
	30	0.50	0.641831	2.0	6.777780	488.0	1.52	51.30	4.00
	45	0.40	0.863922	1.0	4.4000001	176.0	0.79	21.60	0.50
	48	0.87	1.0496821	1.0	3.24	81.0	1.59	16.45	4.44
	50	0.54	0.603339	1.0	6.631580	81.0	0.51	20.30	
	74								

Note; NHID nursing home ID; ENH, entrance hall; DRM, dining room; PTR, physical training room; MPR, multiple purpose room; SST, service station; CMS, community space; DSR, daily service room; LVS, living space.

5.3 Occupancy regression analysis

5.3.1 Data correlation analysis

First, we check the data correlation among the occupancy and these 7 variables. The bivariate correlation analysis is conducted, the result is shown in Table 5.4.

Table 5.4 Data correlation between common space occupancy and space characteristics

		OCP	INT	CNN	DEP	TDP	ARE	VHR	PRX
OCP	Pearson Correlation	1	.422**	.396**	-.326**	-0.145	.473**	0.027	-0.163
	Sig. (2-tailed)		0.001	0.001	0.010	0.262	0.000	0.836	0.206
	N	62	62	62	62	62	62	62	62
INT	Pearson Correlation	.422**	1	.435**	-.857**	-.409**	0.034	-0.003	-.385**
	Sig. (2-tailed)	0.001		0.000	0.000	0.000	0.770	0.982	0.001
	N	62	76	75	76	76	76	76	76
CNN	Pearson Correlation	.396**	.435**	1	-.263*	-0.013	0.169	0.029	0.027
	Sig. (2-tailed)	0.001	0.000		0.023	0.911	0.148	0.807	0.821
	N	62	75	75	75	75	75	75	75
DEP	Pearson Correlation	-.326**	-.857**	-.263*	1	.658**	-0.071	0.049	.481**
	Sig. (2-tailed)	0.010	0.000	0.023		0.000	0.544	0.676	0.000
	N	62	76	75	76	76	76	76	76
TDP	Pearson Correlation	-0.145	-.409**	-0.013	.658**	1	-0.090	-0.013	.566**
	Sig. (2-tailed)	0.262	0.000	0.911	0.000		0.437	0.912	0.000
	N	62	76	75	76	76	76	76	76
ARE	Pearson Correlation	.473**	0.034	0.169	-0.071	-0.090	1	0.072	-0.084
	Sig. (2-tailed)	0.000	0.770	0.148	0.544	0.437		0.538	0.470
	N	62	76	75	76	76	76	76	76
VHR	Pearson Correlation	0.027	-0.003	0.029	0.049	-0.013	0.072	1	0.031
	Sig. (2-tailed)	0.836	0.982	0.807	0.676	0.912	0.538		0.789
	N	62	76	75	76	76	76	77	77
PRX	Pearson Correlation	-0.163	-.385**	0.027	.481**	.566**	-0.084	0.031	1
	Sig. (2-tailed)	0.206	0.001	0.821	0.000	0.000	0.470	0.789	
	N	62	76	75	76	76	76	77	77

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

It can be seen that the occupancy(OCP) is significantly correlated with spatial integration(INT), spatial connectivity(CNN), spatial mean depth(DEP), and area size(ARE) by $r(62)=0.422$, $p(Sig.)<0.05$; $r(62)=0.396$, $p<0.05$; $r(62)=-0.326$, $p<0.05$; $r(62)=-0.473$, $p<0.05$ respectively. For these that Sig. >=0.05, it can be say that there is no significant correlation with OCP.

However, the high correlation doesn't mean high influential effect. The general consideration is to select IVs that are not highly correlated with each other. Because high correlation exists between INT and DEP ($r(76)=-0.857$, $p<0.05$), and between DEP and CNN ($r(75)=-0.263$, $p<0.05$), this reminds us the DEP might be removed for OCP regression analysis.

To confirm this consideration, the coefficient of determination R^2 was used to sort each IVs. The linear regression for OCP with these IVs were performed by adding each IVs, the IVs that results best R^2 will be selected. The result is shown in Fig. 5.20.

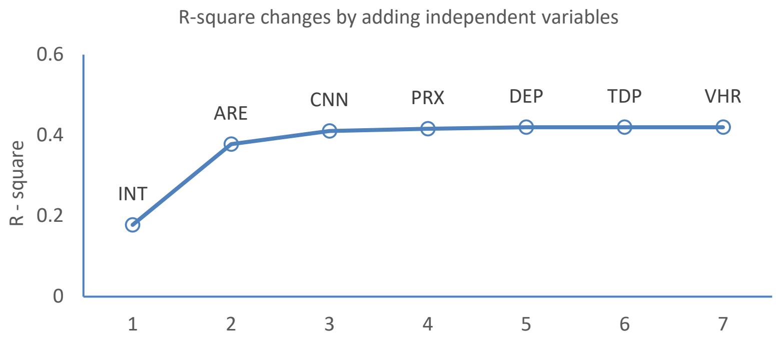


Fig. 5.20 Change of R-square value with different IVs(Source: created by author)

Fig. 5.20, the changes of R^2 for space occupancy regression, suggests that three significant IVs(INT, ARE, CNN) are proper combination of IVs for space occupancy regression because the R^2 doesn't increase significantly after CNN, even the other four IVs were added.

As a result, the IVs of INT, ARE, and CNN are selected for further space occupancy multiple regression analysis.

OCP = f(INT, ARE, CNN)

5.3.2 Occupancy regression model for all common space

5.3.2.1 Regression model parameter

The utilization purpose of common space in nursing home may different in different common space, this may affect the occupancy rate. First we take all these seven common facilities as a general common space, and analyze the association between occupancy and space configuration.

The IBM SPSS data statistical analysis tool is used, and multiple linear regression is performed(stepwise method). Among different regression models with different IVs, the result of best regression model is shown in Table 5.5.

Table 5.5 Regression result for all common space

Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
3	.641[b]	0.411	0.381	2.84085

a. Predictors: (Constant), INT, ARE, CNN
b. Dependent Variable: OCP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	327.274	3	109.091	13.517	.000[b]
	Residual	468.084	58	8.070		
	Total	795.358	61			

a. Dependent Variable: OCP
b. Predictors: (Constant), INT, ARE, CNN

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.(p)	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
3	(Constant)	-4.206	1.441		-2.920	0.005	-7.090	-1.322
	INT	3.752	1.443	0.297	2.601	0.012	0.864	6.640
	ARE	3.301	0.777	0.431	4.249	0.000	1.746	4.855
	CNN	0.506	0.280	0.208	1.809	0.076	-0.054	1.066

a. Dependent Variable: OCP

Table 5.5 model summary tells that spatial integration INT, area size ARE, and spatial connection CNN this three spatial variables are significantly related to space occupancy OCP with $F(3,58) = 13.517$, p=0.000<0.001. The multiple regression coefficient(R) is .641, indicating approximately(R square) 41.1% of the variance of the space occupancy can be predicted by using spatial integration INT, spatial connection CNN, and space size ARE for space occupancy analysis.

With the unstandardized coefficients of B in Coefficients table, we get the space occupancy OCP regression equation:

OCP(%) = f(INT, CNN, ARE)

= 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206 (1)

5.3.2.2 Regression model analysis

1. Coefficients of each variables

INT – The coefficient of spatial integration INT in space occupancy model is 3.752, indicates every unit increase in spatial integration, the space occupancy will be increased by 3.75 percentage in case other spatial variables(CNN, ARE) are constant.

ARE - The coefficient of space area size ARE is 3.301, that is, every square meter per resident increase in space area size, the space occupancy will increase 3.30 percentage when other spatial variables remain unchanged.

CNN - The coefficient of spatial connectivity CNN is 0.506, which tells every unit increase in spatial connectivity, the space occupancy will be increased 0.51 percentage in case other spatial variables(INT, ARE) are constant.

2. t-statistics of each coefficient

The t-statistics(t column) and associated 2-tailed p-values(Sig. column) in coefficient table of Table 5.5 tells whether a given coefficient is significantly from 0(or no effect) at the 0.05 alpha level[Note 7, Standardized Beta Coefficient]. It can be seen that:

INT – The coefficient of INT(3.752) is significantly different from 0 because its p-value is .012 which is smaller than 0.05.

ARE - The coefficient of ARE(3.301) is significantly different from 0 because its p-value is 0.000(0.000079), which is much smaller than 0.05.

CNN - The coefficient for CNN(.056) is nearly significantly different from 0 for the reason that its p-value is 0.076, which is just little bigger than 0.05.

Finally, the intercept is also significantly different from 0 at the 0.05 alpha level.

Therefore, equation (1) is fairly a good space occupancy regression model with space inherent spatial configuration for general common spaces in Japanese nursing home. That is

OCP(%) = f(INT, CNN, ARE)

= 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206 (1)

3. Relation between space utilization and Space syntax metric alone

Based on above common space occupancy regression model for nursing home in Japan, except the space spatial metrics INT and CNN measured by Space syntax theory, the space geometric metrics, space area size per resident is confirmed to be significant variable. Which tells, due to the uniqueness of elderly residents' slow movement and space recognition, the methodology and application of SS theory alone for general peoples' recognition and involvement in space is not always applicable to elderly residents in nursing home.

5.3.3 Occupancy regression model for common space without dining room

Comparing with other common facilities(common space), the occupancy of dining room(DRM) has its uniqueness that it is generally used in pre-defined time interval. For this reason, we remove dining room from common spaces and perform the occupancy regression analysis.

5.3.3.1 Regression model parameter for common space without dining room

The regression result for common spaces without dining room included is shown in Table 5.6.

Table 5.6 Regression result for all common space without dining room

Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
3	.724[b]	0.525	0.495	1.49266

a. Predictors: (Constant), INT, ARE, CNN
b. Dependent Variable: OCP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	117.970	3	39.323	17.649	.000[b]
	Residual	106.946	48	2.228		
	Total	224.916	51			

a. Dependent Variable: OCP
b. Predictors: (Constant), INT, ARE, CNN

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.(p)	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
3	(Constant)	-1.233	0.831		-1.484	0.144	-2.904	0.437
	INT	0.378	0.830	0.052	0.456	0.651	-1.291	2.047
	ARE	1.646	0.697	0.237	2.362	0.022	0.245	3.047
	CNN	0.834	0.152	0.626	5.484	0.000	0.528	1.140

a. Dependent Variable: OCP

In table 5.6, the model summary and ANOVA table tell that spatial integration INT, area size ARE, and spatial connection CNN this three spatial variables are significantly related to space occupancy OCP with $F(3,48) = 17.649$, $p=0.000<0.001$. The multiple regression coefficient(R) is .724, indicating approximately(R square) 52.5% of the variance of the space occupancy can be predicted by using spatial integration INT, spatial connection CNN, and space size ARE.

However, the t-statistics in Table 5.6 coefficients table tells the coefficient of INT(0.378) is not significantly different from 0 because its p-value is 0.651 which is much bigger than 0.05.

As a general regression rule[Note 9 what does it mean], the spatial integration INT should be removed for further space occupancy regression analysis. After remove INT, the space occupancy regression result is shown in Table 5.7.

Table 5.7 Regression result for all common space without dining room

Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.723[b]	0.522	0.503	1.48055

a. Predictors: (Constant), ARE, CNN
b. Dependent Variable: OCP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	117.507	2	58.753	26.803	.000[b]
	Residual	107.409	49	2.192		
	Total	224.916	51			

a. Dependent Variable: OCP
b. Predictors: (Constant), ARE, CNN

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.(p)	95.0% Confidence Interval for B Lower Bound	Upper Bound
2	(Constant)	-0.915	0.448		-2.045	0.046	-1.815	-0.016
	ARE	1.657	0.691	0.239	2.400	0.020	0.269	3.045
	CNN	0.867	0.133	0.650	6.527	0.000	0.600	1.133

a. Dependent Variable: OCP

Table 5.7 tells that area size ARE and spatial connection CNN spatial variables are significantly related to space occupancy OCP with $F(2,49) = 26.803$, $p=0.000<0.001$. The multiple regression coefficient(R) is .723, indicating approximately(R square) 52.2% of the variance of the space occupancy can be predicted by using space area size ARE and spatial connection CNN.

Because both the coefficient of ARE(1.657) and CNN(0.867) are significantly different from 0 with $p=0.020 < 0.05$, and $p=0.000(0.000000358) <0.05$ respectively, we get the space occupancy OCP regression equation for common spaces without dining rooms included as:

$$OCP(\%) = f(ARE, CNN) = 1.657 * ARE + 0.867 * CNN - 0.915 \qquad (2)$$

5.3.3.2 Regression model analysis

The coefficients of ARE is 1.657, that is, every square meter per resident increase in space area size, the space occupancy will increase 1.66 percentage when other spatial variables remain unchanged.

The coefficient of spatial connectivity CNN is 0.867, which tells every unit increase in spatial connectivity, the space occupancy will be increased 0.87 percentage in case other spatial variables are constant.

Same as model 1, except the space spatial metrics CNN measured by Space syntax theory, the space geometric metrics, space area size per resident is confirmed to be significant variable. Which also tells that the methodology and application of SS theory alone for general peoples' recognition and involvement in space is not always applicable to elderly residents in nursing home.

5.4 Discussion

5.4.1 Value range of spatial configuration variables(ARE, INT, CNN)

The sample data value range of space area size, spatial integration, and spatial connectivity in this study is listed in Table 5.8.

Basically this prediction model of space occupancy is valid for the spatial variables value changes in the range shown in Table 5.8[Note 7 Standardized Beta Coefficient]. That is, the area size is between 0.06 m^2/residents to 1.28 m^2/resident, the spatial connectivity ranges from 1.0 to 8.0. The values of spatial variables exceeds too much of this range will lead the prediction of space occupancy invalid.

By this data range of spatial variables, the predicted occupancy of common space value range is listed in Table 5.9. That is, approximately the applicable occupancy of space is in the range of 0.0% to 10.41% by this space occupancy prediction model.

On the other hand, the actual surveyed occupancy value range from the 12 nursing homes is from 0.07% to 15.87%. The predicted occupancy from regression model matches part of the actual surveyed result, this should also be keep in mind when apply the regression model in actual design work.

Table 5.8 Value range of spatial variables for occupancy

	N	Range	Minimum	Maximum	Mean	Std. Deviation
ARE	76	2.34	0.06	2.40	0.52	0.46
INT	76	1.2075	0.4966	1.7041	1.0361	0.2888

CNN	75	7.00	1.00	8.00	2.24	1.41
OCP,%	62	15.80	0.07	15.87	2.72	3.61
Valid N (listwise)	62					

Table 5.9 Value range of predicted occupancy

	INT	ARE	CNN	Model1 ,OCP1, %	Model2, OCP2, %	Actual surveyed occupancy
Lower value	0.4966	0.06	1	0.00	0.05	0.07
Up value	1.7041	2.34	8	14.16	10.00	15.87

And, this common space occupancy regression model is based on the survey data from 12 nursing homes. There might be difference of coefficient values or even significant variables if the survey data are different. Of course the more survey data conducted, the closer the regression model with real occupancy situation.

5.4.2 Selection of space occupancy regression model

Two common space occupancy models are investigated up to now, they can be used in different scenarios. The first scenario is to take all common facilities as general common space target, the second scenario is to exclude dining room from common facilities.

However, in our investigation for 12 nursing homes, the occupancy difference between dining room(0.60% ~ 15.87% from Table 5.3) and other common facilities(0.07% ~ 9.70% from Table 5.3) is obvious, this difference might have more impact than the effect from different physical spatial configurations.

5.4.2.1 All common facilities as a general common space target – Model 1

The regression model 1 basically applies to common facilities without considering the occupancy difference between dining room and others(for example, in the floor where there is dining room located). In this model, the occupancy difference between dining room and other rooms might be more than the difference by different physical spatial configuration.

In this case, the spatial integration, space area size, and spatial connectivity are significant IVs to space occupancy, regression model is:

$$OCP(\%) = f(INT, CNN, ARE)$$

$$= 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206 \quad (1)$$

It can be seen that increase in spatial integration, area size, and spatial connectivity are effective way to raise space occupancy.

5.4.2.2 All common facilities except dining room as common space target – Model 2

The regression model 2 applies to common facilities with considering the occupancy difference between dining room and others(for example, in the floor where there is no dining room located). In this case, the space area size, and spatial connectivity are significant IVs to space occupancy.

$$OCP(\%) = f(CNN, ARE)$$

$$= 1.657 * ARE + 0.867 * CNN - 0.915 \quad (2)$$

In this occupancy regression model, the increase in area size, and spatial connectivity are effective way to raise space occupancy.

Table 5.10 summarizes the recommendation of the space occupancy model for each common facility plan design.

Table 5.10 Recommendation on space occupancy model on each common facility occupancy

	Option 1	Option 2	IVs
ENH	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT
DRM	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206		INT, ARE, CNN
PTR	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT
MPR	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT
SST	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT, VHR
CMS	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT
DSR	OCP = 1.657 * ARE + 0.867 * CNN - 0.915	OCP = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206	ARE, CNN, INT

5.4.3 Effective way of raising space occupancy

Because the spatial connectivity, spatial integration, and space area size are significantly related to space occupancy for most of common facilities in nursing home, the increase of routines link to common facilities, design the space layout with higher spatial integration, and bigger area size per resident are valid way to improve resident space occupancy for most of common facilities in Japanese nursing homes.

Specific to each common facility.

For entrance hall, spatial connectivity and area size per resident are two significant variables related to space occupancy, and spatial integration is also a significant variable when taking all common facilities include dining room as a general common space class. Statistically, 1 m^2 per resident area size increase can raise ENH space occupancy by 1.7%, and one connection route can increase ENH space occupancy by 0.9%.

For dining room, the spatial integration, spatial connectivity and area size per resident are three significant variables related to space occupancy. In some case(option 3), only increase of spatial integration is also a valid way to improve dining room space occupancy. According to our regression model, every unit increase in spatial integration will lead space occupancy be increased by 3.75%, 1 m^2 per resident area size increase can raise occupancy by 3.3%, and every unit spatial connectivity can raise occupancy by 0.50%.

Similar with entrance hall, the spatial connectivity and area size per resident are two significant variables related to physical training room, and multiple purposes room space occupancy, and spatial integration is also a significant variable when taking all common facilities include dining room as a general common space class. And, in case of taking physical training room, and multiple purposes room as dedicated common space(option 3), only the spatial connectivity CNN is significantly related to their occupancy. Generally, 1 m^2 per resident area size increase can raise their space occupancy by 1.7%, and one connection route can increase ENH space occupancy by 0.9%.

Service station is little special. Generally the spatial connectivity and area size per resident are two significant variables related to its space occupancy, the shape also shows the influence, the narrow shaped service station will decrease its occupancy.

For community space, the spatial integration, the area size per resident, and spatial connectivity and are three significant variables related to space occupancy. By taking as general common facilities, every unit increase in spatial integration will lead space occupancy be increased by 3.75%, 1 m^2 per resident area size increase can raise occupancy by 3.3%, and every unit spatial connectivity can raise occupancy by 0.50%.

The day service room has its unfitness. Generally the increase in area size per resident and spatial connectivity can increase its space occupancy, and investigation also shows its occupancy can be increased in narrow shaped space.

5.5 Common space design use case

5.5.1 Introduction

This chapter introduces an example of using space occupancy regression model for nursing home common space plan design. This example is to simulate the changes of common space layout in design plan to have a higher occupancy, aims to provide a reference for the work flow of common space design from the perspective of having efficient occupancy in Japanese nursing homes.

5.5.2 Design workflow

According to above common space occupancy regression model, if not considering the occupancy difference between dining room and other facilities, the space occupancy can be predicated by spatial integration, space area size ARE, and connectivity CNN, that is, the model 1:

$$OCP = f(INT, ARE, CNN) = 3.752 * INT + 3.301 * ARE + 0.506 * CNN - 4.206 \quad (1)$$

if considering the occupancy difference between dining room and other facilities, the space occupancy rate can be predicated by model 2:

$$OCP = 1.657 * ARE + 0.867 * CNN - 0.915 \quad (2)$$

where the INT is spatial integration, CNN is spatial connectivity, ARE is space area size per resident.

Based on above regression model, to have a higher occupancy of a common space, increase the space connection with surrounding space, and enlarge the common space area size per resident within the applicable range are effective means. Needless to say that selection of design plan based on this regression model should follow the design essential requirement from customer, the budget plan, and the Japanese general building law and regulation.

Therefore, the work flow here is to simulate different common space layout design, calculate the two Signiant predictors CNN, ARE, and calculate the occupancy rate based on the regression model, and select the design plan with higher predicted occupancy rate.

The workflow is shown in Fig. 5.21.

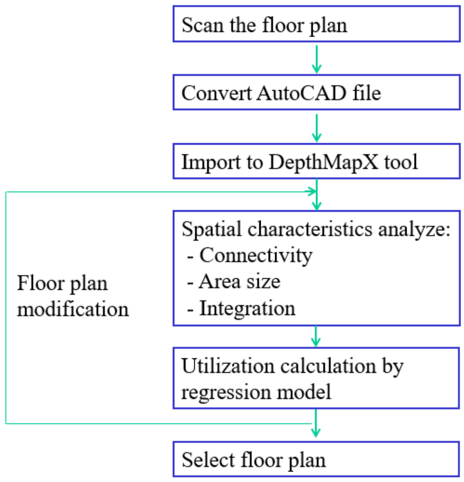


Fig. 5.21 Virtual common space spatial layout design model(Source: created by author)

5.5.3 Use case - Improve the occupancy by adding spatial connection

For nursing homes that the relocation of common space is difficult, there is an option to improve common space integration by increasing the connection with surroundings.

This example is an nursing home(NHID 45) built in 1994 in Tokyo region, the site area size is 3,895.36m^2, floor areas size is 5,517.19 m^2, 88 residents capacity, and a 100m^2 community space.

Fig. 5.22 is a design example of Japanese nursing home which was built in the year of 1999. The community space is located in the center of the site plan, but only has the connection to the EV hall in the bottom, the satire in the left top corner, and the corridor in left hand(Fig. 5.23, left and middle).

Fig. 5.22 Original common space floor plan(left), and spatial mean depth(middle) and integration result(right) (Source: created by author)

The spatial configuration of original design plan(plan A) of community space(CS) is shown in Fig. 5.23(middle, right), it can be seen that the connectivity, mean depth, and integration are 2, 4.0500, and 0.9631 respectively(Table 5.11). The predicted occupancy rate by regression model is 1.54% shown in Table 5.11 by model 1, and 1.38% by model 2.

Table 5.11 The spatial configuration and predicted occupancy rate by different design plan

Design plan	ARE(m^2/p)	CNN	MD	INT	Model 1, OCP(%)	Model 2, OCP(%)
Plan A	0.34	2.0	4.0500	0.9631	1.54	1.38
Plan B	0.34	3.0	3.3170	1.2813	3.24	2.25
Improvement					110%	63%

From the site plan in Fig. 5.23(left), it is hard to relocate the community space to other place, the other option is considered.

Within the same space area size, we simulate to increase the connectivity with surroundings in plan B. A connection to light court in the right-hand corridor as shown in Fig. 5.23(left) is proposed, that is to open a new connection of “community space – light court – corridor”. With plan B, the spatial characteristics of CS changed to 3, 3.3170, and 1.2813 for connectivity, mean depth, and integration respectively as shown in Fig. 5.23(middle, right), and Table 5.11. And, the predicted community space occupancy rate is 3.24% by model 1, approximately doubled to original plan A, and is 2.24% by model 2, which is 63% improvement.

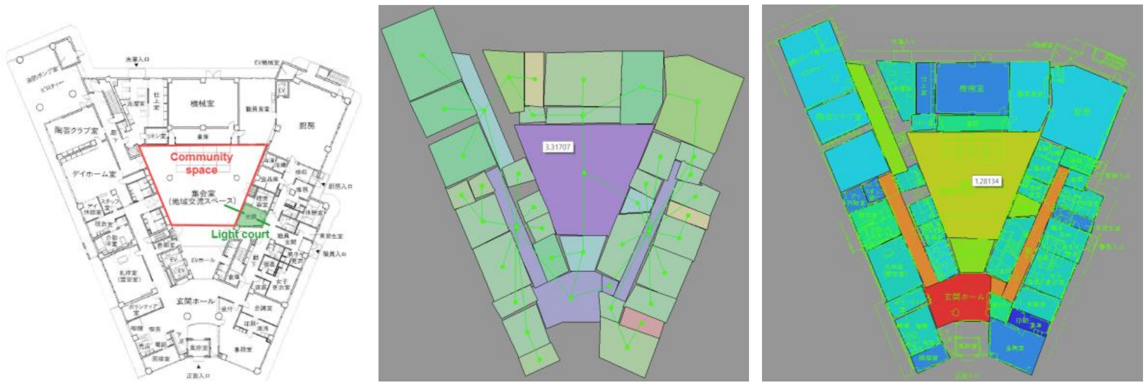


Fig. 5.23 Proposed common space floor plan(left), and spatial mean depth(middle) and integration result(right) (Source: created by author)

So, with same area size and same location, the occupancy rate can also be improved by adding connection routine. Within the increase of connectivity, the mean depth, and integration spatial attributes are also improved.

5.6 Summary

In this chapter, two multiple linear regression models for common space occupancy and spatial configuration are analyzed. One is to take all common facilities as a general common space category, another one is to exclude dining room due to its uniqueness in utilization time interval. The analysis result for first model shows that the spatial integration, space area size, and spatial connectivity are significant IVs to space occupancy, and one unit increase of spatial integration, spatial connectivity, and 1m2 per resident of area size would raise space occupancy by 3.75%, 0.51%, 3.30% respectively. The analysis from second model reveals that the space area size, and spatial connectivity are significant IVs to space occupancy, with increase of 1m2 per resident of area size, one unit of spatial connectivity would lead the occupancy raised by 1.66%, and 0.87% respectively.

Besides, a nursing home common space spatial configuration design model use example is introduced. The example is to simulate the increase the spatial connectivity only for the community space in a nursing home built in the year of 1999. By the adding one connectivity, the spatial integration of changed from 0.9631 to 1.2813, and the predicted occupancy rate is about double to original.

Therefore, allocate common facility to place with higher spatial integration, more spatial connectivity with surroundings, and expand space area size per resident are valid ways to raise the space occupancy of common space in Japanese nursing homes.

Note:

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Chapter 6 Conclusion

6.1 General summary

This study is to clarify the common space spatial configuration in Japanese intensive care nursing home, and explores the association with space occupancy, for contribution to spatial design for better resident's social exchange. The factors of spatial configuration in this paper includes space area size per residents, shape, distance to living space, and the spatial metrics which is measured by Space syntax theory.

Firstly, the common space area sizes and factors of spatial configuration form Space Syntax theory are analyzed and compared through the past 35 years nursing home samples for clarifying the spatial characteristic changes.

Secondly, actual spatial occupancy by residents are observed through the field survey in 12 nursing homes, and the tendency of occupancy in each common space are clarified.

Thirdly, the spatial configuration is combined with spatial occupancy to perform the multiple linear regression analysis, then the spatial integration, area size per resident, and spatial connectivity are extracted as significant factors to common space spatial occupancy in Japanese nursing home.

In detail, chapter 1 clarifies the research background, purpose, objective and significance of this study with the inclusion of previous literature review.

As the rapid proceedings of aging and super aging society, the quality of life of elderly people has raised people's attention. Meanwhile, many researches have verified the importance of social activity and social life to peoples healthy and longevity life, and demonstrated the importance of common space to people's social life. But on the other hand, investigation shows that the common space occupancy rate in Japanese nursing home is low. This raises the needs on common space spatial design to promote the space occupancy, and to improve people's social life and to raise resident's quality of life.

This chapter also covers the research methodology in this study. It simply introduces the Space syntax theory, the concept of the spatial characteristics, the Space syntax DepthMapX computer tool, and the workflow to deploy in nursing home spatial configuration evaluation. After that, the method for common space area size calculation, and space occupancy survey, as well as the multiple linear regression between space occupancy and spatial configuration is introduced.

Chapter 2 studies the transition of common space area size in Japanese intensive care nursing home from past 35 years. The investigation to nursing homes(79 in total) published in Japanese architecture magazines shows that the total area size of common space per resident was gradually increased since the 1980s from 3.2m^2 to 8.1m^2 in 2010-2015. In detail, the area size per resident for dining room, physical training room, multi-purpose room etc. daily life category common space was increased from 2.1m^2 in 1980s to 6.5m^2 in 2010-2015, community space, meeting room, conversation space etc. common facilities was increased from 0.4m^2 in 1980s to 1.2m^2 in 2010-2015, the service facility common space like service station, beauty salon, shop etc. were increased from 0.1m^2 in 1980s to 0.3m^2~0.5m^2 in 2010-2015. On the other hand, the area size of entrance hall, lobby and guest room, family room, day service etc remained less changes in the whole period. This reflects the tendency of increasing the dining room, physical training room, multi-purpose room etc. daily life common facility and community space area size to enhance the residents' daily life and enrich social exchange in Japanese nursing homes.

Chapter 3 analyzed the common space spatial structure in Japanese intensive care nursing home and how it was transited from past 35 years. The investigation of spatial configuration from Space syntax theory reveals the spatial centrality(space with the highest spatial integration value) in Japanese nursing home has been changed from the corridor in the 1980s to hall space in modern Japanese nursing homes. And, the community space, physical training room, service station, and, dining room, etc. common facilities were also started to be the spatial centrality in some of Japanese nursing home after the 1995s.

About the overall changes of spatial configuration, the community space shows the increase in spatial integration and spatial connectivity in the past 35 years, from 0.78 in 1980s to 1.09 in 2010-2015, and from 2.0 in 1980s to 4.29 in 2010-2015; the physical training room shows small increase in spatial integration and spatial connectivity, from the 0.99 in 1980s to 1.02 in 2010-2015, and from 1.83 in 1980s to 3.13 in 2010-2015. Because both spatial integration and connectivity are the indicator of accessibility, this spatial transition tells the tendency to allocate place with higher spatial centrality for community space and physical training room in Japanese nursing homes. On the other hand, the analysis also reveals that the service stations which were allocated in place with high spatial integration in classical large-scale care nursing homes are allocated in lower spatial integration in modern unit care nursing homes.

Chapter 4 details the intensive survey of common space occupancy in Japanese intensive care nursing home. Totally 12 nursing homes around Tokyo area are selected where the occupancy rate of residents in eight common facilities from 8:00am to 18:00pm were surveyed, which involved 1070 target residents, and presented total 96 common space occupancy data.

The selection of nursing homes takes into the consideration of residents' health condition etc. human factors, data shows the health status of surveyed nursing homes is in average level of all Japanese nursing homes, therefore survey data should be applicable to other nursing homes in Japan.

The survey data reveals that the average occupancy of entrance hall in the surveyed nursing homes is 3.92%, dining room is 9.70%, community space is 1.52%, physical training room is 0.77%, and the total average occupancy of all common facilities is 3.59%, which is in accordance with the result by other researchers that the time staying in hall, lobby, community space, physical training room etc. common space was only about 4% to less than 10%. This data also verifies the benefit to raise the common space utilization in Japanese intensive care nursing home.

Together with the common space area size in Chapter 2, spatial configuration data in Chapter 3, this survey data is used in Chapter 5 for common space occupancy regression model analysis.

In Chapter 5, the space occupancy regression model with space configuration were performed, which includes space layout characteristics measured by Space syntax syntactic metrics, the spatial integration, spatial connectivity, spatial mean depth, and spatial total depth, and space area size, shape, and proximity. Based on the common characteristics in occupancy time and purpose in common facility, a general occupancy regression model for all common facilities, and specific regression model for common space exclude dining room were obtained.

The regression model for all common facilities as general common space are extracted with the spatial integration, area size per resident, and spatial connectivity as significant spatial configuration factors, which tells that generally the space occupancy(occupancy rate) can be increased by increase in spatial integration, per resident area size, and spatial connectivity.

This regression model basically applies to common facilities without considering the occupancy difference between dining room and others(for example, in the floor where there is dining room located).

And, when taken all common facilities except dining room as a common space, the space area size, and spatial connectivity are significant spatial configuration factors.

This regression model 2 applies to common facilities with considering the occupancy difference between dining room and others(for example, in the floor where there is no dining room located).

Because only space area size and spatial connectivity are significant variables, this model is much easier to use in actual nursing home common space design practice.

However, compared with the actual occupancy survey result, the predicted occupancy from regression model matches part of the actual surveyed result, this should be kept in mind when apply the regression model in actual design work. Also, the survey shows that the occupancy difference between dining room and other common facilities is obvious, this difference might have more impact than the effect by different physical spatial configurations when using regression model 1.

As a conclusion by the two common space occupancy models, with certain range of spatial configuration and space occupancy within the 12 surveyed nursing homes, allocating common facility to place with higher spatial integration, more spatial connectivity with surroundings, and increasing the average space area size per resident are valid way to raise the space occupancy in Japanese nursing homes.

This chapter also introduces a nursing home common space design use cases based on the derived space occupancy regression model. By simulating the increase of spatial connectivity only, the community space occupancy is improved by 25%.

6.2 Prospects of future study

The utilization of common space in nursing homes may be affected by a number of factors. The space spatial structure like space area size and spatial characteristics is part of these factors. Except the factors considered in this research, the space height and environmental factors like temperature, lighting, decoration, and equipment are not considered in this research.

And, the space utilization can also be different for residents with different genders, age, and health conditions. This research didn't make differences for different residents' utilization.

In addition, the residents may have different behaviors in common space, like stand up, have conversation, active movement, or sedentary. In our research, this difference in behavior was also not considered.

And, the common space occupancy also varies a day in different time interval depending on space function. This difference is not addressed in detail in this study.

Further, the limited utilization survey data limits the regression analysis was being performed to take multiple common facility categories as one general common facility.

Besides, except taking consideration of having higher occupancy for residents, the common space design should also take into consideration for staff's movement in providing nurse care.

In summary, by introducing Space syntax theory and common space occupancy intensive survey, a preliminary common space occupancy regression model with spatial configuration for Japanese nursing home are proposed in this research. Based on this occupancy regression model, the increase of spatial integration and spatial connectivity is valid way to have higher occupancy for entrance hall, dining room, physical training room, and multiple purpose room. In addition to spatial integration and spatial connectivity, the increase of area size per residents is also a valid way to have high efficiency space occupancy of community space.

However, this investigation didn't take consideration of the difference in residents' gender, age, health condition, and didn't take consideration of the difference of residents' behavior; and the limited occupancy survey data also restricts the regression model be performed by taking multiple common facility category as a general common facility. All these aspects can be detailed in future study.

List of Publications

Journal

1. Common Space Spatial Layout Transition in Japanese Nursing Home - By Space Syntax point of view. Asian J. Environment-Behaviour Studies., Vol.3, No.7, pp.21-30, 2018
2. CCRC Common Facility Spatial Structure: A Study by Space Syntax. Asian J. Environment-Behaviour Studies., Vol.2, No.5, pp.1-13, 2017
3. 1978 年以降の特別養護老人ホームにおける共有空間の室機能及び面積の変遷日本建築学会計画系論文集, 2017 年 8 月 12 日提出, 2018.03.19 採用。2018 年 7 月, 第 83 巻第 749 号, pp. 1183 – 1192

International Conference

1. Community space spatial layout transition in typical Japanese nursing home. Proceedings of the 13th European Architectural Endoscopy Association, Sep. 6th ~ Sep. 8th, 2017, Glasgow.
2. Japanese Nursing Home Common Space Spatial Layout Changes in The Past 35 Years. Proceedings of the 11th Space Syntax Symposium, July 4th ~ July 7th, 2017, Lisbon.
3. Common Space Spatial Layout Design Model in Nursing Home. 2018 Design Communication Association Conference, New York, Oct. 7th~ Oct. 10th, 2018.

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